

The introduction of a carbon price and the use of agrichar in the sugarcane industry

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Abstract: The Australian Government's proposal to put a price on carbon is likely to have a significant impact on the price of farm inputs (diesel, fertiliser, water and electricity). Furthermore, offsets (reduction or removal of greenhouse gas emissions that counterbalances emissions elsewhere in the economy) are a potential area of expansion of interest to the agricultural sector. Agrichar is one of the new technologies and farming practices being investigated to counteract carbon-price-imposed costs. Its two claimed benefits, which relate both to the profitability of sugarcane growers as well as to climate change, are the reduction in fertiliser application and the carbon which agrichar can store in the soil for hundreds to thousands of years. This study drew on the Farm Economics Analysis Tool (FEAT) developed by the Queensland Department of Primary Industries and Fisheries specifically for the sugarcane industry. An analysis was conducted for a typical sugarcane farming enterprise in the Herbert region of north Queensland. The scenarios included in the analysis recognised the change in input prices as a price is put on carbon, the change in farm practices when agrichar is included in operations and the potential to trade in offsets from that additional carbon stored by the use of agrichar. The sugarcane grower was found to benefit from the inclusion of agrichar into the operations. Agrichar is seen as a potential and viable option for sugarcane growers and should be considered as an alternative under the emissions trading scheme to minimise the impact of the rise in input costs. Further scientific and policy development could result in the possibility for stored carbon to be traded in the offsets market, providing additional, although minor, cash flow to the grower.

Keywords: Carbon price, sugarcane profitability, carbon offsets, agricultural adaptation.

Introduction

This paper examines the potential impacts of the introduction of a price on carbon on the Australian sugarcane industry. The sugarcane industry is one of Australia's largest and most important rural industries (Canegrowers 2008). It has the capacity to produce more than 4.75 million tonnes of sugar annually. Depending on prices, the industry generates direct revenue of about $1.5 billion to $2 billion. Under a carbon price, sugar growers' costs will increase, due to an increase in the price of inputs.

However, a new product which is used instead of fertiliser and has long-term benefits may possibly be available on the commercial market. This is known as 'biochar' or 'agrichar'.

The objectives of this study are to:

1. overview the introduction of a carbon price and its potential impacts, especially on the sugar industry;
2. outline the agrichar technology and investigate its impacts on input use as well as the possibility of using it in the trading of offsets;
3. examine the profitability of agrichar in sugarcane farming.

These objectives were examined by developing four scenarios, which were then used to conduct an economic analysis. Given that the use of agrichar in farming practices is at an experimental stage, the costs and benefits are somewhat uncertain. The advice in this study is based on the current state of knowledge, however, the approach used will enable this study to be updated once more technical and policy information becomes available. It is assumed that agrichar will be recognised in the domestic offset market. The impacts on the cost of inputs are the current best estimates of the effect of a price on carbon.

Background

Emission abatement costs, reflected in increased prices of fuel, electricity and energy-dependent farm inputs (e.g. fertiliser, electricity, fuel) will reduce farm competitiveness, lowering the value of export sales and increasing import pressure in domestic markets. This will particularly be the case in those sectors—grains, horticulture, beef, sugar and cotton—that are facing increasing competition from Eastern Europe, Asia and South America (Keogh 2008).

Four agricultural inputs have been identified as changing in price once a price is placed on carbon emissions. These are diesel, water, electricity and fertiliser. The Queensland Farmers' Federation provided estimated increases, which are outlined in Table 1 and used in Scenarios 2, 3 and 4 of the economic analysis.

The sugarcane industry is important to Australia's economy, with the majority of production occurring in Queensland. Over the years, the industry has been actively pursuing changes in farming systems, the key change being from burning to a process of green cane trash blanketing (GCTB), which involves the retention of sugarcane trash. The industry is subject to many environmental constraints, mainly in respect to the degradation of the Great Barrier Reef, due to its proximity to the reef and land use conflicts. Growers are constantly in the spotlight for excessive use of nitrogen fertilisers, which enter the surrounding water systems and flow into the Great Barrier Reef, harming the ecosystem. Recently a new farming input, agrichar, has been developed, offering another way toward sustainable operations with a reduced impact on the environment. Adopting new, more sustainable farm management practices can improve the image of growers by demonstrating that they are 'doing their bit' for the environment.

Agrichar (Figure 1) is produced by pyrolysis (the chemical decomposition of organic material by burning in the absence of oxygen). "Instead of 'slash and burn' farming techniques that release carbon dioxide into the atmosphere, 'slash and char' would put carbon dioxide back into the ground" (Dover 2007). Agrichar contains a stabilised form of carbon that has the potential to generate a sustainable increase in soil carbon. Agrichar captures atmospheric carbon and stores it safely in the soil, providing additional greenhouse gas mitigation along the way.

Figure 2 shows that when char is added to yellow clay soil of limited biological activity, it is transformed into some of the richest soils.

Benefits of agrichar include:

- Agrichar can play a vital role in climate stabilisation through sequestering carbon and reducing greenhouse gas emissions from agricultural soils.
- "Agrichar provides further mitigation of greenhouse gas emissions through the reduction in nitrous oxide emissions from the soil" (Downie 2007).
- According to Best Energies (2008), agrichar improves soil capacity for: nutrient retention (reducing ongoing fertiliser inputs), moisture retention, increasing and holding carbon levels (sequestered from the atmosphere), active earthworms and useful microbes and balancing pH in some soils.
- Application of 20 tonnes per hectare will raise the organic carbon level of the soil by 0.7% to 1% (Benjamin 2008).
- Generally farmers would use one application of 10 to 20 tonnes per hectare of agrichar and this one application would have a long-term benefit in the soils (Benjamin 2008).
- Nitrogen fertiliser use can be reduced by 100% if using manure-based biochars and possibly 50% if using wood-based biochars (Van Zwieten, pers. comm.).

Agrichar in the context of trading carbon sequestration offsets

An added challenge for the design of a carbon reduction policy will be finding ways to recognise the sequestration of carbon in soils and vegetation, or the incorporation of carbon into the soil through processes such as agrichar (Keogh 2008). This process provides opportunities for both lower emission reduction costs and increased farm productivity, but will require careful development of the carbon reduction policy rules to ensure that appropriate incentives are created.

The Kyoto permanence principle is a key element in the international carbon market model. It requires that credits created through avoided emissions and sequestration credits used to offset emissions are permanent (Article 3 of Kyoto Protocol). Permanence is defined as greater than 100 years. "There is opportunity for agricultural soils to sequester huge amounts of carbon as biochar, which is a permanent, low risk sink" (Best Energies 2008). Agrichar would be considered a long-term sink for the purpose of reduction in emissions. Once agrichar is incorporated into the soil, it is difficult to imagine any incident or change in practice that would cause a sudden loss of stored carbon. This addresses the issue of permanence under the Kyoto Protocol. Sharpe (2008) believes agrichar lasts for thousands of years, increasing the possibility for including soil carbon sequestration.

Accountability of agrichar is more straightforward than with other soil sequestration methods. Tracing the source of carbon in soil back to a change in agricultural practice is difficult and therefore not accepted under the Kyoto Protocol. As these limitations do not exist for agrichar sequestration, there is no reason why the associated emission reductions should not be allowed into trading markets under current agreements (Lehmann 2007). The nature of slow pyrolysis technology ensures that its benefits are measured and easily auditable for the calculation of carbon offsets (Vyse 2008).

Agrichar will comply with the additionality criteria, as it is a new product and a change in farming practices that can be verified.

However, there is a limitation on recognising the use of agrichar as an offset as it is still in the experimental stage. Further research needs to be undertaken on issues such as:

- Best methods to incorporate into soil;

- Most cost-effective application methods and rates;
- The payback periods for various applications;
- If benefits change with type of soil;
- Is it truly a substitute for fertiliser;
- If further applications are necessary;
- How much can be produced and available in the foreseeable future;
- Supplying agrichar in substantial quantities.

Environmental externalities

The use of agrichar has environmental benefits. This report does not consider the indirect benefits associated with agrichar from reduced pollution of surface or ground waters. These externalities occur because of the decrease in fertiliser use due to agrichar's improved nutrient retention and moisture retention.

Methodology

A combination of personal communications and secondary resources was used to compile the data used in this study. The primary tool to conduct the economic analysis was the Farm Economic Analysis Tool (FEAT), developed by the Queensland Department of Primary Industries and Fisheries (DPI&F). It was necessary to include a risk analysis as much of the information used in this study is at an experimental stage. The Excel add-in tool @RISK was used for this purpose. A discounted cash flow was developed to evaluate the proposed changes to the farming system. Four scenarios were developed to address the objectives of this study.

Farm Economic Analysis Tool (FEAT) is an annual steady state model, which does not account for transitional factors, such as farmers altering farming practices once fertiliser prices prove to be too expensive. It is a whole farm economic decision model specifically designed for sugarcane growers and can be used to evaluate the economic impact of a change in farming practices (Cameron 2008). FEAT builds on a detailed model of the farming system and farm resource use to allow impact assessment of alternative farming practices.

FEAT was used to evaluate: (1) the impact of a carbon price policy on the sugarcane farmer; and (2) the benefits to the grower if existing farming practices were changed to include the use of agrichar.

@RISK was used for the risk analysis as it integrates well with the Excel-based FEAT program. Cumulative probability distributions were used to calculate expected ranges of values. A standard discounted cash flow (DCF) analysis was used to evaluate the proposed changes to the farm from incorporating agrichar into the existing farming system. The DCF analysis estimates the net present value (NPV) of the incremental net cash flow stream over 20 years. It arises directly as a result of estimating the difference in the annual cash flow pattern for the farm, with and without the proposed change.

A breakeven analysis was carried out on the price of char to find when it is unviable to change from the current practices to apply char.

Scenarios

Four scenarios were developed to run in FEAT, taking into account possible carbon prices, the introduction of agrichar and the trading of carbon offsets. Bernard Milford (pers. comm. 2008) from the Canegrowers Organisation assisted with the development of each scenario. A concise statement of the scenarios appears in Table 2.

Scenario 1: Base Case

Scenario 1 is the base case—a typical dryland sugarcane farm in the Herbert region. The data for the base case were provided by Mark Poggio from DPI&F in Ingham, based on information from a previous study conducted in 2007. Because these data were obtained from the 2007 study, it needs to be noted that since then there has been a considerable increase in the price of fertiliser. In 2007, prices were DAP $700/tonne, NK $650/tonne, lime $100/tonne, and GF 501 $650/tonne compared with mid-2008 prices of DAP $1,710/tonne, NK $1,115/tonne and GF 501 $1,210/tonne. A sensitivity analysis was carried out on this.

The base case is for a 39.96 hectare dryland sugarcane farm in the Herbert region, which consists of a plant crop, four ratoons and fallow. Each of the six paddocks is of equal size (6.66 hectares). The expected sugar price is $295/tonne, with expected yields as follows:

- Plant: 97.5t/ha
- Third Ratoon: 76.88t/ha
- Fourth Ratoon: 71.88t/ha
- First Ratoon: 91.25t/ha
- Second Ratoon: 81.88t/ha

Scenario 2: Base Case + Carbon price

Scenario 2 considers farm operations under increasing carbon prices. As farmers are price takers and inputs are inelastic (mainly in the short run), there will be a reduction in profit due to the increase in the price of inputs. Perry (2008) estimated the change in farm inputs for the price of carbon traded in the market (see Table 1).

It is assumed that carbon will be priced at \$20 per tonne of CO_2 equivalent. As the farm used in the study is a dryland system, the relevant increases in its costs are diesel, at 6c/L and fertiliser at \$52.60/tonne. Since electricity is only used for domestic purposes, its cost is not accounted for in this model.

Scenario 3: Base Case + Carbon price + Agrichar

Scenario 3 builds upon Scenario 2, with the inclusion of agrichar into the farming operations. The agrichar is applied when planting, and therefore it takes six years before the entire farm is applied with agrichar. Fertiliser still needs to be applied to the remaining ratoons each year. This process is outlined in the farm plan matrix (Figure 3). Once all six fields have been applied with agrichar, no fertiliser needs to be applied again. Farmers apply one application of agrichar, which would have a long-term benefit to their soils (Van Zwieten in Benjamin 2008).

The following data represent the use of agrichar in farming systems:

- Application rate = 20t/ha (Downie in Benjamin, 2008);
- Cost of char = \$50–\$200 per tonne (Van Zwieten in Benjamin, 2008);
- Fertiliser reduction can be 100% if using manure-based biochars and 50% if using wood-based biochars (Van Zwieten, pers. comm.);
- Application cost = \$40/ha (Poggio pers. Comm.; Strahan pers. comm.).

Due to the large range of the estimated price of char in the commercial market, an expected value was calculated using @RISK. The expected char price used was \$122.50/tonne.

Scenario 4: Base Case + Carbon price + Agrichar + Offsets

Scenario 4 takes into account the second characteristic of char—its potential to sequester and store carbon. Agrichar meets the criteria outlined for offsets under the Kyoto Protocol. These criteria are additionality, measurability and permanence. Growers who adopt char into their system could possibly trade the *'additional'* carbon sequestered from changing practices, providing additional cash flow.

The following assumptions were made:

- at a rate of 20t/ha of agrichar, soil carbon will increase by 1% (Downie in Benjamin, 2008);
- an average of 28.6t/ha soil carbon in the Herbert region (Bernard Schroeder, pers. comm.);
- expected carbon price = \$27.50/tonne (calculated using @RISK);
- can only trade additional carbon sequestered (i.e. 1% of 28.6t/ha).

To comply with the Kyoto Protocol, growers can only trade the additional carbon sequestered by converting to the use of agrichar. The calculations are shown below.

28.6t/ha of soil carbon

1% additional soil carbon from agrichar = 28.6 x 0.01 = 0.286t/ha

As only apply agrichar on planting

Year 1: 0.286 x 6.66 = 1.9047 tonnes of additional soil carbon (plant)

27.5 x 1.9047 = 52.38

Can trade 1.9047 tonnes of carbon each year at a price of \$27.50/tonne

Therefore, carbon offsets = \$52.38 (cash flow)

Year 6: total farm under char

0.286 x 39.96 = 11.42856 tonnes of additional soil carbon

27.5 x 11.42856 = 314.29

Once entire farm applied with agrichar, can trade 11.42856 tonnes of soil carbon at a price of \$27.50/tonne.

Carbon offsets = \$314.29

Table 3 outlines the additional cash flow of the carbon offsets each year. It is assumed that offsets will be able to be traded each year.

The main assumption for Scenario 4 is that the additional carbon sequestered by agrichar will be able to be traded in the offsets market. This may or may not be the case. It depends on the form of the policy eventually developed. Further policy and science needs to be developed if soil carbon is to be included in the offsets market in future years.

Results

Table 4 presents key results from the FEAT modelling of the various scenarios. The table outlines total income, variable costs, gross margin and farm business profit. The main farm financial criterion used to compare the results is farm business profit. Farm business profit is the return to the business after variable costs and fixed costs are allocated.

Each of the scenarios has a total farm income of \$70,477 and a total fixed cost of \$92,150. This is based on the assumption of the same income stream and the same fixed costs for each scenario. Note that total fixed cost is far greater than total income, indicating that the typical cane farm is not viable under the price assumptions used in this study.

The change in gross margin between each scenario is due to the change in variable costs (gross margin = total income – variable costs). In the base case (Scenario 1), variable costs equal $43,266, increasing to $44,466 in Scenario 2. This is due to the increase in input prices (fertiliser and diesel) following the increase in the carbon price. Scenario 3 (year 1) and Scenario 4 (year1) have significantly higher variable costs due to the introduction of agrichar into the farming system. In year 1, char is applied at planting with the four ratoons having fertiliser applied. Scenario 3 (year 7–20) and Scenario 4 (year 7–20) have significantly lower variable costs of $27,555 when compared with the other scenarios. This is because once year 7 is reached, no agrichar or fertiliser is applied as discussed previously.

Figure 4 displays a graph of the risk analysis of each of the scenarios modelled in FEAT using the @RISK program. The graph indicates the cumulative probability of attaining particular levels of farm business profit under each of the scenarios. This graph can be interpreted in the following way. At point A, there is an 80% probability the farm business profit under Scenario 2 will be less than -$61,873, with a 20% probability that farm business profit will be greater than this.

Scenario 3 (year 7–20) and Scenario 4 (year 7–20) are seen as the better options when the decision is based on farm business profit. The farm business profit for Scenario 3 (year 7–20) is -$49,428 and -$49,114 for Scenario 4 (year 7–20). This compares to the base case where a farm business profit of -$64,939 was achieved. The difference between the farm business profits of Scenario 3 (year 7–20) and Scenario 4 (year 7–20) is due to the additional cash flow from the trading of carbon offsets. Both of these scenarios provide a smaller loss because no fertiliser or agrichar needs to be applied. Thus while the cost of agrichar reduces farm business profit in year 1, its impact in reducing fertiliser usage and overall cost is felt in years 7 to 20.

Because the benefits and costs of agrichar occur in different periods, a net present value of the stream of costs and benefits using discounting analysis needs to undertaken to determine the relative merits of using agrichar.

The discounted cash flow (DCF) was developed through the use of FEAT. The DCF analysis was used to evaluate the benefits of changing from existing farming practices (Scenario 2 – base case, carbon pricing) to operations that include the use of agrichar (Scenario 3). These two scenarios were chosen for the DCF as both include the price change of inputs under increasing carbon prices (fertiliser and diesel). Also Scenario 3 was chosen over Scenario 4, as currently the carbon sequestered by agrichar is not recognised as an offset. The cash flow from the offsets is minimal and would not have much impact on results. The criterion measured is the net present value (NPV). The NPV represents the current value of the investment over a 20-year period using a discount rate of 8%.

Table 7 displays the total farm income ($70,477), which is constant throughout all scenarios, and also the total farm costs of Scenario 2 and Scenario 3. This figure only displays year 1 to 7, as beyond this costs remain the same. It is seen that until year 5, the total costs of continuing operations under current conditions (Scenario 2, green cane trash blanketing) are less than that of using agrichar. However, from year 5 onwards, the total costs are less under Scenario 3. This is where the value of agrichar is evident. The benefits of change (both undiscounted and discounted) are seen in Figure 6.

During the 20-year period, the benefit of changing to the use of agrichar is $66,640. The benefits are not seen until year 5 due to the applications of agrichar and fertiliser. The benefit is due to the decreased use of fertiliser and agrichar to a point where none is applied. The figures for years 5 and 6 are the same as no fertiliser is applied to fallow, only agrichar. Table 5 outlines the changes in fertiliser and agrichar costs during the years (refer to the farm plan matrix in Figure 3).

The cost of applying agrichar is $2490/hectare. As it is only applied upon planting, the area applied is 6.66 hectares. The remaining four ratoons have fertiliser applied at a cost of $448.85/hectare for each ratoon (6.66 hectares). Each year char is applied upon planting and one less ratoon is applied with fertiliser as char has already been applied to that field. This process is followed until all fields are applied with agrichar and therefore there are no more costs for fertiliser or agrichar application.

This study did not place a value on the environmental externalities from changing existing operations to include agrichar. Sugarcane farmers are criticised for damage to the Great Barrier Reef due to their use of fertilisers and run-off into waterways. With the use of agrichar, fertiliser use is reduced, providing a positive externality. Agrichar is expected to reduce emissions of nitrous oxides from soils beyond replacing fertilisers, further contributing to an improved balance of greenhouse gases. Due to lack of data, this effect could not be quantified. Hence, results shown above constitute a significant underestimate of total benefits.

Sensitivity analysis

The discount rate used in the DCF was altered to see the effect on the NPV of changing farming practices. The results are shown in Table 6.

At a discount rate of 5% and 10% it is still beneficial to change existing farming practices to include agrichar.

A sensitivity analysis was conducted on the price of agrichar to determine at what price it is no longer viable to switch from existing farming systems to the inclusion of agrichar (i.e. NPV is equal to zero).

Figure 7 is a graphical representation of the NPV of change with respect to the price of agrichar ($/tonne). As the price of char increases, there is less benefit gained from changing practices. It is expected that agrichar will be available in the commercial market at a price range of $50 to $200 per tonne (Van Zwieten in Benjamin, 2008). At $50/tonne the NPV of change is $144,855. At $200/tonne the NPV of change equals $15,072. For prices beyond $225 there is no financial benefit of including agrichar in farming operations.

If agrichar is sold in the market at the expected price range of $50 to $200 per tonne, then it is beneficial to change from existing operations as the NPV of change is positive.

There has been a significant increase in the price of fertiliser since 2007. This increase in fertiliser prices will have a significant impact on farm profitability. A sensitivity analysis was carried out with the current fertiliser prices inputted into the FEAT model with the remaining data held constant. The results are seen in Table 7. A comparison with Table 4 clearly shows the extra benefits in the early years that result from the reduction in fertiliser use as agrichar is applied.

Conclusion

This study has examined the profit impacts on a select group of famers of some aspects of carbon pricing. Even before the inclusion of agriculture in the scheme, there will be flow-on effects, which will be felt at the farm level through an increase in the price of inputs.

Each of the scenarios has a total farm income of $70,477 and a total fixed cost of $92,150. The changes in gross margin between each scenario are due to the change in variable costs. In the base case (Scenario 1), variable costs equal $43,266, increasing to $44,466 in Scenario 2 when a price is placed on carbon. This is due to the increase in input prices (fertiliser and diesel) under the emissions trading scheme. Scenario 3, with agrichar but no offset trading, (year 1) and Scenario 4 with agrichar plus offset trading (year 1) have significantly higher variable costs due to the introduction of agrichar into the farming system. In year 1, agrichar is applied at planting with the four ratoons having fertiliser applied. Scenario 3 (year 7–20) and Scenario 4 (year 7–20) have significantly lower variable costs of $27,555 when compared with the other scenarios. This is because once year 7 is reached, no agrichar or fertiliser is applied.

A DCF model was developed, which indicated that during the 20-year period there is a significant advantage in changing to the use of agrichar when the decision criterion is farm business profit. By comparing the results of Scenario 2 (existing farming practice under a carbon price) with the use of agrichar (Scenario 3), it is evident that benefits can be achieved from year five onwards when there is a change in farming practices. During the 20-year period, the benefit of changing to the use of agrichar is $66,640. The benefit is due to the decreased use of fertiliser and agrichar to a point where neither is applied.

The major limitation of this study is that both policy and science regarding carbon emission policy and agrichar are in development stages. Further development in policy and scientific research in soil carbon inclusion into the offset market is required, as it is not currently recognised. Forestry is currently the only way to trade sequestered carbon in the offset market. The major assumption in Scenario 4 is that the additional carbon sequestered by agrichar will be included under the policy. The relevant points as to why agrichar could be included in the offsets market were discussed. However, improved research is required for char, as currently there is some information lacking. This includes:

- Whether it really is a substitute for fertiliser;
- Optimal application rates;
- How long the benefits last—i.e. is there a need for future applications;
- Yield benefits;
- Whether the benefits change under different soil conditions.

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Disclaimer

The author is responsible for any errors. Opinions expressed are his alone and do not necessarily represent the policy of the Queensland Department of Primary Industries and Fisheries.

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Appendix

Table 1. QFF estimates carbon price impact on farm inputs

Input	At $20/tonne	At $40/tonne	At $60/tonne
Electricity ($ per MW/hr)	$20	$40	$60
Fuel Diesel (cents/litre)	6 cents	12 cents	18 cents
Fertiliser (urea) ($ per tonne)	$52.60	$105.20	$157.80
Water ($ per ML)	$2.90	$5.80	$8.70

(Source: Perry, 2008)

Table 2. Scenarios

Scenario	Background
1 Base Case	Typical dryland sugarcane farm in the Herbert Region: base case.
2 Base Case + Carbon price	Scenario 1, plus the alterations to the price of inputs following the introduction of a carbon price
3 Base Case + Carbon price + Agrichar	Scenario 2, plus the use of agrichar in the operation.
4 Base Case + Carbon price + Agrichar + Offsets	Scenario 3, plus the trading of additional carbon sequestered from char in the offsets market.

Table 3. Carbon credits/offsets

Year	1	2	3	4	5	6
Cash flow from offset	$52	$105	$157	$210	$262	$314

Table 4. Summary of Scenario results

Scenario	Total Income	Variable Costs	Gross Margin	Farm Business Profit [a]
1 Base Case	$70,477	$43,266	$27,211	- $64,939
2 Base Case + Carbon price	$70,477	$44,466	$26,011	- $66,139
3 (year 1) Base Case + Carbon price + Agrichar	$70,477	$56,295	$14,181	- $77,969
3 (year 7-20) Base Case + Carbon price + Agrichar	$70,477	$27,755	$47,222	- $49,428
4 (year 1) Base Case + Carbon price + Agrichar + Offsets	$70,477	$56,295	$14,181	- $77,916
4 (year 7-20) Base Case + Carbon price + Agrichar + Offsets	$70,477	$27,755	$47,222	- $49,114

[a] Farm business profit is equal to gross margin minus total fixed cost. In all scenarios total fixed cost is equal to $92,150. In Scenario 1 for example, farm business profit = $27,211 - $92,150 = -$64,939.

Table 5. Total fertiliser costs when agrichar is used

Year		1	2	3	4	5	6
Scenario 3		Plant	Ratoon1	Ratoon2	Ratoon3	Ratoon4	Fallow
		6.66	6.66	6.66	6.66	6.66	6.66
Char Cost	2490	16583.4	16583.4	16583.4	16583.4	16583.4	16583.4
Ratoons		4	3	2	1		
Fertiliser Cost	448.85	11957.36	8968.02	5978.68	2989.34	0	0
Total Fert Costs		28540.76	25551.42	22562.08	19572.74	16583.4	16583.4

Table 6. NPV of change with a discount rate of 5%, 8% and 10%

Discount Rate	NPV of change
5%	$101,784
8%	$66,640
10%	$49,752

Table 7. Results with use of mid-2008 fertiliser prices

Scenario	Total Income	Variable Costs	Gross Margin	Farm Business Profit
1 Base Case	$70,477	$56,370	$14,107	-$78,043
2 Base Case + Carbon price	$70,477	$56,473	$14,004	-$78,146
3 (year 1) Base Case + Carbon price + Agrichar	$70,477	$65,619	$4,857	-$87,293
3 (year 7-20) Base Case + Carbon price + Agrichar	$70,477	$27,755	$42,722	-$49,478
4 (year 1) Base Case + Carbon price + Agrichar + offsets	$70,477	$65,619	$4,857	-$87,240
4 (year 7-20) Base Case + Carbon price + Agrichar + Offsets	$70,477	$27,755	$42,722	-$49,114

Figure 1. Sample of Agrichar

(Source: www.m-easy.co.jp/03/biochar.html, 2008)

Figure 2. Change in soil characteristics from agrichar

(Source: Lehmann 2007)

Figure 3. Farm Plan Matrix

Field / Year	1	2	3	4	5	6
1	P char	R1	R2	R3	R4	F
2	R1 char	R2	R3	R4	F	P char
3	R2 char	R3	R4	F	P char	R1 char
4	R3 char	R4	F	P char	R1 char	R2 char
5	R4 char	F	P char	R1 char	R2 char	R3 char
6	F char	P char	R1 char	R2 char	R3 char	R4 char
7	P char	R1 char	R2 char	R3 char	R4 char	F char

LEGEND	
P =plant R1 = ratoon 1	**APPLY CHAR**
R2 = ratoon 2R3 = ratoon 3	**APPLY FERTILISER**
R4 = ratoon 4 F = fallow	**CHAR ALREADY APPLIED FROM PREVIOUS YEAR**

Figure 4. Probability distribution of farm business profit

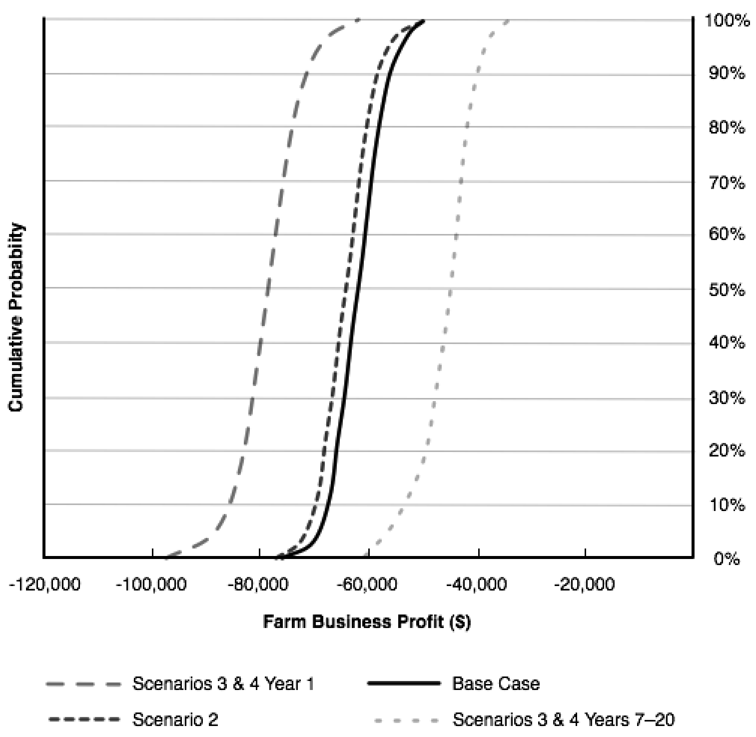

Figure 5. Total Farm Income and Total Farm Costs for Scenarios 2 and 3 over a 7-year period

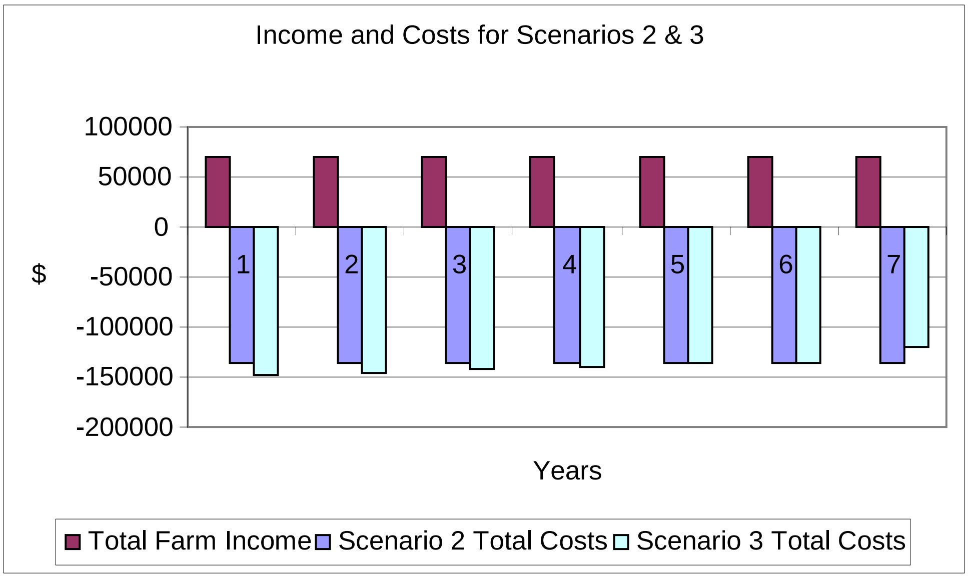

Figure 6. Change in farm business profit due to the change in farming systems

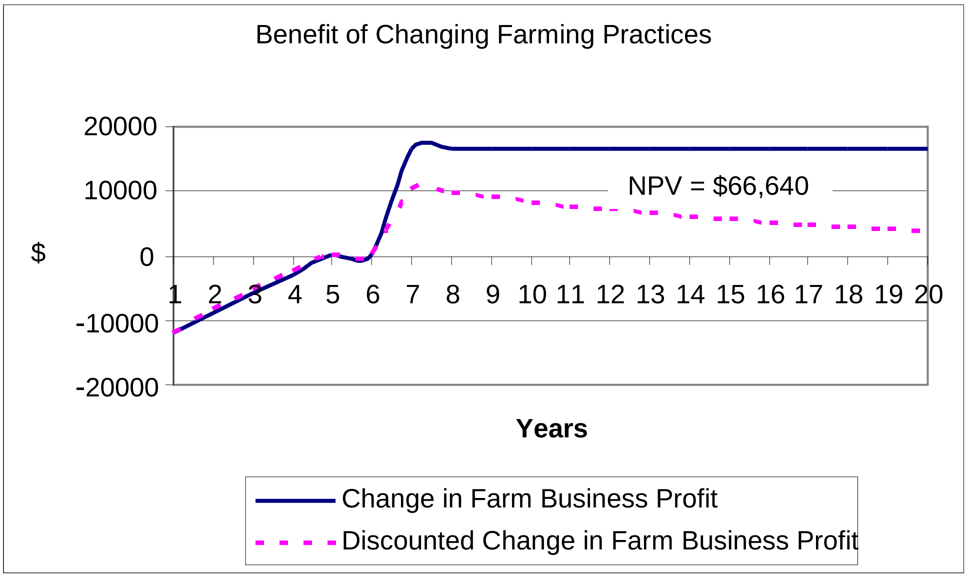

Figure 7. NPV of change with respect to agrichar price