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# Climate and production

## The impact of climate on agricultural production in New Zealand

## Report for the Pacific Food System Outlook September 2008 meeting

## Preface

NZIER is a specialist consulting firm that uses applied economic research and analysis to provide a wide range of strategic advice to clients in the public and private sectors, throughout New Zealand and Australia, and further afield.

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NZIER was established in 1958.

## Authorship

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# 1.Climate and the economy

Climate in New Zealand is firmly linked with the country's economic performance, as a significant amount of the country's economic activity is based on agriculture production. New Zealand based research has shown the relevance of climate on agricultural production through its influence on soil moisture, rainfall and air temperature.[1]

Climatic variability is at times evident in changes in agricultural output. Severe droughts and floods have a notably impact on national, as well as regional agricultural production. However, due to the myriad of factors which affect production, gradual changes in climatic conditions are not as easily linked with variability in output.

It is very likely gradual climatic changes have had, and will continue to have a role in changing agricultural output. Estimates of future weather patterns in New Zealand suggest some areas will get wetter and warmer, improving dairy productivity in these regions, while other regions, currently supporting sheep and beef farming, will get drier, suggesting farming in these areas will become more difficult. Climate change models estimate that the incidence of droughts and floods will increase, which will negatively impact on agricultural production.

## New Zealand's greenhouse gas emissions

Although New Zealand emissions from fossil fuel combustion are small, the country ranks 12th in the world for greenhouse gas emissions per capita. This is due to the large output of dairy production in the country and the greenhouse gases emitted during dairy production.

New Zealander's are generally environmentally conscious people and, as a country, have looked for ways to limit their impact on possible climatic changes. The main policy tool before parliament, to incentivise firms and individuals to reduce greenhouse gas emissions, is the *Climate Change Emissions Trading and Renewable Preference Bill*. Although many New Zealanders support the idea of the policy, the bill in its current form does not have popular support.

## Report outline

This report considers the impact of climatic conditions on agricultural production. It briefly considers some responses to climatic impact on agricultural production, and what New Zealanders, in turn, are doing to limit their impact on climatic changes. The agriculture industry is discussed because of its significance to New Zealand's economy and export income.[2]

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[1] Tait. A. B, 2005. *The economic implications of climate-induced variations in milk production.*

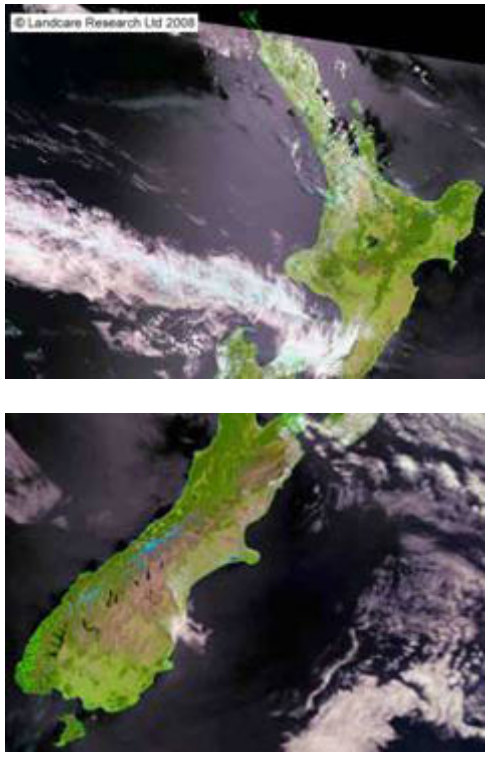
[2] Dairy and meat products generated over a third of New Zealand's 2007 export income. Statistics New Zealand Infos

# 2.New Zealand's climate

New Zealand has a variety of climatic conditions. Tempartures range from sub-tropical in the far north of the country to temperate in the south. Western regions are typically wetter than eastern areas, due to a mountain chain along much of the lengths of the two islands, protecting eastern areas from the prevailing westerly winds and rain. Dryer pasture to the east of the mountain range is immediatealy apparent in Figure 1. Sunshine hours are generally higher in eastern areas.

***Figure 1 Climate impact on pasture growth***

The difference in pasture growth in western and eastern regions of New Zealand




Source: New Zealand Met Service, Landcare Research

The range of primary activities done in different regions of New Zealand reflects the variety of climatic conditions. Horticulture, arable crops, dairy, sheep, beef and deer farming are done at different locations around the country. Pastoral farming is common in many areas, with the more productive, wetter and warmer grass growing regions generally used to farm the more profitable dairy cows. Sheep and beef farming is often done in regions to the west of the mountain range, which are drier and less suited to growing lush grass.

# 3. Climate effect on production

Broadly speaking New Zealand climatic conditions have both acute and gradual affects on agricultural production. The acute impact of drought and floods on

production can be estimated, whereas the affect on production from gradual changes are very difficult to quantify. New Zealand primary production is highly adaptive to changing markets and price fluctuations. Any observed changes in agricultural output, such as the high rates of conversion of farm land to dairy production, are much more likely to be a function of international prices and other non-climatic variables rather than changing climatic conditions. Because climate changes over the last 50 years have been relatively small, it is unlikely that they would have, to date, motivated much of a shift in production.

While there is evidence of extreme weather impacted on agricultural output, assigning changes in agricultural production to gradual climatic changes is very difficult. However, climate change models suggest that future agricultural production will be shaped by gradual climatic changes.

The effect of droughts and floods on agricultural output is almost always negative, with the severity of the event determining how badly output is affected. On the other hand, gradual changes in climatic conditions could have both positive and negative influences on agricultural production. Wetter warmer conditions in some regions are likely to promote pasture growth and therefore increase dairy production. Droughts will probably become more severe in other areas of New Zealand, limiting all primary production where irrigation is unavailable.

## 3.1 Drought

Being surrounded by water, and having numerous alp-fed rivers reduces the severity and incidence of drought in New Zealand. However, droughts do occur, and increasing demand for water may be exasperating their impact. The area of irrigated land, and demand for water in New Zealand has been steadily expanding since 1990, due largely to growing primary production. Today 77% of consented water use in New Zealand is for irrigation.[3] Over the same period the supply of water for irrigation has been roughly stable. As a consequence, even in areas where irrigation is generally available, water supply is often restricted during periods of low or no rain.

Generally, drought describes a lack of precipitation for a period long enough to adversely affect vegetation, crop production or animals. A useful rule of thumb definition for a drought in New Zealand is a period of three or more weeks without rain. 21 days without moisture is long enough to impact on grass growth.

A drought will reduce output from agriculture during and in the years immediately after the drought. During a drought pasture growth deteriorates, which has an immediate negative impact on livestock condition and in the case of dairy farming, milk production (unless supplementary feed is sufficient to maintain

[3] Ecoclimate *www.ecoclimate.org.nz/*

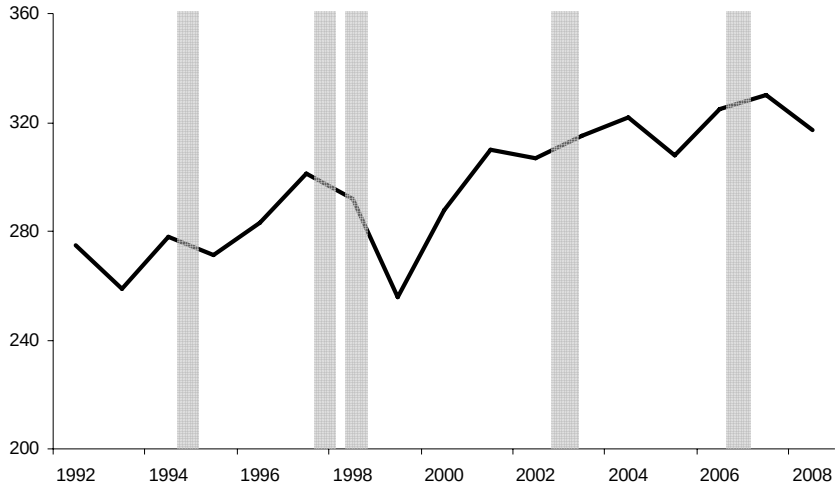
animal weight). Often stock numbers are reduced in response to the lack of feed. In the periods directly after a drought the reduced livestock numbers and poorer livestock health negatively impact on farm production.

### 3.1.1Drought and dairy production

Figure 2**Error! Reference source not found.** shows total New Zealand primary dairy production since 1992, with shaded areas representing periods of drought.

***Figure 2 Drought affect on milk-solid production***

Average kg of milk-solids produced per cow in New Zealand, (shaded areas = periods of drought)




Source: The Livestock Improvement Corporation

Two things need to be clarified regarding drought affect on milk-solid production. First, the effects from drought are to a large extent region specific while displayed milk-solid production is the national average. Hence, droughts which largely occur in regions where there is little dairy output have had marginal impact on national milk-solid production. Second, the timing of drought can have a significant impact on dairy production. A dry summer will have less affect on dairy output than a dry spring, the maximum milking period. A third caveat is that there are other factors as well as drought influencing dairy production. Production per cow in 2008 possibly decreased as more marginal land was converted to dairying in 2007 and 2008, in response to high international prices.

However, despite these factors blurring the link between drought and output, the relationship between drought and milk-solid production is still clearly apparent in Figure 2. The increase in national milk-solid production either slowed, or production decreased, during three of the four more severe droughts to occur in New Zealand since 1992.

The impact of the 2006/07 drought is not clearly apparent in national level data, because dairying is not common on the East Coast where the drought was experienced. However, regional milk output in the East Coast during the 2006/07

drought was 31.9% below the regional average of the previous eight years.[4]

The key feature of the chart is the sudden decrease in national milk-solid production per cow during the 1997/98 and 1998/99 droughts. It is likely that the impact from these droughts was particularly large because two consecutive droughts provide less opportunity for pasture and stock to recover in between droughts.

The Ministry for Agriculture and Forestry (MAF) estimate that the 1997/98 drought resulted in a loss of NZ$918 million, or the equivalent of 0.9% of New Zealand's 1997 GDP. At odds with Figure 2, the estimated loss from the 1998/99 drought was a smaller NZ$539 million, or 0.5% of GDP. MAF also estimated that the favourable climatic conditions of 1999/2000 resulted in gains of NZ$356 million in GDP.[5] Even with good conditions through 1999/2000 it was not until 2001 that national production had returned to a level greater than in 1997.

### 3.1.2 Drought and meat production

The latest drought to severely affect primary production in New Zealand occurred in the 2006/07 season. As mentioned above the effects from the 2006/07 drought were largely felt in the East Coast of the North Island, where the farming of sheep and beef cattle is the main primary production activity. 20% of New Zealand's sheep and beef farms are located in the East Coast region.

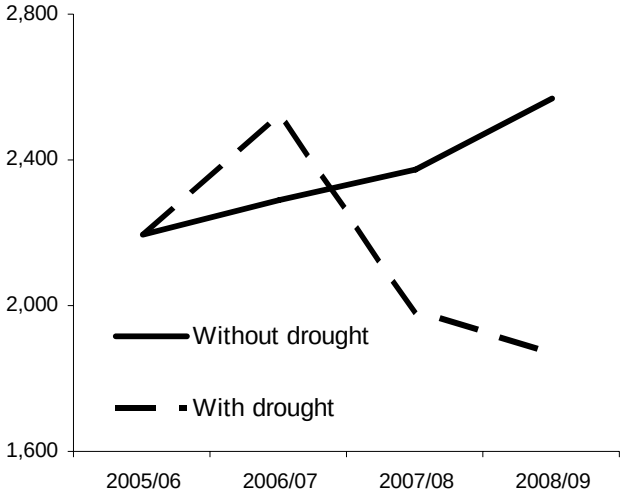
MAF have estimated the economic effects of the 2006/07 drought on the sheep and beef farming sector for a three year period to 2008/09, see Figure 3.

[4] Livestock Improvement Corporation, 2007 statistics. Measured as the average kilogram of protein produced per hectare of dairy land in Gisbourne.

[5] Ministry of Agriculture and Forestry 2000 in Tait. A. B et all 2005

***Figure 3 Economic impact of the East Coast drought***

Estimate value added from East Coast sheep and beef farming with and without the 2006/07drought ($ million)




Source: The Ministry of Agriculture and Forestry

The net direct loss to the sheep and beef sector as a result of the drought was estimated to be $297 million, or 0.27% of GDP.[6] As can be seen from Figure 3 the negative economic impact from the drought was expected to continue for a number of years. Generally it takes some time for stock health, stock numbers and pasture to fully recover. The peak in value added in the period during the drought is a result of increased livestock sales in response to deteriorating pasture growth. The longer run consequence is reduced stock in the future for breeding and sales.

## 3.2 Freshwater floods

Floods occur when continuous or very heavy rainfalls overwhelm drainage systems, or water from a waterway escapes its normal limits, inundating usually dry land. Generally, floods hamper agricultural production because pasture is inundated and hence inaccessible to stock. Slips, silting and longer periods of flooding can cause longer term deterioration to pasture and impeding speedy returns to full production. Milking may be affected if plant or equipment is damaged or farms are cut off from milk tanker access.

New Zealand typically experiences between one to three floods each year, although most of these are not considered severe. Severe flooding has occurred only two to three times in the last 12 years according to the New Zealand Metrological Service, one of these was in February 2004.

During the February 2004 flood, a large storm caused many rivers around the

[6] Bevin. S 2007 *Economic impact of the 2007 East Coast drought on the sheep and beef sector.*

southern North Island to break their banks, inundating large areas of farmland and roads as well as residential properties. Over a hundred people were evacuated from their homes in the lower North Island. A number of the houses which were flooded were unable to be repaired and had to be destroyed. Some houses were washed away in the floods.

MAF have estimated the impact from the flood on pastoral farming, horticulture and forestry to be in the region of NZ$159 to $180 million. These costs were mainly due to lost production during the floods, lost produce, and the cost of rebuilding or repairing damaged infrastructure, such as buildings and fences. The cost of purchasing feed, replacing lost stock and re-grassing was also significant.

## 3.3 Producers response to climatic changes

A survey by AgResearch and the National Institute of Water and Atmospheric Research (NIWA) provides some indication on how farmers in Gisborne, one of the drier regions of New Zealand, are responding to expectations of more frequent extreme weather. Over a period of nearly 30 years the regions' farmers have experienced extreme droughts, a cyclone, three floods and eight dry seasons.

In response to these events farmers have derived a range of coping strategies:[7]

- More flexible stocking strategies
- Earlier lambing, to allow for timely decisions on destocking
- Improved subdivision of paddocks, focusing on the most reliable water supplies
- Use of drought resistant pasture species
- Strategies that prevent paddock over-grazing
- More dams in paddocks, and water systems installed on flats
- Well planned animal health and production systems, and detailed monitoring of pests and diseases
- More regular use of climate forecasts for planning

## 3.4 A gradually changing climate?

There is evidence of recent changes in climate and weather patterns in New Zealand, which also possibly influence primary production. NIWA have used a range of methods, including measuring glacier recession, to show New Zealand's air temperature has warmed approximately 1.0 degrees Celsius since the late 18$^{th}$

[7] NIWA 2007, *Climate variability and change*

century.[8] Since 1977, westerlies have become more persistent and there has been heavier rainfall and more damaging floods in the south west of the South Island. In the north and east of the North Island conditions are drier and sunnier.[9]

However, due to numerous other factors causing changes in agricultural output it would be misleading to claim recent changes to New Zealand agricultural production are solely, or even largely in response to gradual changes in climate. On the other hand, if climatic conditions in New Zealand continue to change as predicted agricultural output is likely to change in response.

Yields in agriculture (and forestry) are expected to rise in some regions of New Zealand due to longer growing seasons, higher temperature, more rainfall, and the associated higher levels of carbon dioxide in the atmosphere. Other areas are likely to experience the same increase in temperature in combination with less precipitation. NIWA predicts that western parts of the country will be wetter and on average soil conditions in eastern areas of New Zealand will become drier. There is expected to be an increase in drought and extreme rainfalls as a consequence of the changing climate.

It is estimated that future flows in alp-fed rivers will be higher due to increased rainfall in western regions. This will provide additional water for irrigation for agricultural production in some areas. On the other hand, there will be increased demand for irrigation. It is unknown whether the possible increase in alp-fed river water supply will compensate for the likely increase in demand for irrigation.

# 4. Policy response to emissions

New Zealand accounts for only about 0.2% of total worldwide greenhouse gas emissions, however, due to the high level of agricultural output in the country New Zealand ranks 12th in the world on emissions per capita. New Zealand is unusual in that around half of the country's greenhouse gas emissions are nitrous oxide and methane from agriculture. Emissions from fossil fuel combustion (excluding transport) are small relative to other countries. As well as the relatively large output of dairy products in the country, there is extensive availability and use of renewable energy generation.

The main policy tool before parliament, to incentivise firms and individuals to reduce greenhouse gas emissions, is the *Climate Change Emissions Trading and Renewable Preference Bill*. The Bill will become law on 19 September 2008.

Under the ETS:

- the quantity and nature of greenhouse gas emissions produced are required to be monitored and reported to a regulator

[8] NIWA 2007, *Climate variability and change*

[9] NIWA 2007, *ibid*

- every significant emission has to be matched by surrender to the regulator of entitlements to emit
- the quantity of emission entitlements available to be surrendered is limited by the supply of entitlements issued for each year by the regulator and the availability, acceptability and cost of entitlements from other jurisdictions
- firms compete to purchase the number of entitlements they are required to surrender, given the level of emissions they are obliged to match
- this establishes a price for emission entitlements
- firms will reduce emissions if it is more profitable to do so by introducing new lower emitting technology or reducing output than to pay this price; firms will buy entitlements if this is the more profitable option at the market price for entitlements
- in this way, the lowest cost and most economically efficient means to reduce emissions tends to be both discovered and adopted.

There are three essential elements to an ETS – the entitlements, the cap and the ability to trade. The cap is set by the regulator to achieve the environmental outcome of reducing greenhouse gas emissions and to create a scarcity value for the entitlements which encourages people to seek ways to reduce emissions. The ability to trade ensures that emissions are reduced at the lowest possible cost.

New Zealand has struggled to develop the public consensus necessary to support legislation to implement market-based arrangements to incentivise firms and individuals to reduce emissions of greenhouse gases. The *Climate Change (Emissions Trading and Renewable Preference) Bill* was passed with a small majority and does not have general support from the community and stakeholders. As a result, it is likely to be subject to significant amendment in the future.

# Appendix A References

Bevin. Sean 2007. *Economic impact of the 2007 East Coast drought on the sheep and beef sector.*

Ecoclimate at *www.ecoclimate.org.nz/*

Livestock Improvement Corporation, 2007. National and regional dairy statistics 1992 to 2008

The Ministry of Agriculture and Forestry New Zealand at *www.maf.govt.nz/*

The Ministry for the Environment 2001. *Climate change impacts on New Zealand.* Downloaded from http://www.climatechange.govt.nz

National Institute of Water and Atmospheric Research (NIWA) 2007. *Climate variability and change.*

Tait. A. B, J. A. Renwick and A. H. Stroombergen 2005. *The economic implications of climate-induced variations in milk production.* The New Zealand Journal of Agricultural Research , 2005 Vol 48: 213 – 225.

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# The Pacific Food System Outlook

15-17 September 2008

# Primary production

- GDP
  - About 7% of New Zealand's GDP
- Employment
  - Almost 7% of labour force directly employed in primary production
- Export income
  - Almost half of 2007 export income from primary sector
  - Dairy alone provided 1/3 of 2007 export income

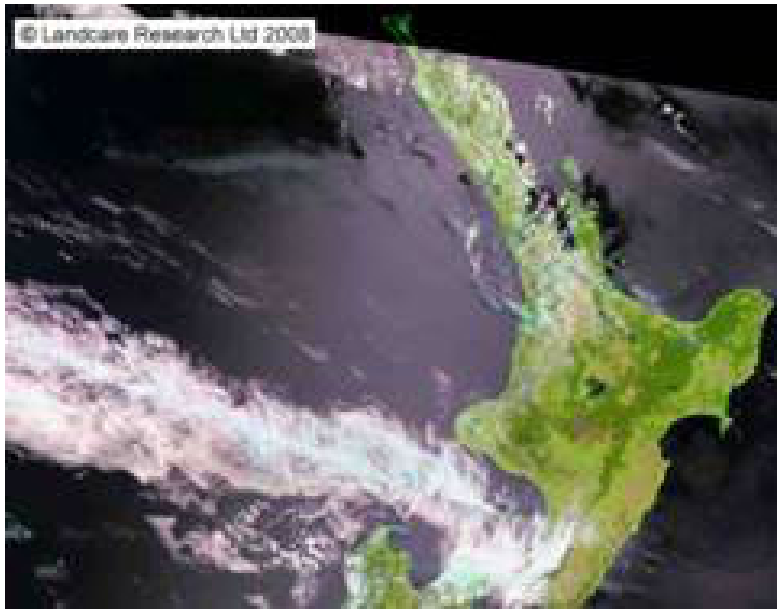
# Climate affect on production

- Climate affect on pasture growth / dairy agricultural production determined by
  - Rainfall days
  - Soil moisture deficit
    - rainfall needed to return the soil to saturation
  - Growing degree days
    - number of degrees that the average temperature is above a baseline value (5° Celsius)

Source: Tait & Renwick (NIWA) Stroombergen (Infometrics)

# Evidence of changing climatic conditions?

- Gradual changes
  - Air temperature has warmed by about 1.0 degrees Celsius since the late 18th century
  - Heavier and more persistent rain in west
  - Drier in east
- Increasing incidence of severe weather
  - More severe and greater incidence
    - Droughts
    - Floods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# Climate affect on production: gradual

- Variable production
  - Markets and prices
    - Can not attribute changing output to gradual changes in climatic conditions
- However:
  - Rising air temperature
    - More growing degree days
    - But also more soil moisture deficit in some areas
  - More rain in west and drier in east
    - Increasing alp-fed water supply
    - Increasing water demand
  - Higher concentrations of carbon dioxide
    - Increased photosynthesis ‘carbon fertilisation’ effect

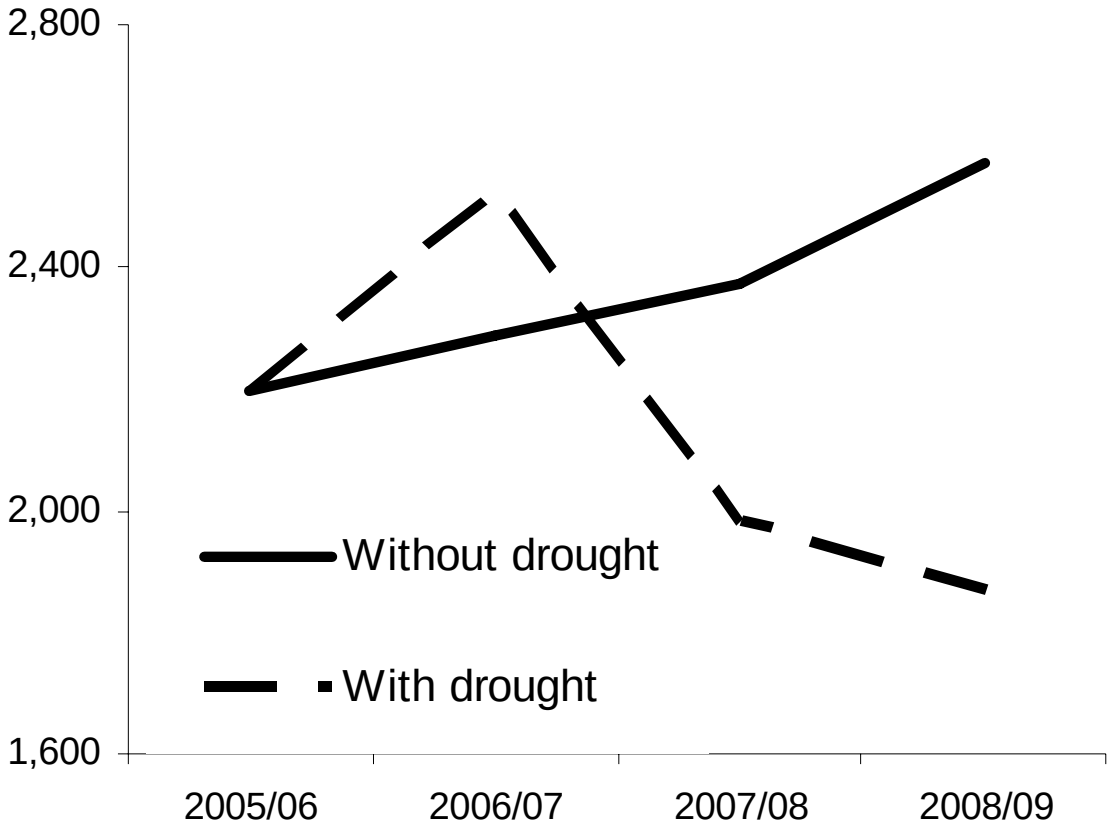
# Climate affect on production: drought

Kilogram of milk-solids produced per cow


Source: LIC, NIWA

# Climate affect on production: drought

Value added from East Coast sheep and beef farming ($ million)



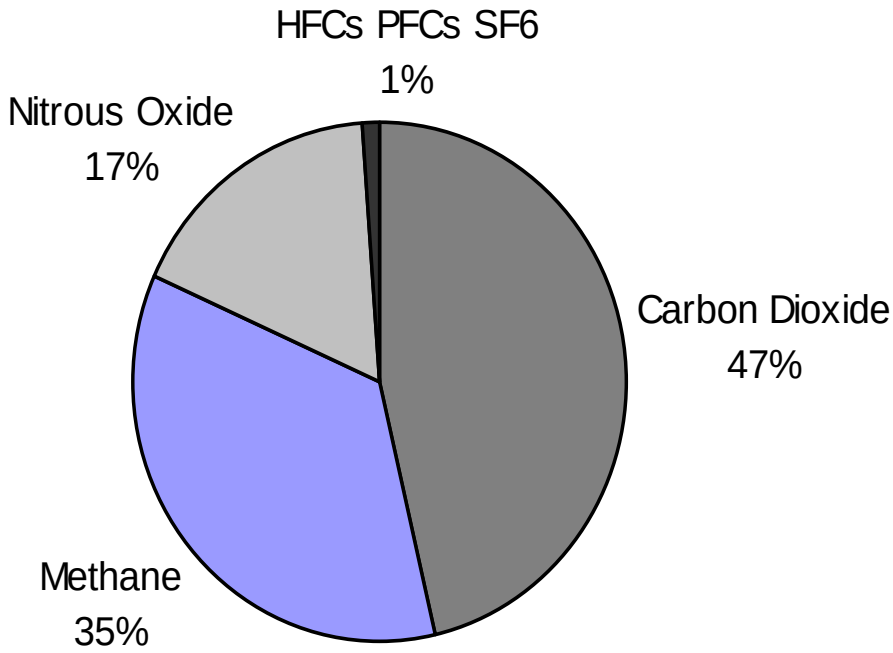

Source: MAF

# Producers' responses

- More flexible stocking strategies
  - Earlier lambing to allow for de-stocking if needed
- Subdividing paddocks to make use of reliable water sources
- Use of drought resistant pasture species
- More dams and water systems
- Monitoring of pests and diseases
- More regular use of climate forecasts for planning

Agresearch and NIWA

# New Zealand emissions

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# Climate Change (Emissions Trading and Renewable Preference) Bill

- quantity and nature of greenhouse gas emissions monitored and reported
- emissions have to be matched by surrender of entitlements to emit
- entitlements to emit issued for each year by regulator
- firms compete to purchase the number of entitlements they are required to surrender
- this establishes a price for emission entitlements
- firms will either reduce emissions or buy entitlements, depending on which is more profitable

# Emissions Trading Scheme

- Encourages discovery and adoption of lowest cost and most economically efficient means to reduce emissions?
- Should:
  - shift production and consumption to reduce emissions
  - help find the minimum cost for reducing emissions
- Should not be simply:
  - a tool for making polluters pay for the costs their actions impose on others
  - a means for the government to collect revenue

# High cost of reducing emissions in New Zealand

- Considerable challenges to reduce emissions from agriculture without reducing output
- Currently highly dependent on renewable sources of energy for electricity
  - Expensive to reduce use of fossil fuels for energy generation further
- Low population density reduces the cost effectiveness of public transport