CoastAdapt

Climate change impacts on coastal agriculture

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Impact Sheet 11

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Contents

Introduction

The coastal region in Australia is considered in this context to include coastal plains, regions to the east and south of the Great Dividing Range, and areas within approximately 100 km of the coastline. Coastal agriculture in Australia is dominated by six main industries: sugarcane, dairy, viticulture, horticulture, forestry, and extensive grazing in the sparsely inhabited regions of northern Australia. This report discusses the likely impacts on coastal agriculture in four key bioclimatic regions identified through the CSIRO and Bureau of Meteorology climate futures process detailed on the Climate Change in Australia website. These 'super-clusters' are bioclimatic regions that delineate areas that have similar climate characteristics and patterns and are shown in Figure 1. The future climate change scenarios for each of these super-clusters are provided in the Climate Change in Australia website http://www.climatechangeinaustralia.gov.au (accessed 9 May 2016) and are summarised in Table 1.

Here we present a qualitative, indicative assessment of the likely impacts of changes in climate variables on production in these key sectors. The level of research and knowledge on climate change impacts varies enormously across the considered industries. There are a wide range of assessment tools available to the industries with varying levels of sophistication ranging from simple statistical models, to biophysical simulation models, to whole of supply chain economic models. In some sectors there are also quantitative assessments using biophysical modelling such as GrassGro, DairyMod, and the Agricultural Production Systems Simulator (APSIM) which can integrate changes in temperature, rainfall, and atmospheric CO_2. Consequently the depth of analysis on climate change impacts varies between industries.

Therefore we present a discussion based on climate sensitivities of each industry and possible futures. This reduces the level of uncertainty that is introduced when using analyses that use different datasets and models and therefore produce different future scenarios. Not all of the impacts of climate change on coastal agriculture are detailed here due to the complexities of each of the particular production systems. However, we present a subset that captures the primary and secondary impacts and provides an indication of the complexities of the system.

Sugarcane

Sugarcane is grown in pockets along a 2100 km zone in eastern Australia mostly within 50 km of the coastline, with 94% of production occurring in Queensland. This large spatial coverage means that the sugar industry is exposed to a range of climate zones which experience different impacts of climate change.

Sugar production is sensitive to many aspects of climate. The primary climate drivers are water availability, solar radiation, and temperature (specifically the minimum temperature at which growth starts and the maximum temperature when growth stops).

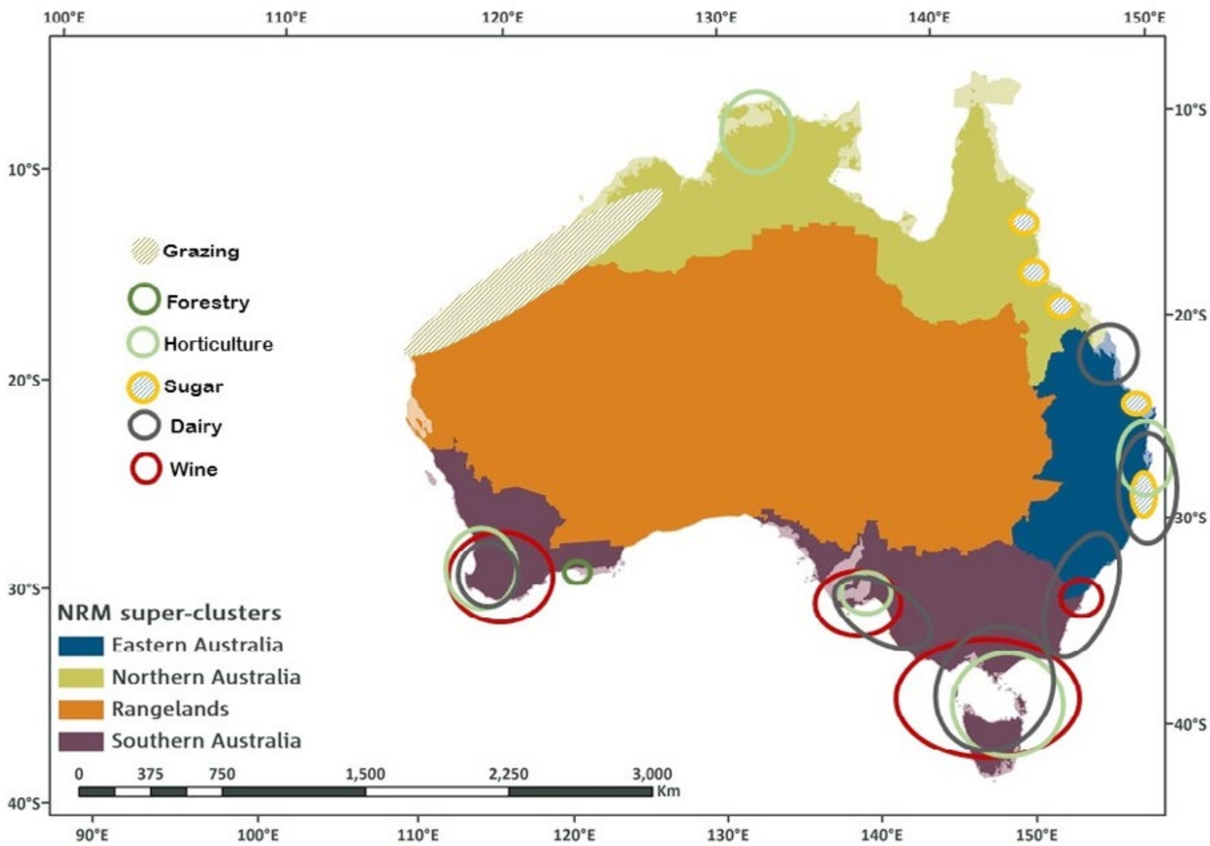

Figure 1: The key agricultural industries operating in the coastal regions of the four climatic regions identified in CSIRO-BOM Climate Change in Australia project. Source: Developed by the author (data taken from Stokes and Howden 2010; the cluster map from the Climate Change in Australia website (CSIRO and BoM); and http://www.agriculture.gov.au/abares/aclump/PublishingImages/Land-use-Aus2005-06-lrg.jpg (accessed 20 July 2016).

Table 1: Summary future climate change scenarios for each of the four key climate regions from the Climate Change in Australia website: Northern Australia (NA), Rangelands (RA), Eastern Australia (EA), and Southern Australia (SA). The values shown are the range of changes (the 10th to 90th percentiles) from approximately 40 General Circulation Models. These future changes are compared with a historical period of 1986-2005 for 20-year periods (centred on 2030 and 2090) and three emission scenarios (Representative Concentration Pathways, RCPs).

	Future time period	Emissions scenario	Super cluster region			
			NA	**RL**	**EA**	**SA**
Temperature	2030		0.5-1.3°C	0.6-1.4°C	05-1.4°C	0.5-1.2°C
	2090	RCP4.5	1.3-2.6°C	1.5-2.9°C	1.3-2.6°C	1.2-2.1°C
	2090	RCP8.5	2.7-4.9°C	2.9-5.3°C	2.8-5.0°C	2.7-4.2°C
Hot days	2030		Increases	Increases	Increases	Increases
	2090	RCP4.5	Increases	Increases	Increases	Increases
	2090	RCP8.5	Increases	Increases	Increases	Increases
Summer rainfall	2030		Natural variability	Natural variability	Natural variability	Natural variability
	2090	RCP4.5	-20 - +10%	Uncertain	Uncertain	Uncertain
	2090	RCP8.5	-20 - +25%	Uncertain	Uncertain	Uncertain
Winter rainfall	2030			Natural variability	Natural variability	Decrease up to 15%
	2090	RCP4.5		Decrease	Decrease	Decrease up to 20%
	2090	RCP8.5		Decrease	Decrease	Decrease up to 30%
Extreme rainfall			Increases	Increases	Increases	Increases

There are regional variations in the significance of these climate drivers on production. For example, in the northernmost growing region in Far North Queensland, sugar production is constrained by low radiation when it's cloudy, and when excessive rainfall causes waterlogged paddocks. In the central and southern regions, excessive rainfall and waterlogging is a smaller risk on production compared with risks from limited supply of irrigation water and temperature.

The impact of increased atmospheric CO_2 and climate change will also affect different risks in the various growing regions. All regions will see an increase in atmospheric CO_2 which will positively affect plant growth (although, as a C4 plant, the response is less than C3 plants), an increase in temperature, an increase in rainfall intensity, an increase in sea level, and an increase in tropical cyclone intensity (Table 1). The change in summer rainfall cannot be ascertained with confidence but winter rainfall is likely to decrease and, in the Northern Australian zone, summer rainfall may change by between -20% and +10%. In general, if rainfall decreases in the northern growing region, yields may increase in response to increased solar radiation. In southern growing regions, a reduction in rainfall would reduce yields and increase demands for irrigation water which has also been reduced.

For the northern region production systems the mostly likely impacts of these changes are increased crop damage from wind and tropical cyclones, poorer crop establishment if spring rain decreases, and increased waterlogging if growing season rainfall increases (see Table 2 for a summary). There may also be secondary impacts such as increased rainfall intensity leading to increased nutrient and sediment runoff into the Great Barrier Reef .

Generalised impacts of climate change on plant production

- **Increase in atmospheric CO_2:** this has a positive "fertilisation" effect. This is essentially an increase in light and water use efficiency.
- **Increase in temperatures**:
  - In cool regions, an increase in temperature may be favourable for plant growth.
  - In warm regions, an increase in temperature may be detrimental.
- **Changes in rainfall:** plant growth increases or decreases as the rainfall increases or decreases.

Growers in the Burdekin and Herbert regions will experience some of the above impacts as well as additional impacts due to increased risk to water supply from the Burdekin Dam. If winter and spring rainfall decreases then this would increase accessibility of the paddocks thereby improving harvesting efficiency.

Rising sea levels are likely to increase rising water table and salinity issues. Poor drainage and tidal intrusion in floodplain production areas will also be exacerbated.

In the Central and Southern growing regions, there is a limited supply of irrigation water which is likely to be exacerbated by the projected decrease in rainfall. An increase in temperatures is likely to increase the length of the growing season and potentially increase productivity (providing all other inputs are not limited).

Presently there is some competition for land between horticultural crops. Although a 1.5 year crop, sugarcane crops managed using ratoon are often extended to four to five years and therefore are more vulnerable to the increased risk of intense tropical cyclones, storms, and other extreme weather events.

In the northern New South Wales (NSW) growing region, the projections of a decrease in rainfall may decrease cloud cover, thereby increasing the necessary levels of solar radiation. Crop growth is presently limited by low winter temperatures and the short duration of growing season (necessitating a crop duration of two years). Projections of an increase in minimum temperatures are likely to reduce this constraint.

The presence of acid sulphate soils and the need for drainage require careful management of the water table. Projections of sea level rise are likely to increase the difficulty of managing water tables and acid sulphate soils and may potentially reduce the areas suitable for crop growth.

Horticulture

Horticulture includes a wide range of vegetables, fruit, berries, tree crops, flowers, turf, and also viticulture which is discussed in the following section. In general, horticulture is most sensitive to temperature, hail frequency, rainfall and water availability especially in relation to plant growth, pest and disease risk.

Most crops have specific temperature thresholds for attaining the highest yield and quality. The impacts vary between horticultural commodities and the specific growing regions. The diversity of species and their agronomic differences, and the often wide-ranging location of growing areas, explains why there are few species-specific impact analyses and few tools with which to assess climate sensitivity. However there are many common impacts of climate change that affect a wide range of industries.

An increase in temperature will affect the phenology of many crops. Changes may be seen in the length of growing periods of many crops, and also flowering, pollination, and dates of harvest. An increase in night-time temperatures will increase respiration and may reduce the size of some fruit. In addition, most deciduous fruit and nut trees have a winter chilling requirement to break the winter dormancy and produce uniform flowering. A warmer climate may reduce fruit quality and yield.

Many horticultural commodities have a small thermal tolerance which makes their production capacity vulnerable to increases in temperature. Changes to growing conditions will impact on the suitability of regions for different crops which may result in an expansion of areas suitable for tropical and sub-tropical crops and a contraction of temperate crops grown across the southern-most regions of mainland Australia. Indeed, changing growing conditions resulting from climate change impacts result in new cultivars introduced into regions in order to match the crop selection with optimum conditions.

There is also potential for changes in the distribution of existing pests, diseases and weeds, and an increased threat of incursions into new crops. An increase in temperature may favour the expansion of the geographical range of pests and diseases as well as the timing of the high risk period. For example, there is potential for warmer climates to allow overwinter survival of key pests such as the Queensland fruit fly; this will have a large impact on marketability of fruit in both the domestic and export markets. In addition, regions where rainfall and humidity decrease will see a decreased risk of fungal problems, while areas with an increase in summer rain and extreme rainfall are likely to experience a higher risk of fungal problems.

Horticultural enterprises require reliable irrigation supplies. Changes in rainfall will affect irrigation demand and water availability. Decreased soil moisture and increased evaporation will increase the water requirements of many crops. However, a decrease in rainfall will change the water harvesting and storage opportunities. This would be significant at a range of scales from the individual farm dam through to large catchment scale storages.

CO_2 fertilisation impacts are crop specific. There are many uncertainties regarding the ability of CO_2 fertilisation to offset increases in evaporation or decreases in rainfall.

An increase in rainfall intensity will increase the risk of soil erosion and off-farm impacts from nutrient runoff.

There is likely to be an increase in crop losses as a result of changes in many key climate factors. These may include losses due to heat stress, fruit drop, sunburn, and more frequent and extreme weather events, including cyclones, flooding and drought. This also has impacts on the entire supply chain such as, for example, the seasonality of markets, the storage and processing infrastructure, and transport logistics for the movement of produce.

Viticulture

Viticulture is practised mainly in latitudes south of 30°S, but also across a range of regional climate types usually within the 12-22°C isotherm. Future possible climates are best sourced from the Southern Australia climate scenarios of Table 2. The suitability of a region for grape and wine production is primarily a function of climate and soil criteria. Different varieties of grapevine have physiological and morphological differences that enable production over a large range of climates.

Vineyards have a lifespan of between 30 and 100 years, which increases their vulnerability to climate change. Grapevines are sensitive to various aspects of climate. Temperature has the greatest influence and is reflected in the quality, style and varietal wine characteristics. The sensitivity of grapevines to temperature occurs through the effects on the phenology; photosynthesis, respiration and transport of assimilated carbon; and the biochemistry and transport of flavour molecules in the berry. While yield potential and fruitfulness are determined by temperature the previous season, the timing of phenological stages (e.g. budburst, flowering, veraison or berry softening and colour change, and maturation) are more sensitive to temperature in the current season. An increase in temperature will advance the timing of the phenological stages and encourage ripening to occur earlier in the season. This results in a compression of the harvesting window, which can have a positive or negative effect on wine production depending on the current climate regime. If the period of fruit processing is too short and intense, the pressure on capital-intensive winery infrastructure has the potential to affect financial viability.

Many perennial horticultural plants, including grapevines, require a number of chilling hours for budburst and uniform flowering. An increase in winter temperatures will reduce the number of hours of chilling resulting in delayed and prolonged budburst of some varieties. However, shifts in weather systems, such as high pressure cells, may actually increase the number of frost events. An increase in frost is likely to reduce yield. Frost risk may also increase as a result of changes in phenology such as an earlier budburst.

Increased atmospheric CO_2 will influence production in a range of ways. In addition to the already mentioned effect of increased atmospheric CO_2 on water use efficiency, increased CO_2 will also affect the amount of vegetative development and therefore shading. Although research has established that increases in CO_2 can have a positive effect on fruit yield, it is not clear if the strength of the effect will offset the negative effect (decrease in yield) cause by increases in temperature which decrease the growing season.

The impact of changes in rainfall will vary regionally and depend on the variety. Table 1 shows that for the Southern Australia region winter rainfall is likely to decrease by up to 30% by 2090 under a high emissions scenario. The impact of a change in rainfall is most significant in terms of irrigation. Vine water use is likely to increase due to higher temperatures; however there will be reduced availability of water due to more variable rainfall and reduced run-off. In addition, there will be a decrease in groundwater recharge (although this is regionally specific). Therefore there will be an increased need to harvest and store a greater proportion of our rainfall than is done presently and also an increased need to use water more efficiently and to reduce losses.

The change in rainfall will also affect the risk of fungal disease such as botrytis. In a reduced rainfall scenario the risks of such diseases are reduced; they increase if rainfall increases. Regardless of changes in mean rainfall, extreme rain events are highly likely to increase. Heavy rain events during the harvest months increase the risk of fungal disease. Altered range and incidence of pests and diseases will require increased management and possibly chemical input.

In addition, there are significant impacts from the increased occurrence of extreme weather events such as drought, hail, bushfires, storms and wind, and heatwaves, as well as changing number and seasonality of cold and frost days.

Growers have identified a significant decrease in wine quality due to smoke taint from bushfires. Bushfires are likely to increase in number and severity across many regions, increasing the risk of smoke taint issues.

Dairy and other intensive livestock

The dairy industry is active in coastal areas (and others) across Southern Australia in the southwest of Western Australia, South Australia, Victoria, Tasmania, and along coastal zones in NSW and southern to central Queensland. Milk production is from both pasture systems and irrigated pasture systems.

Other major intensive livestock industries in Australia include piggeries, poultry, and feedlots. Of these it is predominantly only poultry which is in coastal regions, and this is usually on the outskirts of major cities.

Specific projections for the dairy industry include reduced rainfall in Southern Australia, uncertain changes in the Eastern Australian zone, and an increase in temperature between 0.5 and 1.5°C. There is likely to be increased evaporation and decreased runoff.

Across all intensive livestock industries, the most significant impact is that of heat stress. Heat stress is a function of temperature, relative humidity, solar radiation, and wind or air movement. Heat stress causes strong physiological responses in animals. There is a strong relationship between heat stress and decreased productivity, often because of reduced feed intake during hot spells. Other responses to heat stress include increased water intake, changed metabolic rate and maintenance requirements, increased evaporative water loss, increased respiration rate, changed blood hormone content, and increased body temperature.

Dairy operations become compromised when temperatures are above 27°C regardless of humidity. High producing cows generate large amounts of metabolic heat which needs to be eliminated to enable the cow to maintain a suitably low body temperature. This is often not possible. Impacts of this include reduced milk yield, reduced conception rates, and increased mortality rates.

An increase of 1°C in mean temperature will increase the likelihood that free range pig production may not be viable across many regions.

A decrease in rainfall will see decreased availability of water for livestock consumption, irrigation, and water for evaporative cooling. An increase in temperature combined with a decrease in rainfall will likely increase irrigation requirements. However, a decrease in rainfall, increased evaporation, more frequent and longer drought will likely decrease farm water supplies. Reductions in runoff will be greater than those of rainfall, and therefore impacts will be greater for farmers who rely on surface runoff for irrigation.

Increased levels of atmospheric CO_2 will also affect pasture quality, composition, and productivity, and also crops used for feed. Changes in temperature and rainfall will also affect pasture growth. An increase in temperature could increase pasture growth rates and also affect the seasonality of growth and feed availability. Increased temperatures may also change the composition of pasture by making C4 pasture species like paspalum, kikuyu, maize and forage sorghum more competitive at the expense of the nutritious C3 species like rye grasses.

Forestry

In Australia, the gross value of commercial forestry is dominated by production from plantation forests. Approximately 7% of Australia's forests are native forests managed for timber production, and approximately 1% of the total forested area is classified as commercial plantation forestry. Plantation forestry has a slightly greater proportion of softwood plantations, such as *Pinus radiata* in southern Australia and *Pinus caribaea* and *Pinus elliotti* in South East Queensland, compared with 46% of plantation forests which are characterised by hardwood species such as *Eucalyptus globulus* and *Eucalyptus nitens*. Most of the commercial plantations are in the north-east coastal zone and southern and eastern regions of Australia (as shown in Figure 1); these regions account for approximately 80% of the total area of plantations.

In Australia the distribution of forests broadly depends on climate and soil types. *E. globulus* and *E. nitens* both have extensive natural distribution and broad temperature requirements existing in a range of environments with mean temperatures between 9 and 18°C. This can be compared with other Eucalyptus species in native forests, and not used for plantations, that have distributions with less than 2°C variation in mean annual temperature. This implies that a 2.5°C increase in mean annual temperature would result in nearly half of Australia's 800 species of eucalypt having their entire distribution shifted outside their current climatic range. The reverse is that the *E. globulus* plantations are relatively adaptable to changes in mean temperature.

The level of vulnerability of plantation forestry and native forestry differs. Plantation forestry is considered moderately vulnerable to climate change as the two primary commercial species (*Pinus radiata* and *Eucalyptus globulus*) have relatively broad climatic ranges and can tolerate a range of climate conditions. Native forestry however is considered highly vulnerable because their current distributions are in narrow climate ranges and small changes in climate may have large impacts of future distributions.

The key climate variables to which the forestry sector is most sensitive are: temperature, especially extremes; total rainfall and seasonal distribution, drought frequency and soil water availability; atmospheric CO_2 concentrations; changes in storm frequency and intensity and resultant flooding; and fire weather. Other risks that will increase due to climate change are increased pest and disease risks, and increased bushfire intensity and frequency.

The fertilisation effect of increased atmospheric CO_2 on most plants leads to increased growth as a result of increased photosynthetic rates and improved water use efficiency. Although increased CO_2 may result in increased productivity in general, the magnitude of these increases varies depending on environmental and physiological specificities of plants. Plants that are in a rapid growth phase have a greater response which implies that plantations may benefit more from CO_2 fertilisation as they usually have fast growing trees. In addition, much experimental evidence is from small plants, so we have less knowledge of the response of mature plants of specific species. Some research indicates that the fertilisation effect decreases as trees age.

An increase in temperature often results in increased productivity, depending on the species, location and current climate. For example, the growing season of most species is expected to increase in the cooler areas of southern Australia that are not water-limited. Increased occurrence of heat stress due to increased frequency of days over 35°C, however, may decrease productivity.

In general, productivity decreases as rainfall decreases and increases as rainfall increases. Mortality rates also increase in years of low rainfall. The combination of increased temperatures, increased water requirements and decreased water availability will result in decreased productivity and increased risk of mortality; however these generalisations may not apply to all species. Simulation modelling has increased our knowledge on the interactions between the more favourable changes and has integrated the most likely changes in future climate. Despite the uncertainties in the modelling and the large range of results, there appear to be three main patterns of change in growth rates of trees in regions relevant to coastal agriculture.

- An increase in production with little increase in the risk may occur in the *P.radiata* and *E. globulus* plantations of Tasmania and East Gippsland.
- An increase in production, with an increase in risk of drought, may occur in the *E. globulus* plantations and *E. nitens* in Victoria and the 'Green Triangle' area around the border area of South Australia and Victoria.
- A decrease in production and an increase in the risk of drought may occur in southern NSW and the *E. globulus* plantations in the high rainfall zone of eastern Western Australia.

Such increases and decreases may also occur in other regions that are further inland and therefore not relevant to coastal agriculture.

Changes in log availability vary depending on the region. The impacts are similar regardless of emission scenario. In both 2030 and 2050, climate change modelling indicates that log availability from softwood plantations decreases the most (approximately by 25% by 2030, 30% by 2050), in hardwood plantations by about 10% in 2030 and 15% in 2050, and with logs from native forest decreasing by 2% by 2030 and 4% by 2050.

Table 2: A summary of key impacts on agricultural industries in the coastal regions of Australia.

Industry	Region	Regional impacts
Sugarcane	Northern Australia	Sea-level rise will exacerbate tidal intrusion of flood plains. It may also impact salinity issues. An increase in extreme rain events will increase already high erosion risk causing sediment loading of Great Barrier Reef; also impacts on pests and disease risk. The increased risk of extreme winds and intense tropical cyclonic activity is likely to increase crop damage.
	Eastern Australia	A decrease in rainfall may increase yields due to increased solar radiation. A decrease in rainfall would increase pressure on water availability for irrigation. Increased temperatures will increase length of growing season. Increased landuse pressure from horticultural crops.
Viticulture	Southern Australia	Increased temperature may cause fruit to ripen earlier affecting quality. Compression of the harvest period due to phenological changes will require increased processing capacity. Decreased rainfall will become an issue for irrigation and/or resulting soil moisture.
Horticulture	Southern Australia	Increased temperature may cause phenological shifts. Reduced winter chilling from mean temperatures will affect choice of species and variety. Increased frost occurrence may negate assumptions from increase in mean temperatures.
	Eastern Australia	Decrease in rainfall will decrease water security and availability.
	Northern Australia	Increased extreme rainfall events and tropical cyclone intensity are likely to have serious impacts.
Forestry	Southern Australia	Plantings may be vulnerable.
	Eastern Australia	Little risk to hardwood plantations compared to pine plantations.
Dairy	Southern Australia	Increased temperatures, especially extremes, will cause heat stress issues. Decreased rainfall will reduce water allocations for irrigated dairy.
	Eastern Australia	Likely to benefit from increased temperatures and decreased rainfall. Decreased water availability. Increased heat stress.

In northern Australia, future forestry is threatened by the changing risk of tropical cyclones. Tropical cyclones are projected to increase in intensity, but less likely to change in frequency. They are also likely to track further south than present. The impact of more intense tropical cyclones will increase risks of more severe damage to forests, processing facilities and infrastructure.

A hazard applicable to all climate zones is the ever present risk of fire. An increase in temperatures will increase fire risk. Despite the lack of total GCM agreement in future projections of rainfall, wind speed, and relative humidity, it is likely that fire weather and fire danger indices will increase in the future. There is likely to be a higher incidence of more severe fires.

In summary, the coastal zone native forestry and plantation operations will most likely have an increased risk of reduced productivity and mortality. However the magnitude of the changes is a result of the interplay between gains from increased atmospheric CO_2 and losses due to increased temperatures and areas where water availability decreases. Increases in fire severity and frequency and the incidence of pests and diseases may be more significant than physiological impacts. The regional distribution of plantation productivity will also change, especially in regions already close to their optimal growing temperatures.

Summary

Agriculture in Australia and the natural resource base will be impacted by climate change over the next 100 years. Agriculture is subject to a range of climate risks which will largely (but not totally across all sectors) be exacerbated over the next hundred years, including changes to the key drivers of temperature and rainfall extreme weather, drought, bushfires, and tropical cyclones. The future sustainability of agriculture will require adaptation strategies to these changes.

These regional climate change assessments and impact summaries can assist with assessing possible future environments and risk management strategies rather than providing reliable predictions suitable for planning.

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