IMPACTS OF CLIMATE VARIABILITY ON REGIONAL AUSTRALIA

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Abstract

Australians have to deal with the most variable rainfall regime on earth. In response to this governments have developed policies to ensure that the activities and industries they support are sustainable in the face of this climate variability. Climate variability on a regional scale, and trends in that variability over the past 50 years are expected to have impacts on agricultural policy and farm management techniques.

Introduction

This paper examines Australian climate variability from national and regional perspectives. The overall variability of climate, and trends in time are examined with a view to providing some insight into the implications for Australia’s farm sector. Unless otherwise noted, the term “climate change” employed in this paper is the change in climate brought about by the combination of natural and anthropogenic influences. This is the definition of climate change used by the Intergovernmental Panel on Climate Change (IPCC). This may be contrasted with the usage of the term “climate change” by the United Nation’s Framework Convention on Climate Change, where the term refers only to anthropogenically caused change.

Climate variability – a national perspective

The term “climate variability” is used to denote deviations of climate statistics over a given period of time (such as specific month, season or year) from a longer period mean of the same variable. That is, climate variability is measured by the magnitude of anomalies of climate timescale variables from a long term mean. One measure of Australia’s climate is the annual rainfall averaged over the continental area. A measure of the variability of Australia’s rainfall climate might then be how much this annual area-averaged rainfall varied from year to year against some long-term (30 year or 100 year) mean.
Rainfall, like many other variables, has the characteristic that as the mean increases so does the dispersion (or standard deviation) of the values that make up the average. To compare the variability of the areal average rainfall of different locations or countries, the coefficient of variation is often used. The coefficient of variation (often expressed as a percentage) is given by the standard deviation divided by the mean. From Figure 2, and consistent with the work of Nicholls and Wong (1990) and Nicholls et. al. (1997), it is evident that Australia’s rainfall is highly variable relative to that of the countries that compete with us in the world’s market for agricultural products.
Nicholls (1987) and Nicholls and Wong (1990) note that those places with the greatest rainfall variability are those strongly affected by the El Niño. Related to this observation, but not significant in a global trade sense, is the fact that some small island states near the dateline in the tropical zone have a higher rainfall variability than Australia. In Australia’s case, the El Niño has a strong control over annual rainfall in the North, but in southern Australia, particularly in the coastal zones, the El Niño effect is somewhat reduced thereby lowering the apparent variability of annual rainfall.

The policy implications that flow from recognising Australia has a highly variable climate are straightforward in principle but difficult to apply in practice. They are straightforward in the sense that there is general agreement that as a nation we should only undertake activities and support industries that are sustainable through the full range of climate variability. The difficulty in practice is not unrelated to the timescale of the large swings in our rainfall climate. For example, droughts typically last one year but can extend over two years or more. That is, a drought, at least regionally and possibly nationally, can and does persist for the lifetime (2 or 3 years) of an elected government. For a government in such a situation, it is politically very difficult to advise families in rural communities that cannot meet their bills for food, education or medical items that this is all a part of natural climate variability and they should have made provision for it in the good years. The current Government policy relating to dealing with Exceptional Circumstances illustrates the issues climate (particularly rainfall) variability creates.

The Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), which has now been incorporated into the Primary Industries Ministerial Council and the Natural Resource Management Council, have defined a set of criteria that need to be met for Exceptional Circumstances. Current guidelines for Exceptional Circumstances to be declared in a region or for an industry (ARMCANZ, Resolution 3D, 5 March 1999) state that:

(a) The event must be rare and severe;
(b) The effects of the event must result in a severe downturn in farm income over a prolonged period; and,
(c) The event must not be predictable or part of a process of structural adjustment.

The ARMCANZ criteria define ‘rare’ events as those that occur, on average, once in every 20-25 years. The event is ‘severe’ if it lasts for a prolonged period or greater than twelve months, and is of a scale to affect a significant proportion of family businesses in a region to warrant government intervention. The severity of an event is determined by assessing the impact on the sector, number of producers, size of area, and overall value of production. EC can include combinations of factors formulating an event. Eligibility for EC support arises when rare and severe events are linked to rare and severe income downturn.

This policy poses a number of difficult science issues, not the least being that the event must not be predictable before it commences, but once underway it must be possible, at some point, to predict the persistence of income reduction from the event (such as drought) for a period greater than twelve months. The complexity of the task of predicting the cessation of meteorological drought with lead times of, say, eighteen months is substantial.

Having established the likelihood of persistence of meteorological drought, there may be an imperative to make predictions on global trade conditions in agricultural products on the same timescale so as to be able to make some prediction on the persistence, on farm and related incomes, of the impact of the agricultural drought.

Climate variability – a regional perspective
Viewing only a national perspective masks large regional variations in climate variability. Nicholls and Wong (1990) suggest that variability of annual rainfall increases as:

(a) Mean annual rainfall decreases;
(b) Latitude decreases, and,
(c) The influence of the Southern Oscilliation increases (at least in tropical and subtropical latitudes).

Australia may be divided into climate zones in numerous ways, although for the purposes of this study we have characterised regions on a cropping basis and a larger, broad scale agricultural basis.

The Australian Bureau of Agricultural and Resource Economics (ABARE) has defined three broadscale agricultural zones for Australia (Figure 3):

1. **Pastoral zone**: this zone includes most of the northern tropical areas and the arid and semiarid regions of Australia. Agricultural land use in this zone is characterised by extensive grazing of native pastures. Although some cropping is undertaken, it is impractical on most farms because rainfall is inadequate.

2. **Wheat–sheep zone**: this zone has climate and topography that generally allow regular cropping of grains in addition to the grazing of sheep and beef cattle on a more intensive basis than in the pastoral zone.

3. **High rainfall zone**: this zone forms the greater part of the coastal belt and adjacent tablelands of the three eastern mainland states, small areas in southwest Western Australia, and the whole of Tasmania.

Figure 3 Broad-scale agricultural zones (Pastoral, wheat-sheep and high rainfall) as supplied by ABARE.
Regional rainfall variability for each of the ABARE agricultural zones for the two periods 1900 - 1950 and 1950 - 2000.

For each of these four regions the variability in rainfall has increased with time. In the pastoral zone the primary agricultural activity is cattle grazing, and from the data shown here, that activity could expect increased variability in year-to-year return.

Clark and Harrop (2004) have provided a forty-five year summary of farming demographics. Their data indicate that, nationally, the number of livestock has remained fairly constant but the area under cropping has increased steadily (Figure 6).
Clark and Harrop indicate that the area of cropping is fairly well coincident with the ABARE Wheat/Sheep zone (Figure 7). Noting the increase in area under cultivation and increase in rainfall variability it is of interest to identify whether there are any regional trends within the zone.

![Figure 7](image_url)

**Figure 7**  

The Grains Research and Development Corporation (GRDC) has defined a number of cropping regions which fall within the ABARE Wheat/Sheep zone. For the purposes of this study we have used rainfall data for three cropping zones (Figure 8):

1. **Northern cropping zone**: this zone is characterised by a tropical to subtropical climate with yields dependant upon the conservation of soil moisture from subtropical rainfall. There is a diverse range of cropping options, with the prospect of summer and winter crops.
2. **Southern cropping zone**: this zone is characterised by a temperate climate. Cropping yields depend upon reliable spring rainfall. There is a diverse range of cropping options available although usually restricted to winter cropping unless irrigation is used.
3. **Western cropping zone**: this zone is characterised by a Mediterranean climate with cropping yields depending upon good winter rains. There is a narrow range of cropping options.
Figure 8  GRDC Cropping zones divided into West, South and North zones.

Figure 9  Regional rainfall variability for the three zones combined (All) and for each of the zones separately for the two periods 1900 - 1950 and 1950 - 2000.

Figure 9 shows that for the key cropping zones of Australia (the ‘ALL’ zone), rainfall variability is increasing marginally. In the northern zone variability has decreased whereas for the southern and western zones variability has increased. The combination of the substantial increase in cropping area and increased variability of rainfall in the south and west suggests that government payments under Exceptional Circumstances arrangements must also increase (particularly in the south where variability increase is
the greatest) in these zones unless fully offset by increases in farm efficiency through better water management, use of new, more efficient plant species, or both.

**Climate change and regional climate variability**

Climate variability occurs naturally and can be forced by impact of society on the environment and is the variability about some stable, long term mean. In some sense this is an idealised concept because the long term climate is always changing, however the rapid climate change currently being observed requires that we understand the natural variability if for no other reason than to be able to identify the climate change signal that it would otherwise mask. The preceding sections of this paper have considered rainfall variability, noting that it is a major factor in the Australian economy.

Some climate researchers have concerns that global climate change could enhance climate variability, creating rapidly changing and more extreme levels of climate variability, especially of rainfall. Over the last century Australian average temperatures have risen by around 0.7 °C. Rainfall has increased over northwestern Australia, but decreased in the southwest of Western Australia, and in much of south-eastern Australia, particularly in winter (Figure 10). The cause of rainfall changes is discussed extensively within the scientific community. Changes in the rainfall regime over Southwest of Western Australia are attributed to a combination of natural variability and a trend due to the enhanced greenhouse effect, although recent research suggests that stratospheric ozone depletion may also be causing a southward shift of the westerly wind flow and an associated southward shift in rainfall.

![Trend in Annual Total Rainfall](image)

**Figure 10**  
*Trend in annual total rainfall for the period 1950 - 2003*

Southwestern Australia has experienced a 15% decrease in heavy rainfall in winter (Haylock and Nicholls, 2000) which, given the reliance in that region on good winter rains, may provide problems for agricultural profits. Nicholls (2003) suggests that since 1973, annual rainfall deficiencies in Australia have been associated with much greater temperature anomalies, which suggests that droughts are getting hotter.

The effect of climate change on pasture growth is also expected to be non-trivial. While a rise in carbon dioxide concentration is likely to increase pasture growth, a lowering of rainfall may decrease pasture growth, as well as decrease stocking rates and live-weight gain in cattle (Howden et al. 1999). Many of Australia’s crops are highly affected by
climate variations such as water stress. As a consequence an increase in rainfall variability in cropping regions could influence farm incomes.

The IPPC’s Third Assessment Report (TAR) “Climate Change 2001” states that more intense precipitation events are likely over many mid- to high-latitude land areas and that increased summer continental drying and associated risk of drought are likely in mid-latitudes. In the Australian context this could be expected to lead to an increase in climate variability as would any increase in the frequency and/or intensity of El Niño and La Niña events.

Results presented in Figures 4 and 9 indicate that all but one of the agricultural zones considered here have experienced an increase in variability during the last fifty years of the 20th century in comparison to the first 50 years. Figure 10 shows that accompanying this increase in variability is a decrease in rainfall over much of the most agriculturally productive land in Eastern and Southwestern Australia. Perhaps a key task for agricultural policy makers is to decide how much of the increased risk associated with this increased variability and decreased rainfall is to be borne by the taxpayers (through increased Exceptional Circumstances payouts and the like) and how much by the farming community (through investment in new technologies, changing of practices and crops, and the like).

References:


