DRAFT – Methane and the implications for New Zealand farmers of international climate change policy including metrics

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Abstract
Reisinger and Stroombergen's (2012) modelling suggests pricing all global GHG emissions, including agriculture, should be largely beneficial for the New Zealand economy, especially with a stringent mitigation target. Though this inference may seem counter-intuitive for a country in which agriculture is economically important, when the effects of GHG charges flow on to global commodity prices, the rise in global prices more than compensates New Zealand for the costs of our GHG emissions. In this paper we look at the implications of Reisinger and Stroombergen's (2012) results for a model dairy and model sheep and beef farm, with a focus on methane emissions. Looking at three international policy scenarios around the inclusion or exclusion of agricultural emissions from charges, we conclude that farmer preferences largely align with New Zealand's economic preferences, somewhat depending on the level of liability given to farmers for their emissions. However, farmers see the effects of the different scenarios to a much greater extent. We also compare Reisinger and Stroombergen's (2012) results for using two different metrics, or exchange rates between types of GHGs (greenhouse gases). We look at the 100 year GWP metric, which weighs methane at more than three times the fixed 100-year GTP, which we compare it to. For both New Zealand and our model farms, the differences alternative metrics make is minor, especially when compared with the differences between international policy scenarios. Our results suggest that long term, the best scenario for New Zealand and our farmers is to fully price global agricultural emissions within an international climate change agreement.

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1. Introduction

Although public debate often writes off methane emissions from agriculture as too costly or difficult to reduce in New Zealand, our country and our farmers stand to gain a lot if we engage with the issue. Evidence to date shows that there are some options, now and in the future, for reducing methane emissions from livestock. Given New Zealand has greatly improved our GHG (greenhouse gas) efficiency of livestock production over the past couple of decades due to profit rather than climate change imperatives, and there is still considerable heterogeneity in methane emissions per unit of product (Draft Motu Working Paper, Anastasiadis and Kerr 2011, Mitigation and Heterogeneity in Management Practices on New Zealand Dairy Farms), there is no reason to believe we cannot continue this trend. New Zealand is a far more efficient producer of milk and meat compared with places like the United States and the EU (European Union) (Emissions Trading Scheme Review Panel, 2011). Therefore it could actually benefit us to have agriculture included in a global climate change agreement, where efficient production of these products would be favoured.

Reisinger and Stroombergen (2012) looks at the effects different international policy scenarios have on New Zealand's economic welfare. These scenarios alter the treatment of global agriculture in climate change policy, as well as the metrics used to trade-off the reduction of different GHGs against each other. While Reisinger and Stroombergen (2012) look at how these factors affect New Zealand as a whole, they do not look specifically at what these scenarios might mean for individual sectors, or more specifically individual farms. This paper looks at how a model dairy and model sheep and beef farm would fare in New Zealand under Reisinger and Stroombergen's (2012) scenarios.

Livestock agriculture is responsible for two main GHGs, methane and nitrous oxide, both of which are much more potent than the main GHG, CO_2 (carbon dioxide). Sixty percent of global nitrous oxide emissions are from agricultural, and nitrous oxide contributes about 18% to New Zealand's emissions (Forster et al., 2007), (Eckard et al., 2010), (Clark et al., 2011). However, methane is the second most important GHG, contributing about three times as much to current climate change as nitrous oxide, and almost one third as much as CO_2 (Forster et al., 2007). Of the 50% of methane emissions produced globally by agriculture, roughly two thirds of those emissions are produced by ruminant livestock (Eckard et al., 2010). In New Zealand, this amounts to about 30% of our entire emissions profile, which is a very high proportion compared with the rest of the developed world (Clark et al., 2011). Livestock methane emissions are more difficult to mitigate than nitrous oxide emissions, and methane is more sensitive to the metric used as an exchange rate between gases (Reisinger and Stroombergen, 2012). Therefore, the focus of the discussion in this paper is methane, though some conclusions may also apply to nitrous oxide.

Since the start of the industrial revolution in 1750, methane levels in the atmosphere have increased almost 2.5 times, compared with an increase in CO2 of about 35% over the same period (IPCC, 2007b). However, methane mitigation has had less of a focus compared with CO2 mitigation (van Vuuren et al., 2006), (Dawson and Spannagle, 2009). Given its relative importance as a GHG, it cannot be ignored in climate change policy (Denman et al., 2007). Mitigating all GHGs, rather than just CO2, could lower climate change mitigation costs by 30-40% for the same mitigation target (van Vuuren et al., 2006).

Although changing metrics can drastically alter how methane mitigation is valued, the issue of metrics is minor to New Zealand compared with how global agriculture is treated within a climate change agreement. We find that although the same can be said about our model New Zealand farms, the effects of changing scenarios on them are much greater. If agriculture is included in an international agreement and fully price in each country the gain could be great, whereas if our farmers have to face the costs of their emissions while no other farms around the world do, then the losses could also be great. These results imply that shutting down the debate around reducing methane emissions would represent a huge opportunity cost for New Zealand and our farmers. We are better to engage in the conversation around what to do about methane emissions, to help others develop ways to price or regulate their agricultural emissions, and build on our position as one of the most efficient producers of meat and dairy in the world. We also need to be aware of the potential perils in the uncertain global policy environment, and how we might best deal with them and reduce the uncertainty for farmers.

This paper briefly summarises Reisinger and Stroombergen's (2012) report, before looking at two farm models. We estimate change in profits for a representative dairy and sheep and beef farm under the scenarios and different levels of liability for agricultural emissions. We then discuss the significance of these results and their implications.

2. Reisinger and Stroombergen's study and results

This section describes Reisinger and Stroombergen's (2012) scenarios and relevant details about their modelling assumptions. It then looks at their results for New Zealand under the different scenarios and metrics, given the implications of their international modelling.

2.1. Scenarios

Reisinger and Stroombergen (2012) model a number of scenarios to determine the importance of using different metrics, and of the global policy environment for New Zealand. These scenarios were all modelled to meet a 450ppm[1] limit for the atmospheric concentration of CO2 equivalent[2] at 2100 in the most economically efficient manner. This target is generally considered to be roughly consistent with the international aspirations for limiting warming to 2°C. In order to reach this global target, the authors explore three main scenarios. We have given these scenarios our own names for clarity; they are described below.

All in this Together

In this scenario, all emissions, including global agricultural emissions, face one global emission price all over the world. For New Zealand this means agriculture is charged for its emissions too, though there is free allocation under the NZETS (New Zealand Emissions Trading Scheme – see the end of this section for more details about this part of the modelling). New Zealand is responsible for agricultural emissions under its international emissions reduction target.

Agricultural Conundrum

All countries around the world, including New Zealand, have agricultural emissions included in their national mitigation targets. However, only New Zealand passes any costs of agricultural emissions on to our agriculture sector, through the NZETS. All other countries protect their agriculture sector, relying on their other sectors to make deeper cuts to their emissions at additional cost to ensure the global target is still achieved. As a result, New Zealand farmers face costs not faced by international farmers, while the New Zealand government is still liable for our agricultural emissions, which make up a comparatively large proportion of our national emissions.

Agriculture Out

In this scenario, agricultural emissions are excluded from international mitigation targets. Therefore, New Zealand is no longer liable for our agricultural emissions in our national mitigation target and no longer charges the agricultural sector for their emissions. However, this means that all other sectors around the world must make deeper cuts to their emissions, as in the previous scenario, to meet the global mitigation target.

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[1] Ppm stands for parts per million. Therefore, an atmospheric concentration of 450ppm of CO2 means that out of every 1 million particles in the atmosphere, 450 are CO2.

[2] CO2 equivalent, meaning the same as this level of CO2, even if it is composed of various GHGs.

Baseline

They also included a baseline scenario for comparison. It is not meant to be a realistic projection of the world economy, but gives the outputs of the models when no mitigation occurs.

To understand how these scenarios would affect New Zealand, Reisinger and Stroombergen (2012) assume Zealand emissions are priced at the global price under the NZETS, but policy settings under the NZETS otherwise remain similar to their current settings. These settings include agricultural emissions being freely allocated 90% of their emission credits in 2015, with this allocation being phased out at a rate of 1.3% per year.

To test the effects of different metrics they model each scenario using the 100 year GWP and 100 year fixed GTP metrics. These metrics are described in *Section 2.4*. They determine the exchange rates between the various GHGs so that the value of their mitigation can be traded off against each other.

2.2. Modelling approach

A number of models were required for Reisinger and Stroombergen's (2012) study. More detailed descriptions are provided in Reisinger and Stroombergen (2012), but a brief description of their modelling approach is provided here.

Fristly, the global climate model MAGICC version 6 is used to estimate the values for methane and nitrous oxide using the metrics GWP and fixed GTP. These metrics are then used to estimate the lowest cost paths for the mitigation of GHGs to reach the 450ppm global target under the various scenarios using the global economic model MESSAGE. MESSAGE determines the prices for CO2, methane and nitrous oxide emissions which ensure the 450ppm target is achieved at lowest cost. The effects of these different emission prices on global agriculture are then modelled by GLOBIOM. GLOBIOM models world agriculture demand and supply in much more detail than MESSAGE, and Reisinger and Stroombergen (2012) use it to produce a livestock commodity price index to demonstrate changes in global meat and milk prices, and a horticultural commodity price index to demonstrate changes in crop-based global food prices.

Finally, the metrics from MAGICC, the global carbon prices from MESSAGE and the commodity prices from GLOBIOM are fed into a multi-sectoral model of the New Zealand economy, ESSAM. ESSAM is then used to compare the New Zealand economy under the scenarios described above against the baseline scenario of no mitigation of climate change for the years 2020 and 2050.

2.2.1. ESSAM assumptions in more detail

Reisinger and Stroombergen (2012) assume New Zealand's 2020 national mitigation target is a 15% cut in net emissions, below 1990 gross emission. They assume forestry is absorbing 16.1Mt of CO_2 in 2020 regardless of the scenario, thereby reducing New Zealand's international emissions liability. Furthermore, they assume that policy in terms of liability for various sectors in New Zealand under the NZETS is as it is now, including a 10% obligation for agriculture in 2015, which is gradually reduced over time. However, the prices in the NZETS are assumed to be set by global emission prices, in 2005 US dollars, with a fixed exchange rate of US$0.70=NZ$1.

In the ESSAM model of the New Zealand economy, Reisinger and Stroombergen (2012) include the ability to mitigate nitrous oxide emissions per unit of agricultural output. However, methane emissions are directly linked to output, and they do not include the ability for an efficiency improvements in methane. So the only way methane mitigation is achieved is through a reduction in output[3].

Change in economic welfare compared with baselines were calculated using Real Gross National Disposable Income (RGNDI), which Reisinger and Stroombergen (2012) consider to be a better measure of New Zealand's welfare than Gross Domestic Product (GDP). It measures New Zealand's income from all sources – domestic and from offshore investments – minus income flowing overseas. Overseas income flows includes the purchase of international emission units if the New Zealand government exceeds its national climate change mitigation targets.

2.3. Implications of the scenarios for New Zealand

In this section we summarise Reisinger and Stroombergen's (2012) results of the implications of the scenarios for New Zealand.

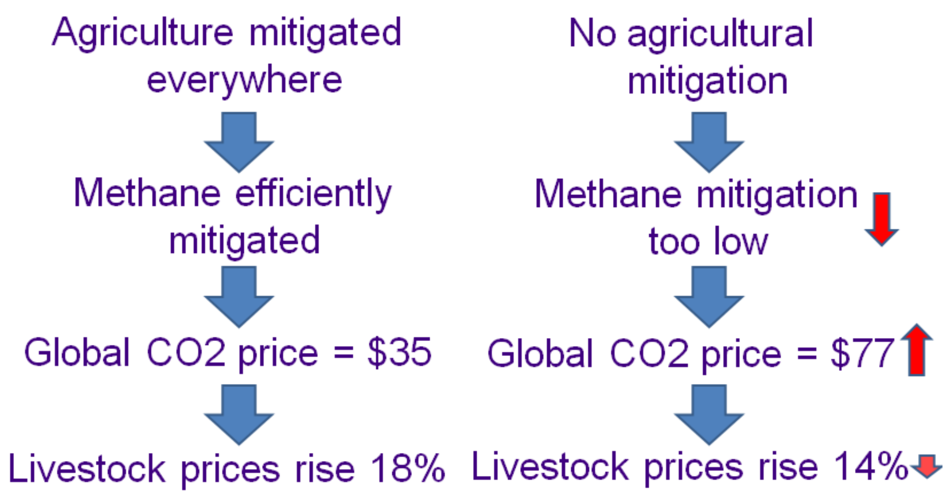
As explained above, there are three main outputs from Reisinger and Stroombergen's (2012) report which are affected by the different international policy scenarios. These outputs are the metric, international CO_2 price and the livestock commodity price. Metrics are covered in *Section 2.4*, and are dependent on specific international policy settings, whereas the latter two outputs are equilibrium outcomes resulting from policy settings. For this section, all figures are given using the standard GWP metric.

[3] Confirmed via personal communication with Adolf Stroombergen.

Although three scenarios are outlined in *Section 2.1*, in terms of pricing global emissions, there is effectively the *All in this Together* scenario, where global agricultural emissions are fully priced, and the other two scenarios, in which they are not. These other two scenarios are identical from the point of view of the international GHG market, in which New Zealand is a price taker. However, although international prices are the same, in the *Agricultural Conundrum* the New Zealand government is liable for New Zealand's agricultural emissions, and in *Agriculture Out* it is not, so the scenarios imply quite different situations for our government.

Figure 1Figure 1 shows how the two outputs relevant to this section are affected by global agriculture being mitigated and not mitigated. Without global agricultural methane being included, around half the sources of methane and nitrous oxide that could be mitigated are now no longer being mitigated. Therefore, other sources of GHGs, especially CO2 sources, must make much deeper cuts, which more than doubles the global CO2 price. Livestock commodity prices still rise 14% over the no mitigation baseline prices by 2020, due to competition for land from forestry, and potentially also the CO2 emissions associated with agriculture. But this is not as high as the 18% rise when agriculture must pay for its emissions.

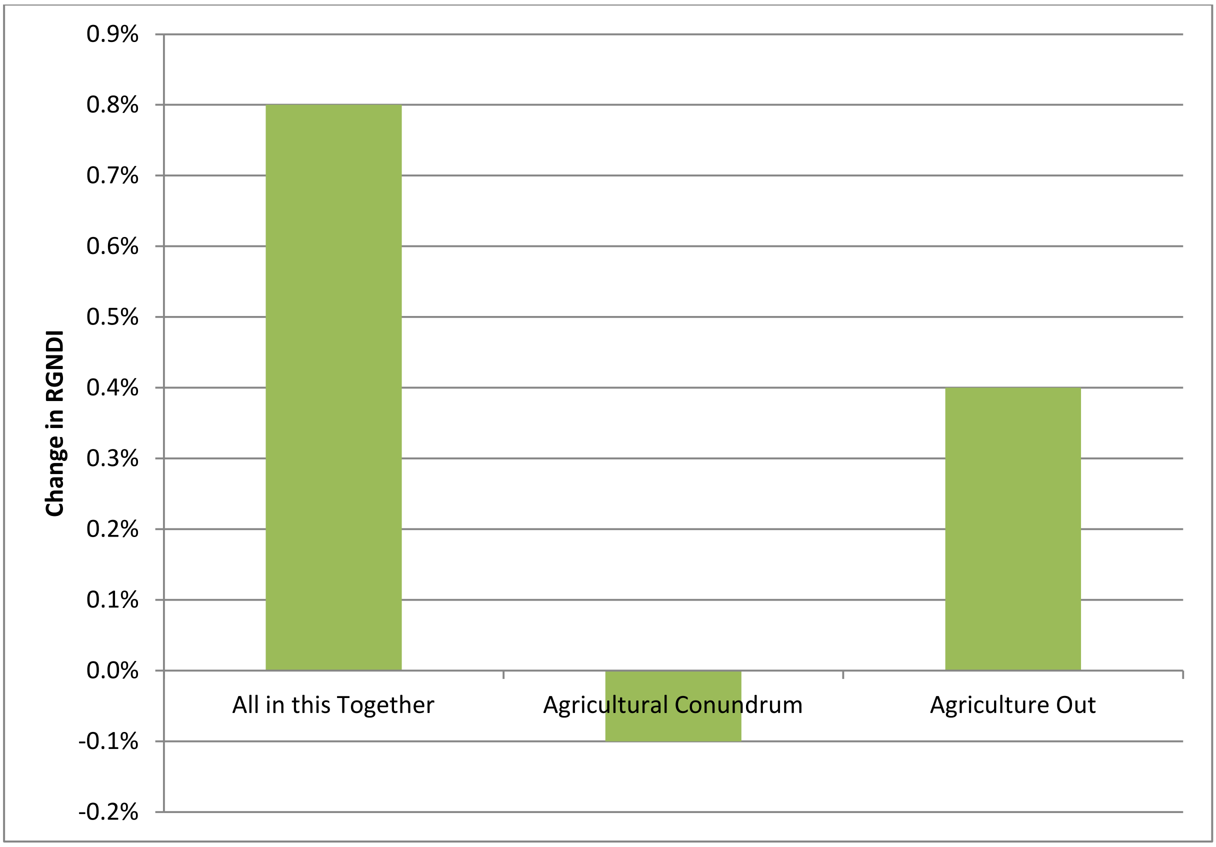
Figure 1 The effects on prices of agriculture emissions being priced and not being priced in 2020 (Reisinger and Stroombergen, 2012).



Reisinger and Stroombergen's (2012) results for 2020 are laid out in *Figure 2* below. As shown, *All in this Together* is clearly the best for New Zealand as a whole, followed by *Agriculture Out*. In both cases New Zealand does even better than the baseline of not having to mitigate, but clearly we want to avoid the *Agricultural Conundrum* happening.

Although New Zealand is liable for all its emissions under the *All in this Together* scenario, the higher livestock commodity prices, and the lower CO2 prices makes this scenario the best for the country. For both *All in this Together* and *Agriculture Out*, New Zealand even faces more economic benefits than costs compared with a world with no mitigation. This occurs because of the rise in livestock commodity prices, even though all scenarios require the New Zealand government to purchase a substantial amount of emissions on the international market, as it never meets the mitigation target of 85% below 1990 emissions in 2020.

Figure 2 Change in New Zealand's RGNDI in 2020 relative to the no mitigation baseline under Reisinger and Stroombergen's (2012) three scenarios using the GWP metric



The *Agricultural Conundrum* is the worst for New Zealand. Under this scenario, New Zealand would have to either pass on emission costs to our farmers without any corresponding global commodity price rises, or not mitigate our agricultural emissions like the rest of the world. This second response would require the government to purchase a large amount of GHG emission credits from the rest of the world given the costs of domestic mitigation. These international credits would have to be paid for through general taxation. Due to distortions inherent in general taxation, raising the funds this way would cost about $1.40 for every $1 required, further increasing the costs to the country's economy (Kerr and Zhang, 2009).

The *Agriculture Out* scenario is New Zealand's second best outcome, as it means we do not have to account for our agricultural emissions. *Figure 2* shows this scenario is slightly better for New Zealand than business as usual as well. Again though, this scenario is not ideal for New Zealand, or for reducing global mitigation costs. Reisinger and Stroombergen (2012) conclude that when global agricultural emissions are completely excluded from mitigation, the cost of meeting the same overall mitigation target increases by 16 to 50%, depending on the increases in agricultural mitigation potential over time. Because of the fact deeper cuts must be made in all other sectors to reach the same mitigation target, Reisigner and Stroombergen (2012) make a large assumption that New Zealand's mitigation target would still be a 15% cut on just non-agricultural emissions. In reality, New Zealand may be required to have a more stringent target in this scenario.

2.4. Metrics

There has been some public debate about metrics and their effects on climate change policy and New Zealand. A metric comparing GHGs acts as exchange rate between them, so that mitigation of one gas can be traded off against the mitigation of another (Reisinger and Stroombergen, 2012). We summarise Reisinger and Stroombergen's (2012) results on how choice of metric might affect New Zealand.

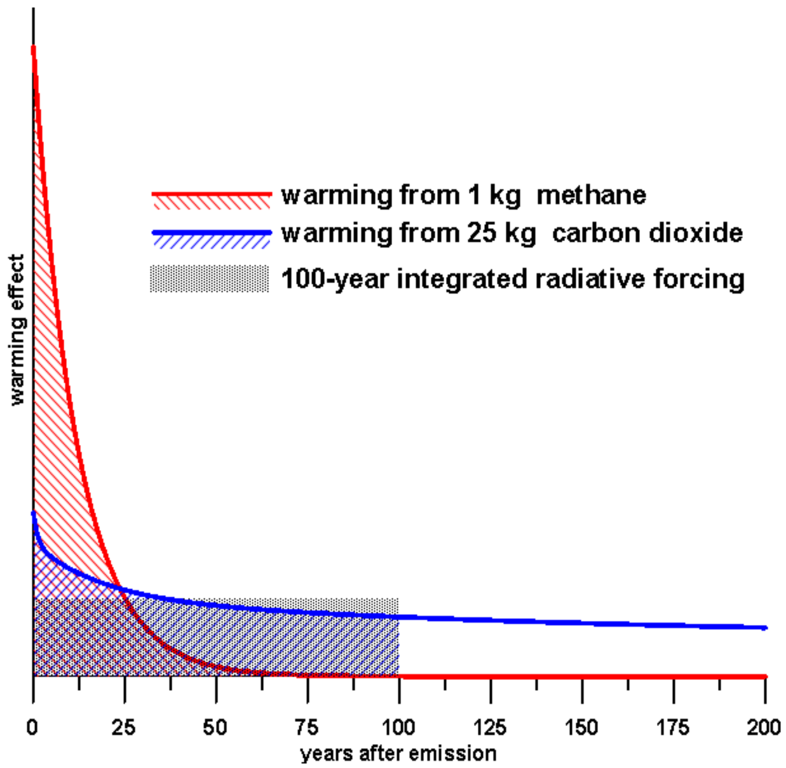
A number of metrics have been developed to compare what are effectively "apples and oranges". Although apples and oranges are different fruit, there are different ways of comparing them – from total number, to weight, to length of time they last in a cool store, to value at a local market, nutritional content, or even a combination of qualities. It depends on the aim of comparing them as to what the most effective metric is. To be most efficient within a climate change context, the metric chosen needs to be the best proxy for the aims of global climate change policy. These aims may include limiting potential temperature change, and rate of temperature change (Tol et al., 2008). As CO2 is the main GHG for climate change, metrics usually measure other GHGs relative to CO2.

2.4.1. GWP

Global Warming Potential (GWP) has been adopted as the standard climate change metric internationally as it used for the Kyoto Protocol (Tol et al., 2008). GWP measures the average radiative forcing of 1kg of a GHG over a 100 year time period relative to CO2 (Forster et al., 2007). The most recent calculations of GWP puts methane at a value of 25 – that is one tonne of methane has the same Global Warming Potential as 25 tonnes of CO2 (Reisinger and Stroombergen, 2012).

Radiative forcing measures the net increase in solar energy retained in the Earth's atmosphere. This means it measures the amount of extra heat energy trapped in the atmosphere resulting from an addition unit of methane being in the atmosphere. Over time this extra energy being trapped will lead to a warming of the atmosphere (IPCC, 2007a). One way of thinking about GWP therefore, is it is like measuring the effectiveness of installing extra insulation in a house ceiling. If a heater is turned on in the house, GWP would measure the average amount of heat energy kept in the house by the extra insulation over a specified time period. This average level of heat energy is then compared between types of insulation. GWP reflects therefore the effectiveness of different types of GHG and retaining heat energy in the atmosphere, but not the direct warming caused by the gases.

Figure 3 The average radiative forcing over time of 1kg of methane and 25kg of CO2 (Reisinger and Stroombergen, 2012).



Different GHGs are naturally removed from the atmosphere at different rates, but GWP averages their radiative forcings over a specified time period. Therefore, choosing a 20 year time period or a 200 year time period creates large changes in the exchange rates between GHGs. *Figure 3* demonstrates how methane and CO2 behave over time, and why the time period chosen has such a great effect. *Table 1* displays the values associated with different time periods. Currently the time frame of 100 years is used under the Kyoto Protocol. Therefore, the combined radiative forcing over a 100 year time period is considered completely relevant, but any radiative forcing from 101 years in the future and beyond are not counted. This means averaging out the effects of very different gases over a specific period of time may not give an accurate picture of how they behave. Deciding what time period to use for GWP is purely a judgement call.

In terms of meeting Reisinger and Stroombergen's (2012) 2100 global mitigation target of 450ppm, they calculate that the 100 year GWP exchanges the gases at a near efficient rate for this particular target. This may not hold true for other targets in other years.

2.4.2. GTP

Global Temperature Change Potential (GTP) is the most prominent alternative to GWP. Essentially it measures the global temperature change in a future year due to the emission of a GHG, relative to CO2. For example, a fixed 100 year GTP measures the predicted temperature change that would occur in 100 years hence due to an additional kg of a GHG relative to CO2. Under a 100 year fixed GTP, a unit of methane is worth 7 units of CO2, so a tonne of methane creates the same temperature rise in 100 years from now as 7 tonnes of CO2. In terms of the house metaphor, where GWP measures the insulation, GTP compares the actual change temperature at a certain point in time. This would be like installing two types of insulation into identical houses with identical heaters at identical temperatures, and measuring the difference in the temperature now, and at the point in 100 minutes time. For methane-like insulation, the conclusion would be its insulation lead to 7 times the increase in temperature as the CO2-like insulation in the other house.

As mentioned, calculating GTP places all weight on the temperature change predicted by a model for one particular year, for example in the year 100 years from now, 2112. This effectively means that all the damages at one point in time is what is weighed as important under this metric, and all other points in time are excluded (Gillett and Matthews, 2010). Like GWP, due to the different decay times of different GHGs, the chosen number of years in the future has a large bearing on the relative values of the gases. *Table 1* below illustrates how the values of methane change under GWP and GTP with the chosen timeframe.

Table 1 Methane emission values for GWP and fixed GTP metrics. They represent how many kilograms of CO2 1kg of methane is worth for various time periods.

Metric	**20 year**	**100 year**	**500 year**
GWP (Forster et al., 2007)	72	25	8
GTP (Reisinger and Stroombergen, 2012)	50	7	0.7

The 100 year fixed GTP is less efficient than the 100 year GWP for meeting Reisinger and Stroombergen's (2012) global mitigation target, adding 5 to 20% on to global mitigation costs above GWP, depending on the scenario and assumptions.

2.4.3. Implications for New Zealand

As GWP and GTP meet Reisinger and Stroombergen's (2012) 2100 global mitigation target at different levels of efficiency and exchange rates between gases, the two metrics imply different global CO2 and livestock prices. This section look at how these prices are determined, what these prices are and what implications they have for New Zealand. As we are looking at just the 100 year GWP and 100 year fixed GTP, we will now refer to these metrics simply as GWP and GTP.

Figure 4 The effects of GWP versus GTP in the *All in this Together* scenario on the CO2 prices and livestock commodity prices in 2020 (Reisinger and Stroombergen, 2012).

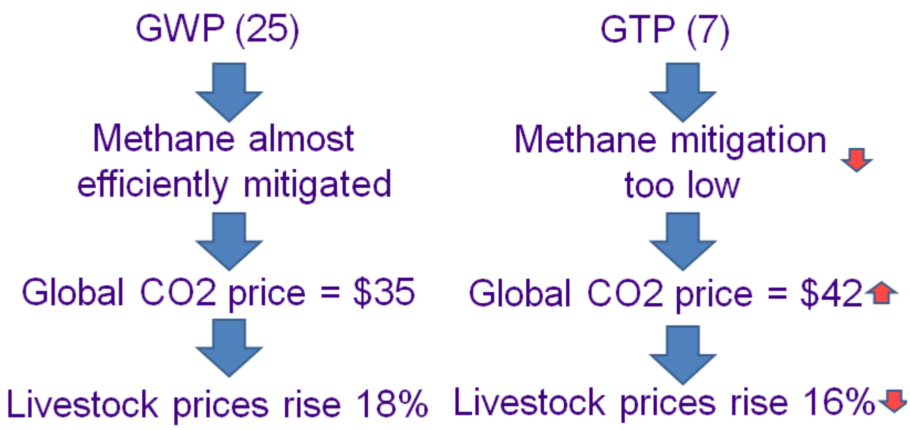


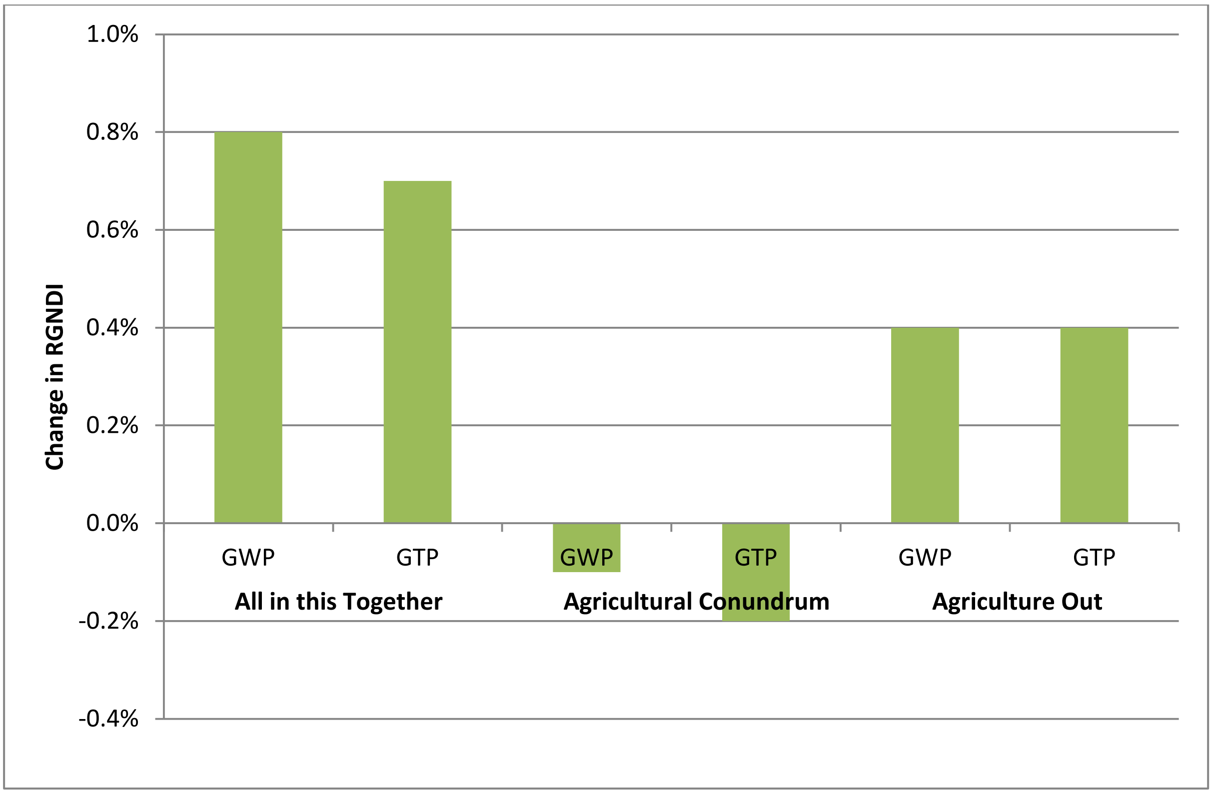
Table 2 The effects of the GWP and GTP metrics on the CO2, methane and livestock commodity prices (Reisinger and Stroombergen, 2012)[4].

Scenario	Metric	CO2 price/tonne ($NZ)	Methane price/tonne ($NZ)	Livestock commodity price increase over baseline
All in this together	GWP (25)	$35	$866	18%
	GTP (7)	$42	$295	16%
The agricultural conundrum	GWP (25)	$77	$1927	14%
	GTP (7)	$88	$618	14%
Agriculture out	GWP (25)	$77	$0 (ag)	14%
	GTP (7)	$88	$0 (ag)	14%

[4] Note that Reisinger and Stroombergen (2012) only calculated the livestock commodity price rise for the final two scenarios using GWP, so have been assumed to be the same for GTP.

As mentioned, GWP is the more efficient metric for meeting Reisinger and Stroombergen's (2012) 2100 target compared with GTP. The implications of these effects are shown in *Figure 4*. Because GTP puts a lower weight on methane emissions, deeper cuts to CO2 emissions are needed to compensate for the lower cuts to methane emissions occurring. Therefore GTP requires a higher CO2 price in order to meet the mitigation target. However, the lower cost of methane emissions under GTP means the agriculture sector faces lower costs, so global livestock prices rise by less. The prices the different metrics create under the three scenarios are all presented in *Table 2* above.

Figure 5 Change in New Zealand's RGNDI in 2020 from the no mitigation baseline under Reisinger and Stroombergen's (2012) three scenarios using the 100 year GWP and fixed GTP



As Figure 5 above shows, the choice of metric proves to be a minor issue compared with the overall scenario New Zealand faces. Though the costs of international emission credits for the New Zealand government are lower overall under GTP, those lower costs are partly cancelled out by the higher CO2 prices, and also by the lower livestock commodity prices. This means the picture presented in *Figure 5* above is not radically different to *Figure 2*, where the issue of metrics is ignored. Note that GWP is always preferred to GTP, including in the *Agriculture Out* scenario. In this case the change in RGNDI is just 0.03% higher under GWP, but in the results Reisinger and Stroombergen (2012) present for 2050, the preference for GWP increases. However, the small differences between metrics in all cases illustrates the fact that the magnitude of changes between metrics within the scenarios is very small compared with the changes between scenarios.

3. Implications for New Zealand farmers

In this section we investigate the implications of Reisinger and Stroombergen's (2012) results for two model New Zealand farmers. Agriculture makes up a large proportion of New Zealand's emissions, economic activity and exports, so the effects on this sector are important. The implications for our farmers may play a role in whether they are willing to support government policy or not.

We find that New Zealand farmers' interests are generally aligned with New Zealand's national interests, but that differences are present. If farmers are liable for the full cost of their emissions, farmers prefer the *Agriculture Out* scenario to *All in This Together*, contrary to the results for New Zealand. Also, in some instances the lower weight on methane emissions under GTP means that it is preferred to GWP by farmers, even though GWP is always preferred for New Zealand. New Zealand farmers' saw much greater affects on their change in profit compared with New Zealand's change in RGNDI, meaning they face much higher potential risks and benefits. Again, the issue of metrics was less important than the issue of the international policy scenario, but it was more important for farmers than the country.

In order to maintain simplicity and realistic time horizons, we concentrate on Reisinger and Stroombergen's (2012) scenarios for 2020, as the results for 2050 are, on the whole, exaggerated versions of the results for 2020.

3.1. Description of models used

To compare the economic welfare of New Zealand with the welfare of farms, we developed two model farms – a dairy farm and a sheep and beef farm. These farms were chosen as they represent average farm models which were published in detail, with enough data to make them fit for our purpose. We input the international livestock commodity price index, and the international GHG prices from Reisinger and Stroombergen's (2012) international modelling into the farm models to get a change in profit from baseline under the various scenarios.

Reisinger and Stroombergen (2012) note that most studies of New Zealand assume there are no affordable agricultural emission mitigation options, though this is clearly not the case. However, it is very difficult to estimate mitigation costs across New Zealand farms, given the lack of data and wide variation between farms (Draft Motu Working Paper, Anastasiadis and Kerr 2011, Mitigation and Heterogeneity in Management Practices on New Zealand Dairy

Farms). As mentioned, Reisinger and Stroombergen (2012) assume mitigation per unit of output for nitrous oxide is possible, but not for methane. For our models we assume no mitigation is undertaken, and no changes in production occur. As a result, the loss of profits we report are overstated. In reality, farmers would respond to the new input and output prices by changing production or taking direct mitigation actions.

The emissions data for both farms are calculated by the computer model OVERSEER. Although current legislation will include agricultural emissions at the producer level – that is, emissions from any farm will be calculated based on average emissions per unit production such as milk solids – this could change. The recent report from the Emissions Trading Scheme Review Panel (2011) recommended emissions be charged on a per farm basis, suggesting OVERSEER could be used to calculate every individual farms' emissions. Therefore, it is possible that the farm models used here will mimic how farms are included in the NZETS, though OVERSEER is continuously being updated in order to provide the most accurate data for farm emissions for every possible New Zealand farm.

Note, all prices are in 2005 New Zealand dollars, estimated using the Consumer Price Index.

3.1.1. Dairy farm

The model dairy farm presented here is based on Beukes et al.'s (2010) average Waikato dairy farm. More information about their model can be obtained from their paper, but some important details are given here.

The farm is based on data from the DairyBase database, which Beukes et al. (2010) use to produce a scaled-down, 25ha farm. It is based on averaging farms which used less than 10% imported feed for the 2006/7 season. We based our farm off their baseline, *Farm A*, which had a stocking rate of 3.0 cows/ha and applied 180kg of nitrogen fertiliser per hectare. This baseline farm, and its associated methane and nitrous oxide emissions provided by Beukes et al.'s (2010) OVERSEER estimates, is used under all scenarios. They provide data on other emissions including operating emissions, which we assume to fully consist of CO2 emissions. No mitigation actions are applied.

We report economic profits per hectare, or earnings before interest and tax. These profit figures exclude any interest and rent payments, meaning they provide a good indication of long run profitability once investments in land are paid off (Kerr and Zhang, 2009). Operating costs per hectare figures are estimated using Beukes et al.'s (2010) figures, while milk prices are estimated using a ten year average of MAF monitor farm data for 2002 to 2011 (Waikato MAF monitor farms 2002-2011). These milk prices and costs per hectare are used to establish the baseline level of profits per hectare.

3.1.2. Sheep and beef farm

Our Sheep and beef farm model is based on Smeaton et al.'s (2011) base Central North Island Hill Country sheep and beef farm. Their farm is based on MAF monitor farm data, though their farm has a higher stocking rate. It is a 635ha farm with 9.8 stock units per hectare, about a third of which is beef (compared with 7.8 stock units per hectare for MAF's 2008/2009 farm). Emissions per hectare are estimated by OVERSEER; we utilise detailed data provided by Duncan Smeaton. These emissions are broken into methane, nitrous oxide, and a minor extra component, which we assumed were all CO2 emissions. Again, no mitigation actions are applied to the farm model.

As with the dairy farm, we use economic profits per hectare. We estimate them using MAF monitor farm data averages for 2002 to 2011. Data for costs and revenues are both estimated using the MAF monitor farm data on operating costs and revenue per stock unit (Central North Island Hill Country MAF monitor farms 2002-2011).

As for the dairy farm, profits are adjusted from baseline using the livestock commodity price index, metrics and emissions prices from Reisinger and Stroombergen (2012). All revenue per hectare is adjusted by the livestock commodity price index, including the small component from wool, as this is our only price change projection data[5].

3.1.3. Robustness of farm models

As a point of comparison, Kerr and Zhang's (2009) numbers for the average profit per hectare of comparable farms are provided, both before and after a $25 emissions charge. These figures are presented for our farm models also, both modelled with no change in farm revenue.

Figures for the average Waikato dairy farm and the national average dairy farm are provided in *Table 3*. The discrepancies between profit figures can at least in part be explained by higher milk prices over the last few years, outside of the eight year average pricing used by Kerr and Zhang (2009). Accounting for this difference, the figures line up even more closely.

[5] Wool revenue makes up 13% of total revenue per Stock Unit in our data

Table 3 A comparison of baseline profits of our Waikato dairy farm with averages estimated by Kerr and Zhang (2009)[6].

Farm	Profit/ha before emissions charge (2005$)	Profit/ha after $25 emissions charge (2005$)	Drop in profit/ha (2005$)	Drop in profit (%)
Average Waikato dairy (Kerr and Zhang, 2009)	$1734	$1460	$274	16%
Average national dairy (Kerr and Zhang, 2009)	$1880	$1605	$275	15%
Our Waikato farm	$2250	$1977	$273	12%

Kerr and Zhang's (2009) numbers for the average profit per hectare of a similar Central North Island Hill Country sheep and beef farm are provided in *Table 4*. As with the dairy farm, recent high prices lead to higher profit figures compared with Kerr and Zhang (2009). Again, the difference between our figures are their figures are not large, so we are confident our model sheep and beef farm is an adequate illustration of an average farm.

Table 4 A comparison of baseline profits of our Central North Island High Country farm with average profit per hectare of comparable Central North Island Hill Country farms, estimated by Kerr and Zhang (2009)[7].

Farm	Profit/ha before emissions charge (2005$)	Profit/ha after $25 emissions charge (2005$)	Drop in profit/ha (2005$)	Drop in profit (%)
Average hard Central North Island Hill Country (Kerr and Zhang, 2009)	$249	$168	$81	33%
Our Central North Island Hill Country farm	$271	$187	$84	31%

3.2. 10% liability for agricultural emissions

This section looks at our results when we put a 10% liability on the farms' non-CO2 emissions. This level of liability is roughly consistent with the policy settings in New Zealand from Reisinger and Stroombergen (2012). We put a 100% liability on the CO2 emissions.

[6] Both figures use the GWP metric currently used under Kyoto, where methane has a weight of 21, and nitrous oxide has a weight of 310.

[7] Both figures use the GWP metric currently used under Kyoto, where methane has a weight of 21, and nitrous oxide has a weight of 310.

Figure 6 Farm change in profit/ha compared with baseline at 10% liability for agricultural emissions in 2020, and Reisinger and Stroombergen's (2012) results for New Zealand's change in RGNDI compared with their baseline scenario.

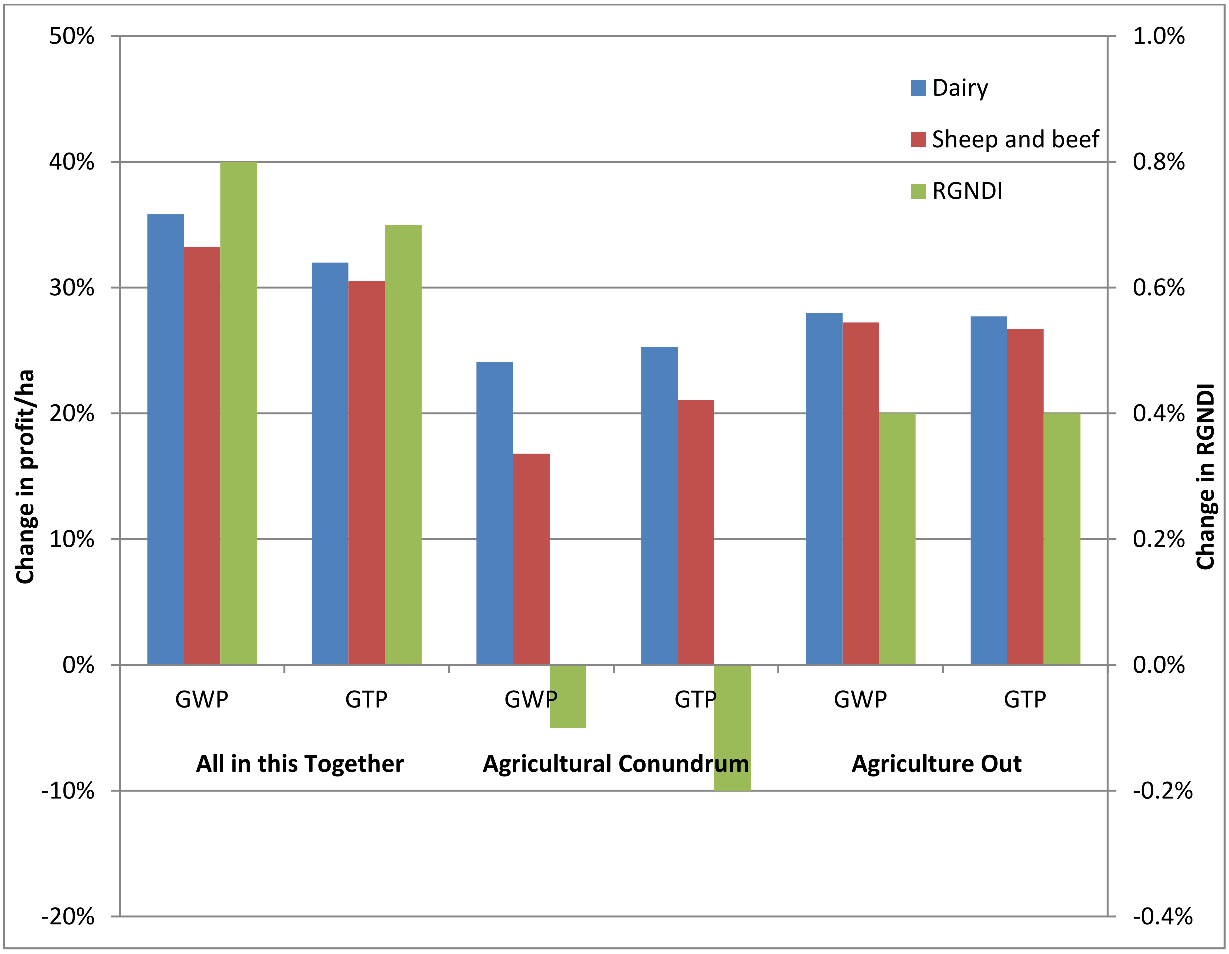
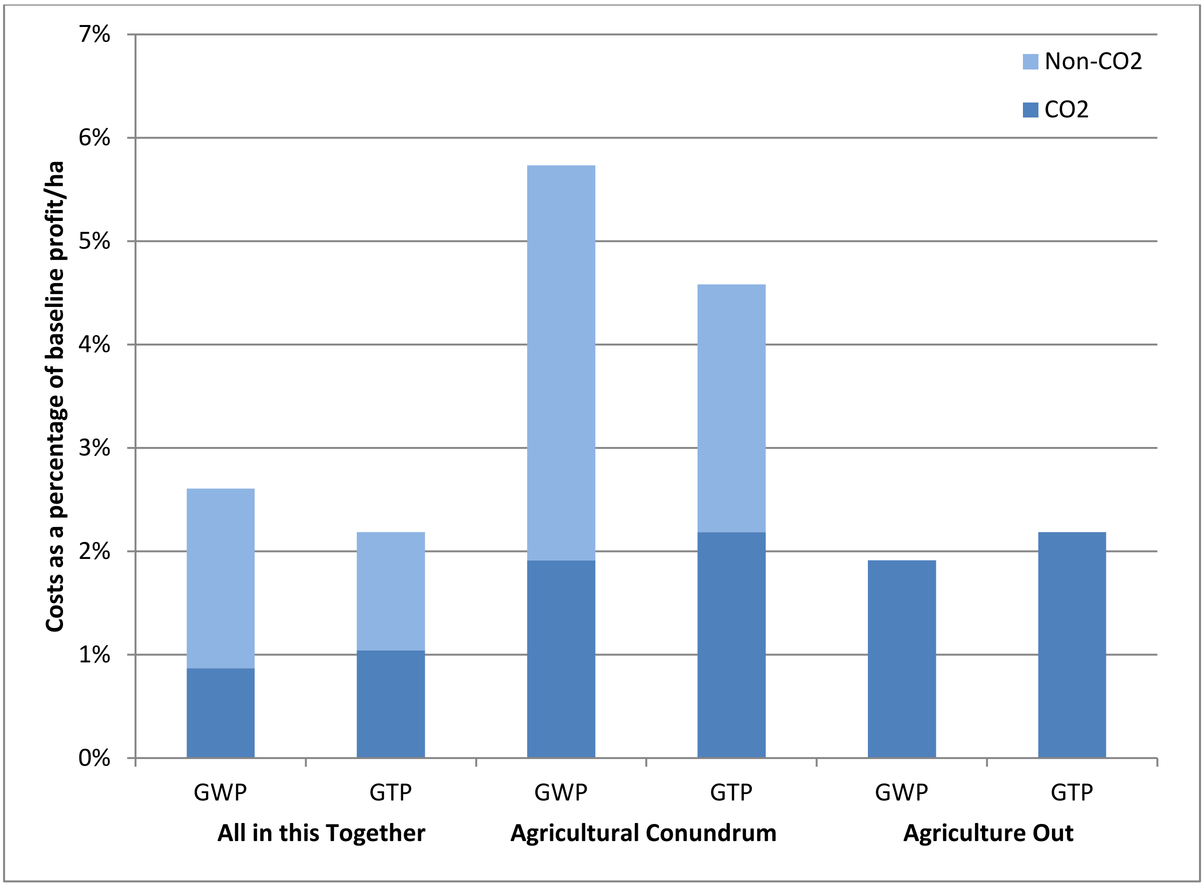


Figure 6 shows the outcomes for our model New Zealand farms and New Zealand's change in economic welfare compared with baseline. Change in farm profit is on the left hand horizontal axis, and change in RGNDI is on the right hand axis. Under all the scenarios the farmers' profits rise significantly, with the dairy farm always doing marginally better than the sheep and beef farm. The rise in farmers' profits are of a much larger magnitude than the changes in New Zealand's RGNDI. The best scenarios for New Zealand align with the best scenarios for the farms, with the choice of metric always being a minor issue.

Figure 7 below shows the costs per hectare for the dairy farm under the different scenarios, which is similar to the sheep and beef costs. The costs help explain how much the differences between the different scenarios and metrics are driven by costs, and how much by changes in the livestock commodity price index. As in *Table 2*, *Figure 7* illustrates that the lowest CO2 prices are associated with the *All in this Together* scenario, and they are slightly higher under GTP than GWP. GHG emission prices rise under the latter two scenarios, with the full farmer liability for non-CO2 emissions in the *Agricultural Conundrum* making this the most expensive scenario by far. Although CO2 emissions cost more under GTP, the lower costs for non-CO2 emissions under GTP makes this the lower-cost metric when non-CO2 emissions are included. This occurs even when non-CO2 emissions are only at 10% liability. Dairy farm costs under the *Agriculture Out* scenario are only marginally lower than the *All in this Together* scenario.

Figure 7 Costs per hectare of the dairy farm as a percentage of baseline profits in 2020, with 10% liability on non-CO2 and 100% liability on CO2 emissions.



The effects of changing metrics are dampened by the low level of liability for non-CO2 emissions. Because of the low level of liability, the costs of emissions for dairy farmers are not high compared to the 14 to 18% increase in revenue, depending on the scenario (see *Table 2*). Therefore, although the country is worse off economically as a whole under the *Agricultural Conundrum*, the shielding of agriculture from the higher emissions charges sees it still have an increase in profits over baseline in the order of 25%. The country however, faces a large emissions bill as it is still liable for agricultural emissions at the high international prices from this scenario, where no other country undertakes any agricultural mitigation.

Sheep and beef face higher costs per hectare as a percentage of their baseline profits compared to dairy. This occurs even though they produce fewer emissions per hectare, because their profit figures are significantly lower per hectare; that is, their emissions per dollar of profit are higher than for dairy. Both farms face the same percentage changes in revenue, whilst costs go up more for sheep and beef, so sheep and beef is always at least marginally worse off than the dairy farm. The actual changes in global prices may well differ between dairy and sheep and beef, and these changes may compensate dairy less and sheep and beef more, though we can only speculate. However, without looking into the drivers of recent prices in more detail, a quick glance at recent meat and dairy price index numbers does not seem to support this speculation as dairy prices have seen larger price spikes than meat prices in recent years (http://www.fao.org/es/esc/en/15/138/highlight_583.html http://www.fao.org/es/esc/en/15/162/highlight_582.html).

With the exception of the *Agricultural Conundrum*, GWP is best for both farmers and New Zealand. In the *Agricultural Conundrum*, GWP is best for New Zealand, but GTP is best for farmers. Although farm costs per hectare are slightly higher under the GWP metric for the *All in this Together* scenario for both farms compared with GTP, the higher livestock commodity prices more than compensates the famers when they are only liable for 10% of their non-CO2 emissions. The lower CO2 prices and higher livestock commodity prices under GWP also means the country does best with GWP under the *All in this Together* scenario.

However, under the *Agricultural Conundrum* and the *Agriculture Out* scenarios, the livestock commodity price index is always modelled as rising 14% over baseline prices. This is because, as mentioned, internationally the two scenarios are equivalent in terms of their CO2 and food prices, but Reisinger and Stroombergen (2012) only modelled this global scenario with GWP (as explained in *Table 2*). Therefore, as emission costs are higher for farms under GWP in the *Agricultural Conundrum*, and as the price change modelled is the same, farmers are worse off under this scenario with the GWP metric. However, under *Agriculture Out*, farmers are only liable for their CO2 emissions, which are less costly under GWP. Therefore, with the same price rise, they do better under GWP with this scenario. Given CO2 prices are higher under GTP, and CO2 prices affect the livestock commodity prices through sectors such as forestry, livestock commodity prices could be expected to be higher under GTP for this scenario. However, as this was not explicitly modelled by Reisinger and Stroombergen (2012) it is hard to say whether this difference would be significant or not.

For New Zealand as a whole, it seems the lower CO2 prices under GWP always results in a higher level of economic welfare, even without the higher livestock commodity prices.

3.3. 100% liability for agricultural emissions

Figure 8 shows how the fortunes of the farmers change when they face 100% liability for their emissions, which gives an interesting point of comparison to 10% liability. New Zealand's change in RGNDI from Reisinger and Stroombergen (2012) is still displayed, though it still puts agriculture's liability at roughly 10% of their non-CO2 emissions.

As is clear from *Figure 8*, farmers profits are much lower than in *Figure 6*, although the results for *Agriculture Out* are exactly the same. Now *Agriculture Out* is the preferred scenario for the farms, with *All in this Together* second and the *Agricultural Conundrum* still last. The degree of change between metrics is now much larger for the farms, with GTP now preferred in the *All in this Together* scenario as well. However, the difference between the scenarios is still overall greater than the differences between metrics.

Figure 8 Change in profit/ha compared with baseline of the farms with all emissions at 100% liability in 2020, and Reisinger and Stroombergen's (2012) results for New Zealand's change in RGNDI[8].

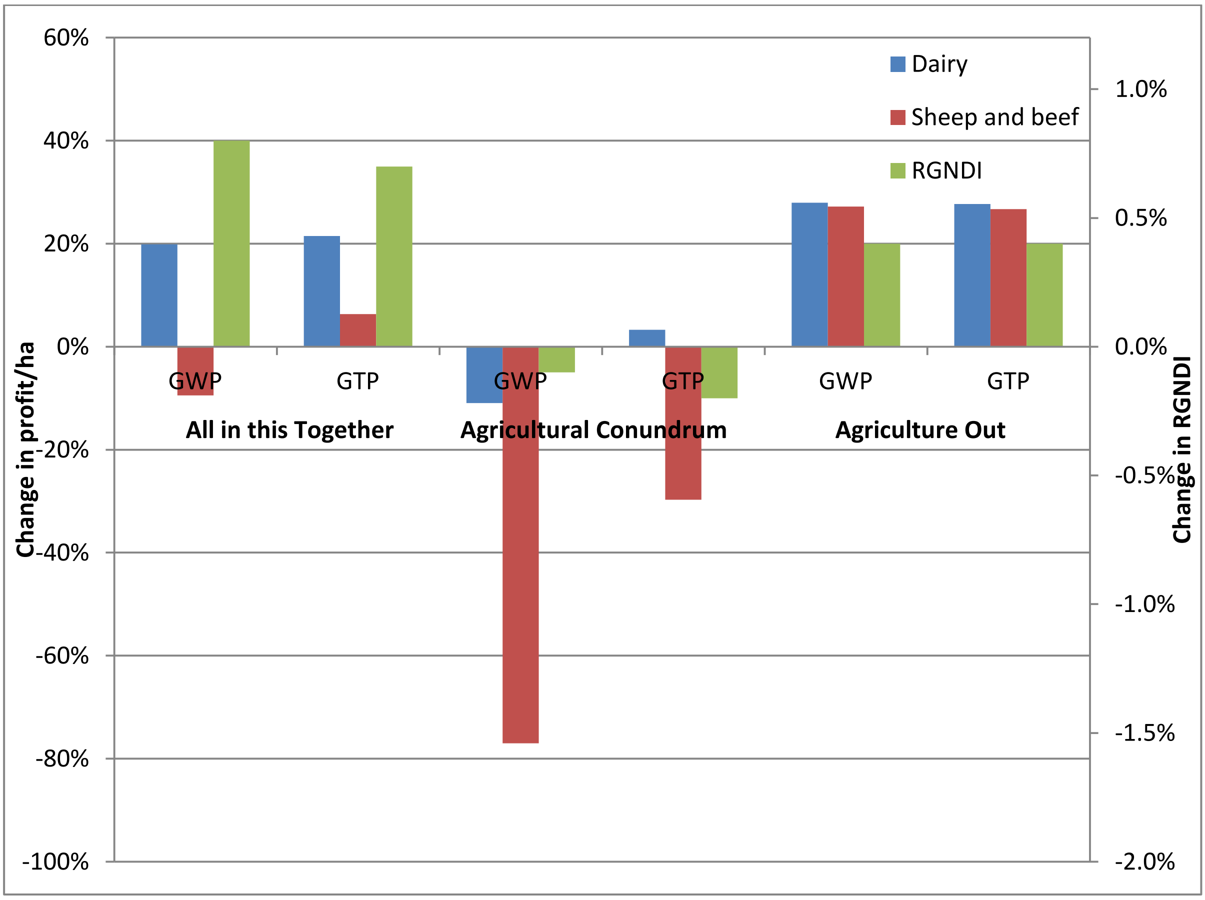


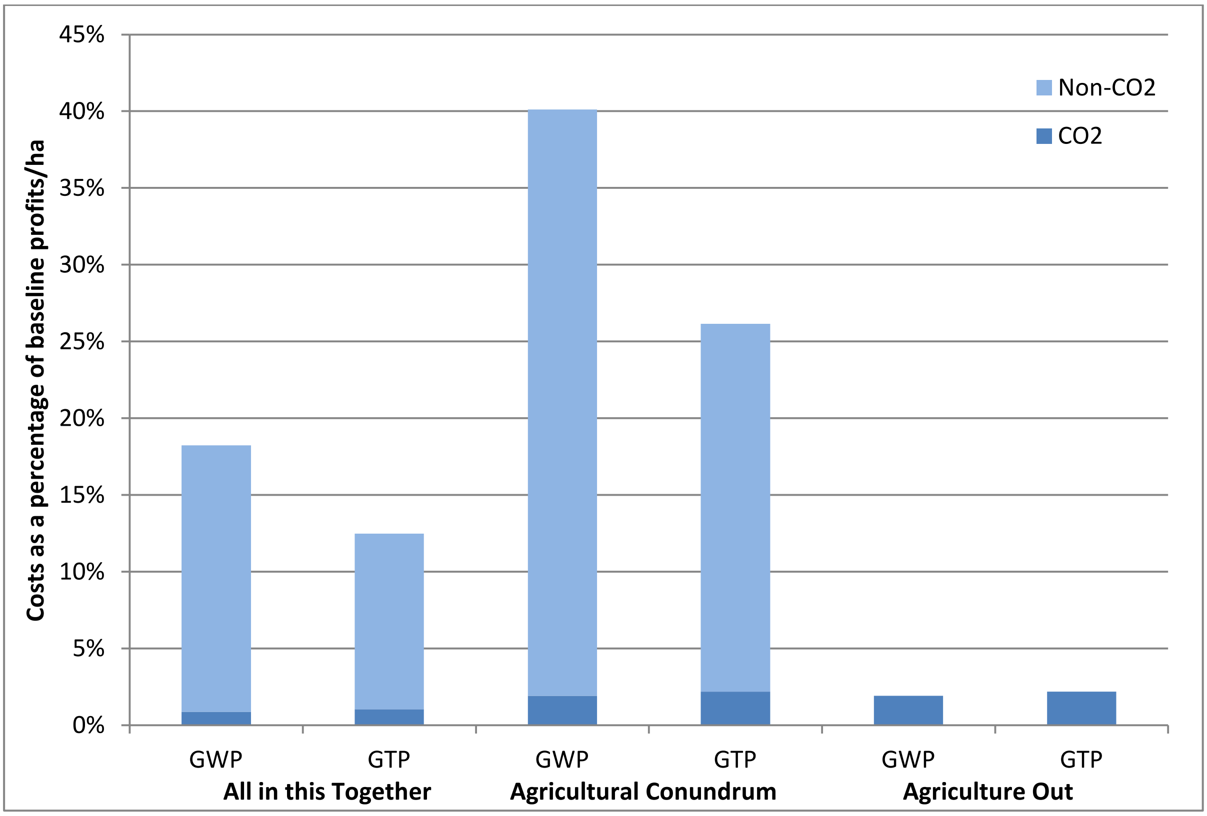
Figure 9 illustrates that when farmers are 100% liability for non-CO2 emissions, they make up a huge proportion of the farms' emissions. Again, it shows a similar but magnified

[8] Note Reisinger and Stroombergen's change in RGNDI use the assumption that agricultural emissions have a roughly 10% liability in 2020

pattern to *Figure 7*. Now, though, for a farm fully liable for their emissions, the large cost differences between the metrics is apparent. Furthermore, the costs more than double between the *All in this Together* scenario and the *Agricultural Conundrum*, and are comparatively small under *Agriculture Out*.

As is the case for 10% liability, sheep and beef costs per hectare as a percentage of baseline profit are just an exaggerated version of the dairy costs. Interestingly, sheep and beef costs per hectare are 108% of baseline profit under GWP, *Agricultural Conundrum*. The higher prices for livestock commodities pushes the farm back into profitability for 2020, though the drop in profit is still large.

Figure 9 Costs per hectare of the dairy farm as a percentage of baseline profits in 2020, with 100% liability on all emissions.



The sheep and beef farm now does much worse than the dairy farm in *Figure 8*, having a lower profit than baseline even under the *All in this Together*, GWP scenario. By 2050, profit has dropped by well over 100% under the *Agricultural Conundrum* for the sheep and beef farm under both metrics, putting the farm out of business in the long term. This does not occur under any scenario for dairy. Still, the difference between GWP and GTP is large under the *Agricultural Conundrum* for both the sheep and beef and dairy farms. Dairy manages a 20% rise in profit under both metrics for *All in this Together*.

We can only speculate what might happen to New Zealand's RGNDI had Reisinger and Stroombergen (2012) modelled it with 100% liability on agriculture. However, it is safe to say that again, change in profit for the farms is much greater than the changes to the economic welfare of the country as a whole. Reisinger and Stroombergen (2012) allow national agricultural production to respond to changes in profit. If the agricultural sector were to face their full emissions costs, it is likely that they would have a lower level of production relative to 10% liability. Therefore, presumably emissions would not be as high for the country if agriculture faced 100% liability. This would mean the Government would have to purchase fewer international emissions credits as it would not exceed the national targets by as much.[9] It is unclear how this would weigh up against the lower income received from agriculture, though in principle it should lead to greater economic efficiency in the long run (?).

The result that with 100% liability the farmers now prefer the *Agriculture Out* scenario should not be surprising. It is intuitive that farmers would prefer all other sectors to take on the full burden of mitigation, rather than facing the same costs of emissions. The farms face 100% of the costs of their emissions under *All in this Together*, compared with not facing any liability for their non-CO2 emissions, where they still see a significant rise in their revenue from the flow on effects of international afforestation and biofuels competing for agricultural land. They do quite poorly when having to pay for 100% of their emissions, under the higher emission price scenario, when no other agriculture around the world pays these costs – though dairy profits are still robust enough to rise slightly using the GTP metric. Now GTP is preferred by the farmers in *All in this Together* and the *Agricultural Conundrum*; the 100% liability for the non-CO2 emissions sees the benefits of higher prices no longer outweighing the much higher costs for methane under GWP.

Dairy still does well under the *All in this Together* scenario, with sheep and beef losing profit under GWP and gaining under GTP. Part of this could be compensated for by separating the change in international milk prices and sheep and beef prices, as mentioned in the previous section, though this is speculation. New Zealand is a relatively GHG-efficient agricultural producer, so when agricultural emissions are priced equally around the world, including in New Zealand, New Zealand profits per hectare should rise. As sheep and beef profits fall under *All in this Together* and GWP, this could provide evidence that sheep and beef prices are understated, and dairy prices overstated when combine in the livestock commodity price index.

[9] Note – all of Reisinger and Stroombergen's results for New Zealand had New Zealand exceed its national mitigation targets

3.4. Drivers and robustness of the results

There are basically two main inputs into our model farms which determine their change in profit – global GHG prices and livestock commodity prices. In Reisinger and Stroombergen's (2012) international models, the treatment of agricultural emissions (and metric used) determines the price of GHGs, which together determine the change in the livestock commodity price index. These factors in turn are determined by the models' assumptions, and how well the two models which determine these outputs (MESSAGE and GLOBIOM) fit together. The global possibilities for mitigation and their costs determine the GHG prices. And further, the extent to which global GHG prices and livestock prices affect each other will ultimately determine the results for our farm models. Therefore, we rely on the realism of Reisinger and Stroombergen's (2012) modelling to ensure the robustness of our results.

3.5. Other real world considerations

Clearly there are important factors in the real world. The effects of potential agricultural mitigation, how New Zealand sets its national target, and issues of where costs fall all come into play when analysing these scenarios.

There are some on farm mitigation actions which are affordable and available to New Zealand farmers. However, Reisinger and Stroombergen (2012) allow only nitrous oxide mitigation on New Zealand farms to occur. In the real world, the New Zealand farms modelled here have access to a range of methods of mitigating their emissions and becoming more GHG efficient, which they would apply when faced with an emissions charge. Therefore, they would not be as poorly off as shown under any of the scenarios in our modelling. The level of mitigation which is less costly than paying for emissions directly would change under each scenario and level of liability. However, this shows that when all farms face 100% of their emissions costs equally around the world, New Zealand farms are comparably efficient. This occurs even when international farms mitigate, and the farms modelled here do not.

Reisinger and Stroombergen (2012) keep the assumptions for New Zealand policy the same throughout the scenarios – for obvious reasons of allowing proper comparisons. However, in the real world the New Zealand government would likely change its policies depending on international realities.

Firstly, allowing the New Zealand farming sector to pay only about 10% of its emissions, while the rest of the world pays 100% for their agricultural emissions (as in *All in This Together*), is not particularly fair, and would harm New Zealand's international reputation, especially given we are so efficient at producing livestock commodities. As a result, we may face trade sanctions under this scenario. However, as discussed already, although New Zealand farmers definitely prefer only 10% emissions liability in the *All in this Together* scenario, we cannot be sure what New Zealand as a whole would prefer.

Secondly, New Zealand has set its current national mitigation targets within the current international context. The New Zealand government may alter its targets depending on how strongly other countries are treating their agricultural emissions, and by whether or not there is a global assumption that agriculture can mitigate and pay for their emissions. Even if most countries did not think agriculture should mitigate, their emissions could still be accounted for in national targets given their importance. However, national targets for countries where agriculture makes up a large part of them, like New Zealand, could face more lenient targets. This seems to be at least partly the case now. Therefore, with *Agriculture Out*, and New Zealand still doing quite well in terms of RGNDI increases, perhaps New Zealand would be urged to take on a stronger target, given our target would now no longer include the large and difficult agricultural part. Given the modelling undertaken has been under the assumption of internationally equal GHG pricing, different New Zealand targets would not affect any of the results for the farmers, but would affect the New Zealand government's international emissions liability, and therefore the change in RGNDI compared with the baseline scenario.

One way of conceptualising the *Agricultural Conundrum* is by thinking of global agriculture as subsidised. Although all agricultural emissions are still important for climate change – both in reality, and in national targets – governments choose to shelter their domestic agriculture sectors from their emissions liability. In essence, this is a subsidy, and it is paid for by all other sectors, as they must make deeper cuts to their emissions. As a result the CO2 price more than doubles. Currently, especially in the developed world, agriculture is heavily subsidised, though in the last few decades New Zealand has chosen not to directly subsidise our agricultural sector. Therefore, within the *Agricultural Conundrum*, the New Zealand government must decide whether or not to subsidise our agricultural sector, in light of other countries doing so. However, the added complexity in this case is the fact that because the rest of the world is subsidising their agricultural sectors, global CO2 prices are being pushed upwards. This situation means that the benefits for New Zealand of not subsidising our agricultural sector is the government potentially having to buy fewer international emission credits due to a decline in our agricultural emissions, but all our other sectors still have to pay the higher CO2 price.

In either scenario where agriculture is not priced internationally, if New Zealand decides to put a price on our agricultural emissions, then the problem of leakage occurs. New Zealand taking this action is more plausible in the first scenario, especially if it is a less extreme version, where some countries follow New Zealand's lead, but others do not. Leakage occurs when emissions are priced in one place, but not another, and as a result some production moves to where the emissions are not priced. In extreme cases this can result in no mitigation occurring; all that is achieved is moving production from one location to another. The extent of leakage will depend on a number of factors, including the relative price of GHG emissions in New Zealand, the ability to produce equivalent food as cheaply elsewhere, given the high quality land available in New Zealand. A further factor affecting leakage is the extent to which a reduction in New Zealand output – a small proportion of global supply – would actually raise global prices enough to increase production elsewhere, given we are considered price takers in the international marketplace. Kerr and Zhang (2009) suggest these factors lessen the extent to which leakage may occur for New Zealand agriculture[10].

3.6. The most likely scenario?

As has been well covered in this paper, the scenarios presented here are extremes. The latest round of international climate change negotiations have agreed to negotiate a new international agreement to start by 2020, with a continuation of the Kyoto Protocol for most, but not all countries until that point. Therefore, there is little chance now that *All in this Together* will occur by 2020, even if it is the most efficient way of meeting global aspirations of limiting temperature rises to 2 degrees.

Given this situation, and given that no countries have yet priced agricultural emissions, it seems the world we will most likely face in 2020 is the *Agricultural Conundrum*, with slightly higher than 10% liability for farmers and using the GWP metric. This is the case if the New Zealand government follows through on its proposed emission reduction target, and introduces agriculture into the NZETS in 2015. So far no other country has put a price on their agricultural emissions (Reisinger and Stroombergen, 2012), although the EU has decided to directly regulate their farmers emissions (Ref?). Other countries have enacted pollution control policies that have complementary effects on GHG emissions, for example restrictions on nutrient pollution (Reisinger and Stroombergen, 2012).

[10] There are a number of policy options to help prevent leakage. The costs of these options may be less than the costs of the leakage, making the worthwhile. Options include border adjustments for imports and exports, output-based free allocation (already included in the NZETS), progressive obligation and an ex-post environmental correction. The strengths and weaknesses of these options are explored further by Kerr and Zhang (2009).

Another major similarity between this most likely scenario and the current situation is that both milk and sheep and beef prices have risen in recent years. Disregarding other potential causes of these price rises, included in these price rises is some minor competition for land from forestry, but also strong competition from biofuels, as covered in *Section 2.3*. This competition from biofuels is similar to the role forestry plays in raising global food prices in Reisinger and Stroombergen's (2012) global modelling. Therefore, through this and other channels, food price rises of 14% by 2020 are very plausible. The 2010/2011 season prices for dairy are 21% higher than the 10 year average we used; similarly 2010/2011 revenue for our sheep and beef farm per stock unit is 17% higher than the 10 year average (Waikato MAF monitor farms 2002-2011), (Central North Island Hill Country MAF monitor farms 2002-2011). Under this likely scenario then, New Zealand farmers can still expect large increases in profit, even if they are facing 10% liability on their emissions, while no other farmers are.

It is currently unclear what the global carbon price might be in 2020, and how closely linked to the NZETS it will continue to be. If this price is lower than the prices modelled here, then farmers and New Zealand may be economically better off, depending on how this affects commodity prices.

Finally, recent agreement in international negotiations mean that it looks like GWP is here to stay, and will be updated to reflect the weightings used in this report (Reisinger and Stroombergen, 2012). However, it is unclear whether or not it will continue to be updated based on the latest science and GHG concentrations.

As for beyond 2020, the scenarios for 2050 for New Zealand reported in Reisinger and Stroombergen (2012) look like an exaggerated form of the 2020 results, as GHG prices, as well as livestock prices continue to increase. As more countries agree to emissions reductions, and more countries see that mitigating agricultural emissions lowers overall mitigation costs, we may move from the *Agricultural Conundrum*, towards *All in this Together*. Developing countries may be less likely to price all their emissions at global prices though, so we may end up somewhere in between. However, from New Zealand's point of view, and to a certain extent for our farmers, the closer to *All in this Together* we get, the better.

4. Conclusion

There are plenty of interesting threads which come out of the results of this paper, of which the reader will have their own conclusions. In this final section we summarise some of the key results.

Clearly New Zealand and our farmers have a strong interest in how global agriculture is included in any international agreement on climate change. This study has shown the importance of the New Zealand government considering international policy when determining domestic policy.

The first key conclusion is that farmers see the impacts of emissions charges much more than New Zealand. Their potential gains and losses to profit are much higher, meaning the risks associated with an uncertain international climate change policy environment are much higher for them than for the country as a whole. Overall though, the *All in this Together* scenario looks most favourable to New Zealand at least, and potentially for farmers, especially when their emissions liability is limited. Getting caught in the *Agricultural Conundrum*, stuck between *All in this Together* and *Agriculture Out* is the scenario we want to avoid. For both farmers and New Zealand, a focus on getting the right scenario is much more important than the debate over which metric we use. At least the New Zealand government can argue for a different national target, depending on the scenario we end up with.

Though it looks like the *Agricultural Conundrum* scenario will fit the reality in 2020 most closely, things may change after that. So far, given it makes sense to include all human emissions within global climate change targets, agricultural emissions have been included in national targets to date. If this continues to be the approach, and given mitigating agricultural emissions can play an important part in lowering mitigation costs, it may be unlikely that we would end up with *Agriculture Out*. To reduce costs we can expect countries to take at least some mitigation actions within the agriculture sector, though given concerns about food security especially in developing countries, how close we get to *All in this Together* remains to be seen. Either way, given the recent international agreement to stick with GWP, mentioned in the previous section, this metric looks the most likely to stay. If agricultural prices continue to rise, whether the rise is caused by climate change mitigation or other factors, the evidence presented here suggests that New Zealand farmers can afford to pay for at least a proportion of their emissions, which is important if agricultural emissions are included in our national mitigation targets.

When it comes down to it, New Zealand should be putting our energy into trying to reach the *All in this Together* scenario. It is by far the lowest cost way for the world to reach our climate change mitigation ambitions, and therefore gives us the best chance of reaching them (Cox and Jeffery, 2010). And it gives the New Zealand agriculture sector another way in which to exploit its supremacy in terms of efficiency. Then we can focus on continuing to be the most efficient livestock producers in the world, and even help others become more efficient. After all, when in comes to climate change, we are *All in this Together.*

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