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Department of Agriculture and Food
Government of Western Australia



Climate Change and Adaptation in South West Western Australia

Phase One of Action 5.5, State Greenhouse Strategy

**A report to the Western Australian Government and
Australian Greenhouse Office**

**Community, industry and government
views on past and future climate change
for South West Western Australia**

Prepared by the Action 5.5 Sub-committee on behalf of the State Greenhouse Inter-departmental Committee

Prepared by Luke Morgan, Department of Agriculture and Food, Western Australia

November 2006

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INTRODUCTION

The Western Australian Government, in collaboration with the Australian Greenhouse Office, is undertaking a study to investigate the impact of climate change on South West Western Australia, and past and potential responses to it. This constitutes Action 5.5 of the Western Australian Greenhouse Strategy, which is:

An integrated global climate and assessment strategy for the South West of Western Australia will be prepared through collaborative action by the AGO, State Government entities, local governments, key stakeholders and the community (Department of the Premier and Cabinet, 2004)

The study comprises two phases, where Phase One is concerned with how residents, organisations, institutions, industries and natural systems have responded to climate changes that began during the 1970s, and which continue to the present. It is also designed to generate information essential for a Phase Two project, which will be a detailed study to assess the vulnerability of the region's various sectors to future climate change and improve their capacity to adapt. Phase Two will increase public awareness and provide targeted information that will help factor climate change risks into decision making.

Phase One comprises three parts:

1. Historical review for the period 1970 to the present.
2. Stakeholder consultation; and
3. Preparation of a scoping study report.

This report documents the outcomes of part two.

To complete part two, a series of consultation sessions were held throughout South West Western Australia during March 2006 at Katanning, Ravensthorpe, Albany, Perth, Bunbury and Geraldton. These locations were chosen to provide coverage of the range of sectoral issues and interests, and are considered to have experienced various levels and impacts of climate change since the mid-1970s. For example, Katanning is considered to be an agricultural area that has experienced changed rainfall patterns, Bunbury is thought to have become hotter and drier, and may be experiencing some impact from sea level rise, and Geraldton appears to have been affected by increased heat and lower rainfall.

A broad range of stakeholder interests were invited to attend from community, industry and government organisations and sectors (a list is included at Appendix Two). Sectors that were well represented were agriculture, water resources, sport and recreation and to a lesser extent biodiversity conservation. Particular sectors were consistently under or un-represented at the sessions and this should be a focus for further work. The health, local government, planning, fishing and tourism sectors need to be better engaged to develop a more complete picture of climate change impacts throughout the region. It should also be noted that attendees were self selecting, and that overall attendance was relatively low, although sessions in southern areas were better attended than those held at northern locations. Total numbers of attendees are provided in Appendix One.

However, whilst certain sectors were under represented during the consultation period, the study team took opportunities to discuss the project with stakeholders on an on-going basis at other forums; for example, a meeting of the Great Southern Area Consultative Committee at Ongerup and a Great Southern Local Government Managers Association meeting at Mount Barker. Additionally regular meetings of the Action 5.5 Sub-committee, which is overseeing the study have provided opportunities to discuss particular sectoral experiences

and responses. These opportunities have gone some way to providing greater coverage of the region's sectoral and inter-sectoral interests. Whilst piggy-backing on meetings that are already happening can be effective, the opportunities to do this are limited by the timeframes of the study. Moreover it is frequently difficult to find out the meeting schedules of unfamiliar networks.

The consultation sessions comprised two parts.

1. Firstly participants were provided with a technical overview of climate changes now known to have affected South West Western Australia. Participants were then asked for their reactions, and to provide comments and observations focusing on local conditions and experiences. The overview was drawn largely from the work of the Indian Ocean Climate Initiative, which is the primary source of climate change science and research for the State. It highlighted:
 - global changes to greenhouse gas concentrations and the atmospheric circulation;
 - the increasingly dry conditions experienced by the region since the 1970s, and resultant decreases in stream flow and implications for water supplies;
 - increased temperature; and
 - increases in sea level.

Specifically it brought to peoples' attention the following trends and sought their responses as to whether or not these had been observed:

- Warming of about 0.8°C since 1910.
 - Daily minima have risen more than daily maximums.
 - Increased number of heat wave days (days over 35°C).
 - Fewer frosts.
 - More intense storm events such as cyclones.
 - Decreased rainfall due to southward shift of weather systems and more El Niños since the early 1970s.
 - Droughts have intensified since the early 1970s; and
 - Sea level has risen between one and two millimetres per year.
2. Secondly a short outline covering SRES (Special Report on Emissions Scenario's) scenarios, consequent climate change projections and the effect of shifts in means on extremes was provided. Participants were asked to comment on the potential impact of these on their lives and activities, and how they believed they would respond. In this second part, participants were also requested to highlight information they thought would be most useful to them in developing adaptation strategies. This section highlighted:
 - projected increases in greenhouse emissions and the inevitability of future climate change despite mitigation efforts;
 - continued trends for less rainfall, increased temperatures and sea level rise; and
 - risks as a result of extreme weather events.

Specific future impacts that were brought to peoples' attention included:

- Australia's most vulnerable ecosystems are the wet tropics, Kakadu, alpine areas, coral reefs, freshwater wetlands, and heathlands in south-western Australia;

- generally less stream flow for southern Australia;
- some agricultural crops may actually benefit from warmer conditions and higher carbon dioxide (CO₂), but this may be offset by reduced rainfall;
- greater exposure of infrastructure to extreme weather events and sea-level rise; and
- health impacts such as greater exposure to heat-related deaths and dengue fever.

The consultation questions are provided at Appendix Three.

The following report details the outcomes and findings of these discussions. It provides some indication of the extent to which climate change has been experienced by people in South West Western Australia, the nature of changes experienced, how they affected peoples' daily lives and how they have responded to them. It also sheds light on the degree to which people see climate change as an issue for the future, how they believe it will affect them and whether they intend planning for its impacts.

Information gained regarding future climate change is important for on-going work in determining future vulnerability to climate change and developing appropriate responses. The outcomes of the sessions have been useful in developing Phase One's final scoping study report and in informing project planning for Phase Two, in particular that substantially more work is needed in raising public awareness and assisting development of adaptation responses.

SUMMARY OF CONSULTATION OUTCOMES

Purpose of consultation

The intention of the consultation sessions was primarily to listen and record peoples' recollections of past climate changes, variability and events, and their views about a future dealing with global climate change. Attempts have not been made to verify comments or observations, and consequently they are presented in the report as stated by the participants. However, as far as possible peoples' comments have been linked with current climate science and meteorological reports. The 'raw' comments from the sessions are provided in Appendix One.

The consultation views can be considered in the context of decision theory; for example Senge's (1990) model of decision-making summarised in Figure 1 below. The study suggests that some people can relate experiences or observations to climate change. However, because they regard it to be such an omnipotent force they conclude that they cannot do much about it, and in any event have more pressing shorter term imperatives facing them. As a result they adopt a view that government will do something, or they will continue to cope or adapt (or more likely react) when they need to. Consequently, in the interim people tend not to do anything specific but may take some *ad-hoc* measures that can in hindsight be rationalised as having had some relationship to climate change.



Figure 1. Senge's model of decision making.

The challenge for the future is to better understand the range of influences at work along these steps in decision chains and develop programs to facilitate change processes that lead to action based on new beliefs about climate change. This can be achieved through disseminating information, and by providing opportunities for people to understand the consequences of different actions, to question their assumptions, conclusions and beliefs, and to encourage them to consider different perspectives, which may alter their observations, filtering and colouring of experiences. The fields of environmental education and agricultural extension can assist in the development of techniques to facilitate this change process.

With this theoretical underpinning, it is useful to assess the comments as a whole and attempt to draw some conclusions about the commonality and differences that emerge between peoples' observations of climate change, and any themes that appear to cut across the range of sectors in the region. These follow in this summary.

Past climate change

Broad acceptance

There was broad acceptance that climate change is a reality. Few if any people came to the consultation sessions to be convinced as to whether it was happening or not, nor were counter-arguments put forward disputing global climate change science. This may indicate broad community acceptance of climate change supported by their observations and experience. However, it was frequently raised that much of the change was probably a result of natural variation, as well as having been induced by human activity, and there was some uncertainty about the extent to which each of these factors has driven past climate changes. Lack of scepticism was not universal, but such views were muted possibly because it was felt to be a minority opinion or in deference to expert opinion.

Whilst there was general acceptance, most people and sectors seem to be coping satisfactorily over short timeframes and did not appear to have thought much about factoring adaptation to a non-stationary climate regime into long term decisions. Many spoke of mitigation actions, but did not believe they needed to develop adaptation strategies. When people hear the evidence demonstrating the region has already experienced climate change and then upon reflection can recall few adverse impacts, they seem to conclude that they must have adapted reasonably well. There were few impacts and behavioural changes attributed to climate change, with people feeling that because of on-going prosperity, well being and environmental health during the past 30 years, any impacts must have been within the region's coping capacity.

Declining rainfall has driven responses to climate change

In the few instances where adaptation responses could be identified, these were more commonly linked to other events, community demand and economic drivers, rather than a conscious acknowledgement of long term climate change. For example, the agricultural sector has maintained productivity in what we now know is a drying climate by adopting new technology and improving management practices. Farmers noted these responses but linked them more to concerns about maintaining productivity and profitability in the face of evolving technology and market conditions, and on-going climate 'variability' rather than what is now called 'climate change'. Their primary motivation was improved efficiency to maintain global competitiveness.

Some farmers indicated that they are now aware of the region's longer term rainfall decline as a result of climate change, and acknowledged that adoption of new technology has essentially 'masked' the identified drying trend since the mid-1970s (and more recently since 2000). With regard to agriculture and forestry there were indications that at some locations these industries may be nearing thresholds in terms of declining rainfall, which will affect their capacity to maintain optimum productivity, particularly agriculture in parts of the Ravensthorpe area and forestry in parts of the Esperance area.

The water resources sector has made the most significant and direct responses to South West Western Australia's climate changes. Representatives from this sector confirmed the region has experienced significantly less rainfall during the past 30 years, that wet (well above average) winters have virtually disappeared, that rainfall events were less reliable and those that did occur were generally lighter, and that much of South West Western Australia was suffering water supply shortages as a result of decreased streamflow and inflow into dams. As a result the State has shifted its reliance on water supply during this time from primarily surface water to a greater emphasis on groundwater and is investing significantly in

alternative supply mechanisms such as desalination. For this sector, adaptation is a direct acknowledgement that rainfall has shown abrupt decreases in the mid-1970s and again around 2000, which has resulted in significant planning and investment in alternative water resource management actions and awareness raising activities. In effect the water resources sector has identified its vulnerability to climate change and planned accordingly.

Whilst reduced water supply has been observed by the State's water resource sector during the past 30 years and adaptation responses have been developed to ensure on-going supply, other sectors reliant on that supply have also experienced impacts. However, many of these seem to have been perceived only more recently. They include:

- impacts on sporting grounds as a result of water restrictions;
- increasing salinity of dams that support horticultural operations where some dams are not receiving sufficient rainfall to flush salt out;
- increased stress on native vegetation and changed fire behaviour;
- increasing competition for groundwater between water supply needs, ecosystem needs and forestry operations; and
- increased algal blooms in some waterways as a result of nutrient enrichment exacerbated by higher temperatures and decreased flushing.

Whilst climate change may have contributed to several of these impacts, climate variation is also thought to be a factor, as are a number of other land and water degradation effects. Participants acknowledge the impact of unsustainable practices such as over-clearing native vegetation, poor fertiliser management, insufficient planning, and pests and diseases, and that climate change is emerging as an additional pressure on some already degraded systems.

Increased media attention is a good yardstick for growing community concern and the State's media is picking up climate change issues for South West Western Australia, particularly in relation to water shortages. Government investment in desalination, divided community opinion about inter-regional transfer of groundwater resources and the plight of the State's farmers during the driest season in 100 years are capturing public and media attention.

Mitigation responses

Whilst adaptation responses may not have been common during the past 30 years, there is evident awareness of global warming and the drive for mitigation strategies, particular during the last five to 10 years in the industry and resources, and energy sectors.

Many industry organisations understand growing community concern about global climate change, and have acted accordingly. The Chamber of Commerce and Industry highlighted that several of its members have already assessed their relative level of risk or exposure to climate change. In many cases they have not waited for government research or policy direction, but taken the initiative themselves as part of business decision making. This includes active steps to offset or sequester carbon emissions, to manage sites to optimise water use efficiency, or working out how best to operate in current and possible future government policy environments. Industry organisations believe government has an important leadership role to play by encouraging industry to take action, but not create trade disincentives.

Alcoa has a global Climate Change Policy to improve energy efficiency at all of its operations through implementing best practice technologies to reduce greenhouse gas emissions. It is developing new technologies to reduce emissions such as residue carbonation at its Kwinana refinery and is partnering with Alinta Limited to build energy saving cogeneration power plants at Alcoa's refineries. Cogeneration at the Pinjarra and Wagerup refineries could save more than 1.8 million tonnes of greenhouse emissions compared with conventional electricity generation.

Another example can be found in Gorgon Project Joint Venture's commitment to greenhouse emissions management. It has developed a proposal that will see the disposal of approximately 2.7 million tonnes of carbon dioxide per year by underground injection into a deep aquifer. This action is based on the organisation's awareness of growing community, industry and government concern about global climate change, which has essentially been integrated into its business decision making.

The State's Water Corporation has also established a number of greenhouse gas mitigation strategies, including a recent strategy to become carbon neutral. The Corporation joined the Greenhouse Challenge Program in 2001/02, and by 2003/04 reported a greenhouse gas abatement of 110, 000 tonnes of carbon dioxide equivalent, or more than 25 per cent of its gross emissions for that year. This was achieved through:

- improving energy efficiency;
- increasing use of renewable energy;
- capture and combustion of methane;
- fuel switching;
- establishing an Energy Management Unit;
- carbon sequestration; and
- a water education media and enforcement campaign (Humphries *et al.* 2005).

Woodside Petroleum Ltd has also joined the Australian Government's Greenhouse Challenge, under which it has:

- committed to investing \$211 million on technical abatement measures;
- identified a projected reduction in emissions of approximately 38 million tonnes carbon dioxide equivalent against 'business as usual' between 2002 and 2022; and
- won awards for greenhouse abatement in 2001, 2002 and 2005.

Woodside is also a foundation sponsor of the Cooperative Research Centre for Greenhouse Gas Technologies, and its sponsorship supports projects such as the first carbon dioxide geo-sequestration project in Australia, being conducted in the Otway Basin.

Perceived temperature changes

Participants at the consultation sessions were advised that annual mean temperature averaged throughout Western Australia has increased by about 0.8°C since 1910. This compares with the global average increase of 0.6°C during the 20th Century. Virtually everywhere in Western Australia has warmed during the last century (Figure 2).

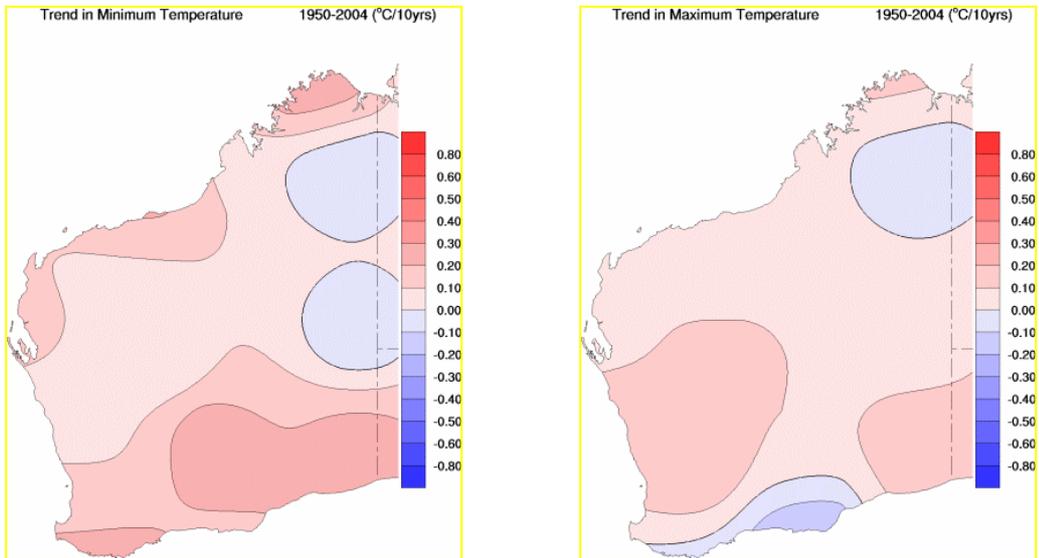


Figure 2. Trends in daily minimum and maximum temperatures, 1950-2004.
 Source: Australian Bureau of Meteorology.

However, trends have not been uniform during the period, with the late 20th Century showing the most consistent period of warming (see Figure 3). Daily minimum temperatures have increased by more than the maxima and averaged throughout the State, the warming following 1950 has been greatest in winter and spring, and least in summer. Whilst these temperature departures may seem relatively small, a one degree increase in mean temperatures is equivalent to many southern Australian towns shifting northward by about 100 kilometres (Bureau of Meteorology, 2006).

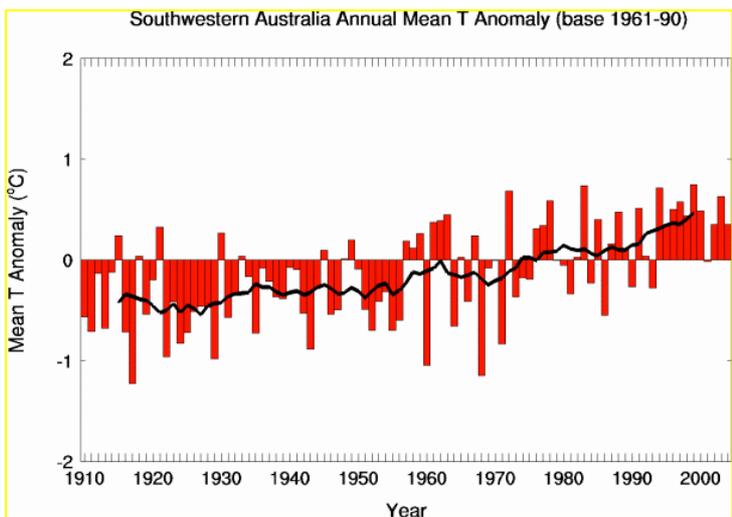


Figure 3. Trends in mean annual temperature, averaged throughout south west WA, 1909-2004.
 Source: Bureau of Meteorology.

The enhanced greenhouse effect is most likely responsible for much of the observed warming, but natural causes have also contributed. It is also likely that other human actions such as changes in land cover have led to increases in some parts of the region (IOCI, August 2005).

Participants confirmed these temperature changes, with people generally feeling that the weather has become hotter and drier during the past 30 years but whilst summer seemed longer it was generally a bit milder. Comments were frequently made that the sun seemed to have more bite to it and that the duration of warmer weather into autumn had lengthened. There were also several comments made that the lead up to summer seemed to be slower, with November and December being generally cooler, but the incidence of unusually hot days during those months being higher. In fact, participants felt that the number of heat wave days (days above 35°C) generally had increased throughout the summer period. This concurs with recent trends observed by the Bureau of Meteorology with 2005 being the warmest year on record. Also in relation to lengthening summer-like conditions, autumn 2005 was particularly warm. April had the largest Australian mean monthly temperature anomaly ever recorded, with a monthly anomaly of +2.58°C breaking the previous record of +2.32°C set in June 1996 (Bureau of Meteorology, 2006).

An anomaly in relation to temperature for South West Western Australia that emerged at several sessions was the increasing incidence of frost events in agricultural areas. Scientific information suggests daily minima are increasing throughout most of the region, but farmers reported the number of frost events appears to be increasing, which has caused damage to crops in recent times. This issue may require further research by the agricultural sector.

Perceived rainfall changes

Participants were also advised that rainfall in South West Western Australia was once considered to be the most consistent and reliable of anywhere in Australia. However, annual rainfall has declined by about 10 per cent since the mid-1970s, with a noticeable shift toward drier winter conditions, which continue to this day (Figure 4). Not only has the number of winter storms decreased but those that do eventuate generally bring less rainfall.

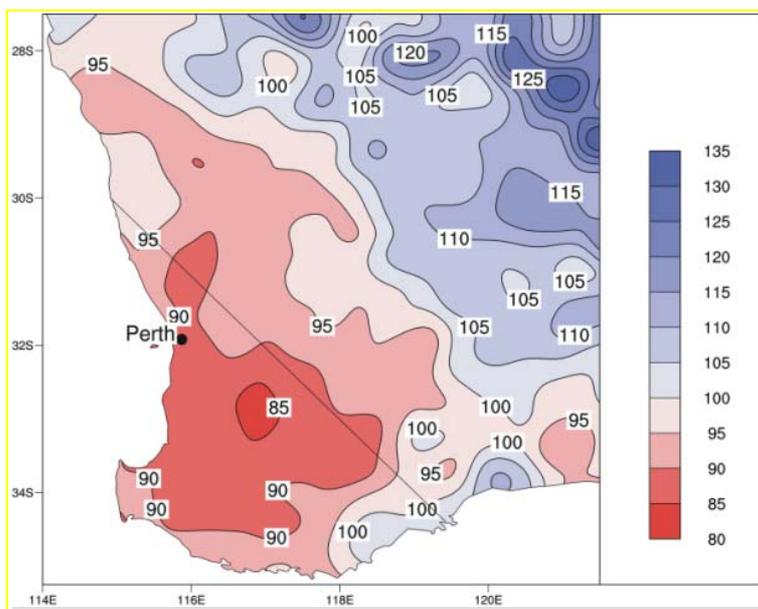


Figure 4. Average May to October rainfall 1976-2001 as a per cent of average May to October rainfall 1925-1975.

Source: Bureau of Meteorology and IOCI.

The run of dry years is unusual when compared with historical records, and also with 1,000 years simulations of Western Australian climate in computer models. However, these dry events are broadly consistent with current climate change projections of rainfall for the region. There are many possible causes for these changes but the underlying drivers are believed to include increased greenhouse gases and the fact that the climate system undergoes natural fluctuations on the scale of several decades (IOCI, August 2005).

In relation to rainfall there was a common view among participants that the break of the season now occurred about two weeks later in the year and that the number of particularly wet years had decreased. One farmer reported that when he moved to a sheep farm in Western Australia in the mid to late 1980s, historical records showed... "*the average rainfall was 21 inches, but since taking up the farm there hasn't been one year when the rainfall reached 21 inches*". In contrast, another farmer's rainfall records at a particular location did not support the drying trend, but showed that growing season rainfall had retained fairly flat trend during the past 40 years. This farmer's records showed an upward trend in yields over the same period because of improved management and some very rough thresholds were discernable. Low yielding years in this area were associated with growing season rainfall of less than 250 millimetres and greater than 325 to 350 millimetres.

Despite such contrasts there was, however, a feeling that winter rainfall was patchier and that the frequency of summer thunderstorms had increased. A number of farmers noted that dams were less full during winter and that summer rainfall fed by the remnants of northern, tropical weather systems now seemed less rare.

There was general consensus that the frequency of extreme rainfall events had increased, particularly storms causing flooding. People could recall a number of relatively recent events where public and private infrastructure had been damaged as a result of floods; for example, floods at Lake Grace in 2005 and at Greenough in 2006. A number of people at coastal locations expressed concern about this trend given rising sea levels and the impact storm surges may have on coastal infrastructure and communities.

The incidence and duration of drought was commonly highlighted as occurring more frequently. Agricultural areas, particularly in the north eastern and south eastern wheatbelt have experienced extensive drought, with Exceptional Circumstances declarations covering various parts of the region having been made every year between 2000 and 2006. This extended dry period has a significant affect on agricultural businesses and in turn adverse impacts for the rural towns that support them. The region is in fact in the grip of its worst drought on record this year, with the region experiencing its driest ever start to winter.

Recent modelling by the Department of Agriculture and Food shows that if drying and warming trends continue as projected, agriculture could change substantially, with cropping becoming an unviable land use over large areas and farm profits in vulnerable eastern and north eastern areas reduced by more than 50 per cent despite profit saving adjustments that can be made (van Gool and Vernon, 2005). This is likely to have major social and economic implications in affected areas and consequential financial implications for Government. By way of example, Exceptional Circumstances declarations during the past five years have had direct business and family support costs of \$78 million, which is compounded by estimated production losses to the State of around \$550 million.

Extended dry periods also have impacts on other business that support agriculture. *The West Australian* (18 June 2006, p. 18) reported the impact the current extended dry spell is having on the fertiliser industry for example. Fertiliser companies anticipate having to carry large quantities of stock through to next year, increasing their storage costs. The same

article highlighted how livestock feed suppliers were struggling to keep up with demand due to extensively dry paddocks throughout the State's agricultural areas. *The West Australian* has also run numerous stories this year outlining the plight of farmers regarding significant crop losses, and that in several areas farmers did not even bother to sow crops.

Other observed changes and impacts

Wind patterns also seem to have changed, with local wind conditions reportedly becoming more erratic (or less predictable). Some participants highlighted activities that could previously be undertaken with confidence on the basis of predictable local winds such as burning and boating. However, local wind predictability appears to have been reduced making these activities difficult and unpleasant. This was noted at coastal locations of Albany and Geraldton, and inland at Katanning and Ravensthorpe.

There was general concern about the impact of climate change on biodiversity. This ranged from effects of damage to vegetation, how climate change may improve conditions for pests and weeds, and increase the incidence of fires, and effects on ecosystem services that various plants and animals provide. People did report damage to vegetation in particular locations but were unsure about the extent to which this was climate related. It would be fair to say that other than the Albany session, biodiversity impacts were not generally reported, except in relation to fire behaviour.

Whilst the water resource and agricultural sectors have already adapted to climate change other sectors seem not to have substantially factored climate change into their planning and operations to date. This is perhaps because the effects so far have not been felt. However, some lifestyle-related sectors, particularly in the area of sport and recreation are beginning to look at climate change as a consideration in future planning, which appears to be based on more recent observations of climate change impacts and growing public awareness. By way of example, the Department of Sport and Recreation included a session on climate change in the program for its annual Active Conference in September this year, which was partly due to its involvement in Phase One of this study.

Future climate change

Following discussion about past climate change, participants were briefed on future projected changes. It was explained that model-based projections for temperature with increasing greenhouse emissions indicate a continued warming trend for most of the planet. CSIRO research shows temperature rises for the south of the State and nearer the coast of 0.1 to 0.65°C each decade from 1990 to 2070 (IOCI, August 2005).

In addition, rainfall projections for the future, suggest that the influence of increasing concentrations of greenhouse gases will become more dominant causing a further decline in rainfall due to higher pressures and fewer storms (IOCI, August 2005). However, there are considerable variations between different models' predictions of the magnitude of the expected decline (IOCI, 2002, p. 19).

The sessions highlighted the great diversity of climate impacts that may need to be managed in the future; from maintaining outdoor recreational facilities in a drier climate to establishing infrastructure that can cope with rising sea levels. With the exception of water resources, the sessions did not reveal many sectoral efforts to assess coping capacity or thresholds in relation to climate change. People expressed the view that with good information and planning they would be able to deal with the future impacts of climate change.

Most people expressed a general sense of needing to learn to live with the impacts of climate change, and that better understanding was essential to allow effective responses. However, whilst adaptation was considered logical when asked about future climate change, few people are yet to genuinely assess and plan adaptation responses. This seems to be largely driven by uncertainty (as opposed to scepticism) about the issues and a lack of information on possible responses. Climate change was seen as a complex, amorphous subject, with people unsure about impacts, and the type of response and level of investment required.

The sessions revealed increasing interest in future projections for climate change, particularly from sectors representing lifestyle, sport and recreation. Almost all sessions had people attend from this broad area. In particular the sector is concerned about the impact of climate change on regional locations, where sport and recreation are integral parts of the social fabric of rural and regional communities. Comments were made that in recent times, town ovals and parklands were suffering as a result of drier conditions and that this trend was expected to continue. This presents particular challenges for local governments, which will need to plan for these impacts when considering future recreation and amenity needs.

This broad sector also raised concerns about future health and safety impacts as a result of sea level rise. Surf life saving organisations anticipate greater coastal usage in the future and that this will increase the burden on their resources. This may be compounded by changes to ocean swells and currents. Sea level rise is potentially a major issue for South West Western Australia, which is experiencing significant population growth at regional coastal centres such as Busselton, Bunbury and Mandurah and where coastal housing developments are booming. A number of people expressed concern about the efficacy of these developments in the face of growing evidence for sea level rise and that this presents a major challenge for local governments and the Government's planning agencies. Industry participants also expressed concern about the impacts of sea level rise on development projects and existing infrastructure such as ports and the need for these to be engineered to withstand more intense storms and storm surges.

Among agricultural participants there were varied responses that seemed to depend largely on locations. At some places they felt they could cope with projected increases in temperature and decreases in rainfall, whilst others in perhaps more marginal areas felt it would not take much change before farming becomes unviable. A common concern amongst farmers was that younger farmers are not well prepared for extreme events as conditions have been reasonably stable in many locations for so long, and technology has allowed increasing productivity. There was also a sense that people were not prepared to live at the extremes of human comfort any longer and that consequently less pleasant climatic conditions could have implications for small communities.

The horticultural industry also expressed concern about the impact of future temperature changes on the quality of fruit and vegetables. Predictions for increased daily minima are a concern for industries which rely on cool mornings and warm days to improve colouration and sugar levels. However, despite predictions for warmer nights, recent observations suggest increased incidence of frosts and cool mornings. This was frequently reported by people during the study. Additionally, a recent article in the *West Australian* (12 June 2006) highlighted how recent cool conditions have been good for fruit quality. However, the same article also described industry concern about declining water supplies, with one grower quoted as saying "*I've never known us to be irrigating in June and my family's been growing citrus for almost 100 years*".

Industry and resource sector participants expressed particular concern about on-going access to water and how issues regarding competing access for water could be resolved. These sectors felt that industries could engineer their way around other climate impacts. They felt that technology would largely overcome climate impacts on workers and infrastructure. However, extreme weather events may pose particular problems for the industry and resources sectors. Extreme weather events require disaster responses which shift skilled labour away from new and on-going industry developments. If the number of extreme events increases this could have an effect on the availability of skilled labour to progress industry projects.

Access to water was probably the single biggest concern people had in relation to future climate change. Farmers expressed concern about on-going capacity to grow crops and water stock, the resources sector is concerned about future access to water and its discharge, tourism and recreation will suffer as a result of reduced water supplies, water dependent biodiversity will be adversely affected as will people through reduced ecosystem services and the importance of potable water for human consumption is not surprisingly a major concern.

Information requirements

The need for more information about climate change emerges as a key issue when discussing the subject with stakeholders. As previously mentioned people accept climate change as a reality but they don't yet fully understand the nature of it or its potential impacts. The consultation sessions suggest a reasonably high level of interest in knowing more about the issue, particularly future predictions, projections and scenarios.

Primary requirements for information that would assist adaptation to climate change were quite similar, with some specific differences reflecting the range of sectors represented at the sessions. The main climate issues people want information about:

- Projections for temperature increases, including the number of extremely hot days (days over 35°C) that are likely.
- Rainfall projections including seasonal shifts.
- Assessment of water cycle impacts as a result of reduced rainfall.
- Predictions of sea level rise; and
- Some indication of the likelihood and timing of extreme events.

People primarily supported a web-based mechanism to receive information, plus a range of other methods. As well as information provision to support planning processes, people felt the issue of climate change generally deserves more attention in the public arena and that awareness raising would be an important activity.

A number of the sessions also raised the need for case studies and scenarios highlighting cross-sectoral issues as a result of climate change impacts. For example, how will a reduction in rainfall affect community water supplies and in turn water dependent industries; or what would happen to a small community if one of its major industries was dramatically affected by climate change. These scenarios would need to include some assessment of likely conflicts and how mutually beneficial responses could be developed.

Indicators for further work

A number of sectors were not well represented at the consultation sessions, including health, local government, planning, fishing and tourism. These sectors need to be better engaged to develop a more complete picture of climate change impacts throughout South West Western Australia. However, these sectors are represented on the Action 5.5 Sub-committee and some information about them has been obtained from other sources outside the consultation sessions for input into Phase One and for planning Phase Two.

Sectors that appear to have particular interest in climate change, based on attendances at the sessions, are:

- primary industries such as agriculture, horticulture and forestry;
- water resources management;
- sport and recreation; and
- industry and resources.

Attendance at southern (Katanning, Ravensthorpe and Albany) sessions was high, and feedback on the outcomes from these sessions was also relatively high. This may suggest that further work would be well supported by community, industry and government organisations in these areas, particularly on the South Coast. Follow up meetings have also been held with stakeholders at Ongerup and Mount Barker on the South Coast as a result of the consultation sessions.

The sessions may also have unearthed some interest among sectors that are becoming aware of a need to deal with climate change. For example, surf life saving is interested in climate change and interest from participants in this area resulted in follow up interest from people involved in coastal health issues.

In relation to Phase Two, the sessions suggest high level community interest in some key areas. On-going water shortage is a critical issue and the potential this has for creating conflicts needs to be assessed. A number of industry users emerged during the study including agriculture, horticulture, forestry and mining all of which will be competing with water for public supply, amenity value and for ecological requirements.

The study has also revealed growing community and Government concern about the impacts of sea level rise. These concerns appear to be growing in the face of significant development of coastal locations, with areas such as Mandurah, Bunbury, Busselton and Cockburn targeted for significant future growth. The study highlights that the State's planning agencies and local governments in particular need to address this issue in the context of climate change. Rising sea level also has potentially significant implications for the tourism industry, which is heavily reliant on natural coastal assets and infrastructure.

Through the study it has become apparent that the health, sport and recreation, and tourism sectors have similar concerns in relation to future climate change. Each sector is concerned about the impact of increasing temperatures on human comfort and well being, and the threat of declining water quality and supply similarly has implications for human use, amenity and well being. An assessment of these variables between the sectors may well yield integrated strategies and mutually beneficial responses.

The study has also highlighted a general lack of understanding about the impacts of climate change on the State's biodiversity. This is not limited to South West Western Australia with climate change impacts on biodiversity worldwide difficult to discern. However, given the region is one of the world's 25 biodiversity hotspots and contains five of Australia's 15 biodiversity hotspots, it would appear an assessment of climate change impacts is needed.

Recommendations

To determine future vulnerability and adaptation needs to climate change in Phase Two will require cross sectoral, integrated assessment. It will require a range of methodologies to work with the range of sectors and interests throughout South West Western Australia. Based on the five models of best practice in extension (Coutts and Roberts, 2003), methods to increase adaptation to climate change are:

1. Provide facilitators for interested groups to develop strategies for adapting to climate change, defining their goals and learning needs and supporting them to achieve these (group facilitation/empowerment model).
2. Continue strong industry-government partnerships to develop specific techniques for prediction, adaptation, or decision support systems and use mass communication, on-site visits, field days, etc. to ensure the broader target community is also informed (technological development model).
3. Organise specifically-designed training and workshops for interested sectors/groups based on stakeholder needs and the latest research and information (programmed learning model).
4. Establish a website, among other forms of communication and public awareness raising, to provide information to support planning and decision making and increase the awareness of climate change in the broader community (information access model).
5. Support ongoing development of a network of consultants to assist the different sectors in their adaptation to climate change (personalised consultant model).

There is also a need to:

- provide evidence of the ways in which climate change is impacting on each sector, initially through the issue of water shortages;
- ensure the specific information needs identified in the community consultation are addressed:
 - prediction for temperature increases, including number of extremely hot days;
 - rainfall predictions including seasonal shifts;
 - assessment of water cycle impacts as a result of reduced rainfall;
 - predictions of sea level rise;
 - some indication of the likelihood and timing of extreme events; and
 - scenarios based on different sectors.

These messages are more likely to lead to action if they are personalised, visual where possible, emphasise emotions (e.g. hope, even fear), repeated from different sources, solution-based and adaptation-based. It will be important to pre-test these messages to establish their effectiveness and to conduct ongoing evaluation of their impact.

For the broader community, key messages will also include clear evidence that climate change is occurring as there will be a degree of scepticism in the broader community.

Additional work also needs to:

- identify any external obstacles to adaptation for different stakeholder groups and, where possible, remove these obstacles; and
- ensure better engagement of the health, local government, planning, fishing and tourism sectors, partly to gain more information on the impacts of climate change on these sectors but also to gauge the level of adaptation.

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APPENDIX I – Notes from consultation sessions

Katanning consultation, 8 March

Context

Katanning is 277 kilometres south east of Perth and 311 metres above sea level. It is one of the major centres in Western Australia's wheatbelt with a population of about 5,000. The predominant land use is agriculture, particular sheep and cropping.

Eight people attended the session at Katanning, all of whom were involved in the agricultural industry.

Observations of perceived climate change since the 1970s

Winds

The Albany Doctor is weaker and very irregular. Burning could be planned with great confidence in the 1980s around the arrival of the Albany Doctor but now you cannot rely on the strength of the Doctor or when it will arrive.

Stronger wind and heat have increased evaporation rates during the past 10 years.

Extreme events

Frosts seem worse. It used to be that frosts occurred later in the season but now they occur in mid-winter. They also seem to occur earlier in the night (10:30 p.m.), which hasn't happened since the 1970s.

Sun intensity

Intensity of the sun on your skin appears greater. Sheep are more likely to get sun-burnt now than in the past. It doesn't necessarily feel hotter just different. The sun has more bite to it.

Rainfall and water resources

Seem to get fewer cold fronts and more rainfall now comes from the remnants of tropical events in the north. There appear to be more thunderstorm events during January and February.

Winter seems to be getting drier. There are fewer heavy rainfall events to fill dams during winter and increased evaporation.

Good rain in April means good crops but there has been less rain in April recently.

Local farm rainfall records show that rainfall in the 1980s did not decrease necessarily but it did appear to be drier. Perhaps this is because rainfall was patchy and irregular rather than occurring consistently through significant frontal events.

More farmers have to cart water, and more dams and roaded catchments are being built in the area to harvest water. Drains installed a decade or more ago maybe becoming redundant as they haven't flowed much in recent years.

Many younger farmers are questioning the value of contour banks, which were established 15 or 20 years ago to control run off and prevent erosion. However, since that time there has been much lighter rainfall until this year when they can see how effective these drains are and in fact why they were needed in the first place.

More attention needs to be paid to catchments and dams. Well maintained and well constructed roaded catchments are essential. It was noted that because of land use change improvements (no till, increased stubble retention, reduced ploughing) more water was soaking in and consequently there was far less run off.

Other

Agriculture has adapted well to drier conditions through developing new plant varieties and farming practices. In particular through no till farming and improved surface water management. These practices weren't necessarily adopted in response to climate change but to deal with erosion and weed control.

The cropping season appears to be getting later. Oats were sown by April and wheat by May but now it is not uncommon to sow up to June.

There has been a marked increase in African black beetles, which are damaging facilities such as the bowling green and consequently require more frequent spraying. Wasps appear not to be hatching and native birds such as plovers, larks and quail are decreasing. However, some parrots are increasing to plague proportions and don't appear to have any natural predators. Furthermore, flooded gums and white gums appear stressed and in poor shape, making them more susceptible to insect attacks.

Comments on future climate change and its implications

Agriculture

There is general uncertainty about climate data and what it means. Many people haven't yet thought about how they will adapt to future climate change. If it gets too dry people may consider selling and moving to areas with more reliable rainfall.

Most farms are increasing stock number, which means they will need more water. Farmers will need to adopt better water harvesting techniques.

People are not willing to live at the extremes any more. Fewer of the younger generation will 'tough it out' during extended dry periods and opt for coastal lifestyles. As a result there will be an increasing need for good farm managers who may run farms from a remote office. This may lead to fly-in fly-out farming on bigger farming operations.

Being able to source suitable labour is a big issue now, which may get worse with the impacts of climate change.

The extent to which people will stay in agriculture will depend on its capacity to adapt and remain profitable, and also provide resources to meet peoples' lifestyle needs.

Future information needs to assist with adaptation to climate change

Information needs to be practical and relevant to farming and rural lifestyles.

Farmers will need to understand how much and when water will be available.

What will be the impacts of consecutive dry seasons on the rising watertable and consequent salinity?

Information will be needed on rainfall patterns. It appears that rainfall levels overall haven't changed but the patterns of when it falls have.

Ravensthorpe consultation, 9 March

Context

The Shire of Ravensthorpe is home to about 1,400 people. The local economy is based on grains and sheep, with mining also becoming a major contributor. Tourism also plays an important role particularly with visitation to the coastal locations and national parks.

Seven people attended representing primarily the agricultural sector, with participants also from regional development and forestry backgrounds. Most of the participants had been in the area for less than 30 years, although some had lived there for much of this time.

The Ravensthorpe session also included participants from Esperance.

Observations of perceived climate change since the 1970s

Winds

During the 1970s and 1980s there were significant wind events and consequently severe erosion. However, these impacts are now rarely seen due to no till farming and lower stocking rates.

Wind management has changed considerably since the 1900s, with farmers now using windbreaks and no till farming practices. There is also better grazing management and over-grazing is uncommon.

Extreme events

There was a very hot event 15 years ago in 1991, which scorched pinus radiata trees down the north west side, through exposure to the afternoon sun.

It is hard to find healthy examples of chittick and banksias on roadsides as they have aged and also become isolated.

A hillside of native plants died in approximately 2003/04, after an extended drought.

Salmon Gums no longer has extreme droughts as it did in the 1960s, although this could be masked by changed farming management practices.

There was frost in October and November 2005 at Lake King and even staggered planting did not offset the risk

A six month dry period had never been seen before.

There was an extremely dry event 18 months ago extending for a six month period.

Sun intensity

Sun has worse bite in Esperance than elsewhere.

Marine

You cannot drive on beaches this summer due to the tidal influence leaving beaches softer, and consequently there appear to be more tourists getting bogged on the beaches.

There is no strong summer pattern to rebuild beaches after winter erosion.

Temperature

Esperance climate is always variable, although trend in climate changes are not observed within dominant variability. Farmers have had to manage this variability.

It has been very hot and dry during the past couple of years and some hilltops are dying in the Ravensthorpe area. An older couple noticed that when Bedford was cleared it led to changing weather patterns.

Since 1965 in Esperance there have been later summers, which have remained hotter for longer. Late hot summers in December harvest have changed during the past 12 years to milder temperatures and higher humidity. The hottest months in Esperance are February and March.

Jerdacuttup is much drier and Condingup is much wetter than they used to be. There are signs of changing weather.

Rainfall and water resources

There is now better water management. Farmers have dealt with decreasing water supplies through management such as no-till.

It has always rained during the harvest season at Esperance. Harvests appear to be moister with farmers now using grain drying techniques to avoid staining. This requires more time management and new equipment.

Other

There are now more fires, although many are being caused by people. However, when wildfires escape they become much larger and more difficult to control due to bigger fuel loads.

The main drivers for change in farming practices are not changes in weather but rather economic drivers such as increasing costs of production.

Farmers put crops in early to make use of first rains and optimise planting to maximise yields but this exposes the increased risk of a single event loss, such as frost. There is increased risk of a frost event at flowering as a result. Can manage risk of sowing all wheat at once by grazing wheat.

There is roughly the same number of good and bad years. Farmers generally sow each year irrespective of weather.

Comments on future climate change and its implications

Agriculture

Farming is a risky business. There might be a need to look at other opportunities.

Climate change is not a factor in plant establishment.

The breakeven point for several crops is at about 1.6 tons/hectare needing 150 millimetres of rainfall. The agricultural sector is getting toward the end of possible varieties that have low water requirements and can tolerate high temperatures. The breakeven point could move to 200 millimetres and if rainfall decreases by 20 per cent then there will be no profits.

More summer rain increases the incidence of sheep fly strike.

Many of the issues farmers react to are not related to climate change, but more often market failure and the cost price squeeze.

Forestry

If it becomes drier this has negative implication for farm forestry. However, if the South Coast experiences increased summer rains, this could be better for the forestry industry.

The rainfall threshold for bluegums is 700 millimetres at Albany, but Integrated Tree Cropping use 550 millimetres in Esperance as its preferred boundary, which is right on the edge of the range for successful establishment, growth and yields.

People and industries have committed to twelve year rotations and hundreds of millions of dollars has been invested.

Plantations and tree belts seem to increase cloudiness and/or light misty rain over the trees.

Groundwater resources are an issue in relation to forestry. Plantations increase demand on groundwater and planting near groundwater resources decreases supply. It will be necessary to improve on-farm water management.

General

Higher temperatures will affect housing efficiency and cause adverse social impacts.

Future information needs to assist with adaptation to climate change

Information needs that were considered to be useful include:

- the number of drought days;
- extreme heat events to make assessments about their impact on crops, stock, plantations and biodiversity; and
- sea level rise.

A comment was also made that further research was needed on the relationship between plantation establishment and climate impacts.

Sources of information to assist adaptation to climate change

Sources of information considered to be most useful in assisting people make decisions about and adapt to climate change include:

- a website such as the Bureau of Meteorology site;
- the ABC's Country Hour;
- local region information notes from State agencies such as the Department of Agriculture; and
- products that could be incorporated into business plans.

A general comment was made that multiple sources of information would be needed to assist people in adapting to climate change.

Who else would be able to provide useful insights on climate change

- Industry leaders
- Agronomists
- Landmark
- Elders
- Bank managers
- Anybody involved in extension
- Local government
- Lobbyists, WA Farmers and LPGA
- CBH

Albany consultation, 10 March

Context

Albany and adjacent areas on the south coast experienced relatively small changes in average annual temperature and rainfall between 1950 and 2005. Even the 1970s 'step change' in rainfall recorded for much of the south west region had little impact on the Albany region, with some areas apparently experiencing increased May to July rainfall after the 'step change'.

Among the 15 workshop participants, many had relatively short experience of the south coast. However, about one third had lived in Albany since childhood (up to 40 years) or had clear childhood memories of Albany's weather. More recent arrivals provided comments based on their experience of the region's weather and on impacts that appear to have been caused by changes to weather.

Observations of perceived climate change since the 1970s

Winds

Albany was known for strong winds and heavy rain events in the 1960s, which are no longer frequent.

The 'Albany Doctor', an onshore afternoon wind, had decreased in strength.

The strength of summer (November/December) easterly winds has decreased.

Many more galahs, but fewer varieties of parrots are found in Albany, possibly because of increased rain inland – is this an event over an extended period of just this past year which has had a lot of rain?

Humidity

Summers were drier and hotter, and now seem more humid.

Mildew incidence in vineyards has changed, indicating a change to ambient humidity – change up or down? More or less humidity – check with Mt Barker DAFWA office?

Extreme events

The Shire of Kent recently experienced flooding from cyclone events which were unusual, and not seen during past 40 years. The impacts of the cyclones could have been exacerbated by native vegetation clearing in the catchment.

The number of extreme (1:50, 1:100; 1:200 year) events seems to have increased. For instance, between 30 March and 2 April 2005, 200 to 250 millimetres of rain fell over the entire Kalgan catchment. Because a high proportion of the lower Kalgan catchment is now in blue gum plantations the relative impact from the middle and upper Kalgan was reportedly larger, which was confirmed in an aerial survey (Ferdowsian, Rogerson and Master). This followed a drier winter and a dry spring and its occurrence at the end of March meant paddocks of annual pasture and annual crop stubbles were at their lowest in ground cover terms (reportedly > 1:200 year event – Beard *et al.*). The four day flow out the Kalgan was 48 GL (more than average flow for a whole year) and is estimated to have transported 48,000 tonnes of sediment into Oyster Harbour and the southern ocean. This was in contrast to an episodic event in the Fitzgerald catchment (> 1:100 in the Sussetta sub catchment) which occurred in January 2006. This extreme rainfall event (cyclonic aftermath) of up to 220 millimetres caused much less damage in the paddocks because of greater cover (stubbles and pastures) following a good annual growing season in 2005 and soft spring. There were also good buffer areas of perennial pastures. Major damage in this instance was to shire roads and major highway infrastructure (incl. Fitzgerald Bridge) (refer Austin Rogerson and Ben Whitfield). Much of the catchment had good vegetation cover as a result of the good 2005 growing season rains so there was little damage to paddocks but there was considerable damage to infrastructure – What has been frequency of extreme (e.g. high rainfall) events? – check with MRWA re. changes to road standards (e.g. culverts) and impacts on roads from extreme events?

Sun intensity

It appears easier to get sun burnt than it was.

Temperatures

People have said that summers (during December particularly) were cooler 50 years ago.

Small businesses have reported that people weren't buying heaters, air conditioners and woollen doonas. Cool in early winter.

Rainfall and water resources

Several creeks that used to flow year round are now dry during summer and autumn.

Rural homes previously had small tanks that satisfied the needs of relatively larger families, but larger tanks now often go dry. Water deliveries are increasing, and there is more investment in stand tanks and water infrastructure. But today homes use many more water consuming machines, e.g. dishwashers, etc.

There is generally increasing concern about the adequacy of water supplies.

The Karris in the Porongorup appear stressed. Even after good rains in 2005 the trees have not recovered and ground water resources remain limited – check impact of increased plantations on groundwater?

Land use changes are reducing leakage and runoff and affecting catchment yield < 600 mm in particular.

A potential conflict in water allocation looms as there is poor understanding where and how much water is available. Some studies were undertaken in 1992 and 1994.

Other

There has been a significant (threefold) increase in severe fire warnings.

PhD student, Peter Speldewinde is studying the impacts of climate change and health.

Tambellup – comment about increased health problems for 45-60 age groups.

Comments on future climate change and its implications

Forestry

With the potential for bigger fires generated from warmer temperatures and lower rainfall, plantations will require greater protection to maintain all the values they provide.

Biodiversity

If reduced rainfall results in soil moisture conditions that are below survival thresholds for particular species, then direct impacts to ecosystem structure, functioning and services are likely. Species could be lost to an area or become extinct in the wild.

Increased temperature and decreased rain could change vegetation structure and increase fire hazards towards both bigger and more frequent fires.

Increased summer rainfall and higher temperatures during wet months could increase the incidence and activity of dieback (*P. cinnamomi*). This could combine with fire to generate much greater impacts on species presence and ecosystem functioning.

Responses could include:

- Increase connectivity, increase scale of reserves and buffers.
- Incorporate climate change, including secondary impacts via altered fire, disease, pest and other regimes, into planning and policy. For example, the South Coast plan for threatened species.
- Better fire management as part of adaptive management. New earth monitoring, communication and fire fighting technologies combined with new fire management practices are generating more effective fire management options enabling fires to be stopped sooner.
- In extraordinary circumstances water could be provided to overcome rainfall loss. However, there would be a limit to the number of such prospective 'ecological museums', with watering being an unrealistic response except in specific instances. Soil moisture monitoring will be important.
- At the site level it is possible to collect seeds to re-establish some species.

Health

There will likely be impacts on health as a result of reduced human comfort and threats from proliferation of insect pests.

Children coming in at 27°C (Albany) and 35°C (Tambellup).

Water

Water supplies are already restricted and a desalination plant is being considered.

Local government

Currently there is a lack of access to data, and lack of information hinders good planning and development.

Impacts on water supply are real issues that could worsen with climate change.

Planning needs to focus on minimising development 'footprints'.

Rises in sea level will have significant impacts on coastal planning, management and development.

But local Government authorities need to be properly resourced to undertake these responsibilities.

Sport and recreation

Grassed playing areas are already affected by compaction and lack of water from lower rainfall.

Increased temperatures would generate demands that outdoor active recreation should not take place during peak daylight hours.

Less sport involvement could have broader health impacts.

Responses could include:

- Moving to indoor facilities, changing times, and a shift from inland to coastal areas.
- There is already pressure for artificial turf and water recycling.

General

More extreme events are likely and responses need to be better. Barriers to coordination causing problems with response.

Responses:

- Decision making arrangements need to recognise relevant geographic areas such as catchments, rather than LGA's on development.
- More responsive and smarter bureaucracies are required.
- Respond through changing working hours as adaptive response.

Future information needs to assist with adaptation to climate change

Information needs that were considered to be useful include:

- Access to compatible sets of information, GIS.
- Expand IOCI study area to SCRIPT eastern boundary.
- Length of dry spells, shifts in seasonality.
- Need map for summer rainfall similar to IOCI map of early winter rainfall changes.
- Need assessment of coastal vulnerability to sea level rise

- Minimum temperatures – large impact when it doesn't cool down, sea breeze by 3 p.m. – housing design, better insulation.
- Impacts on groundwater, rainfall frequency, evaporation changes.
- Humidity and cloudy days – horticulture (disease impact).
- Lightning strike frequency.

Who else would be able to provide useful insights on climate change

- Horticulture and viticulture industries.
- Bowling clubs.
- Main Roads Department.
- Development Commissions.
- Fishing groups.
- Department for Planning and Infrastructure.
- Chamber of Commerce.
- Water Corporation.
- Ratepayers Association.
- Traditional landowners.
- Outreach, Historical society.
- Naomi Arrowsmith – doing water planning, south coast.
- Department of Agriculture – especially hydrologists (Ferdowsian, Lillicrap, Simons & Ryder), Surface water engineering specialists (Rogerson, Alderman, Lisson & Whitfield), Nutrient specialist (Weaver), Soils specialists (Nicholas, Overheu) and FSP and agronomists (Master, Buttler, Hill, and Mctaggart).

Perth consultation, 14 March

Context

Perth is Western Australia's capital city, with a population of about 1,400,000. It is considered to be the most isolated city in the world. Perth has experienced the impacts of climate change, particularly decreased rainfall with a 10 per cent reduction in rainfall resulting in a 50 per cent reduction in streamflow causing significant water shortages.

The three participants at the Perth session were from industry representative organisations. Written input was also obtained from an additional participant with expertise in water resource management following the session. Having said that issues related to water resource management and availability figured heavily in comments made by all the participants.

Observations and comments provided at this session differed somewhat to other sessions and focused heavily on sectoral issues, particularly the mining and resources sector. In addition, there was a tendency to focus on current and future impacts of climate change and how industry will adapt to these changes, rather than on past impacts.

Observations of perceived climate change

Current actions by the resources sector in addressing impacts of climate change are driven by economics and focus heavily on greenhouse gas abatement rather than concerns necessarily about climate change more broadly.

Several companies are already developing elaborate monitoring and reporting systems to support greenhouse gas abatement. In addition, some have developed abatement cost curves.

However, industry bodies strongly recognise the need to be proactive and deal with the repercussions of climate change. There is also recognition within industry that there is general community acceptance of climate change and therefore it is worth investing in. Most industries have moved well beyond debating whether or not climate change is a reality and are dealing with it. Many companies are particularly interested in pursuing technological adaptations to climate change.

However, there are still some sectors of the community and government that are not convinced by the scientific arguments that support climate change.

The availability of water is a major concern and industry believes issues related to water resources must be tackled at a regional level. Future approvals processes are of significant concern to mining companies in terms of water availability, and issues related to discharge.

Industry bodies are also beginning to consider the impacts of climate change on infrastructure that supports their operations. For example, there have been some investigations into impact of road-trains on roads during higher temperatures. However, serious consideration is not being given to increased risk of events such as cyclones and sea level rise. Generally speaking companies do not yet feel they have sufficient technical information to allow them to factor climate change parameters into infrastructure design and maintenance.

The spacing and frequency of rain bearing fronts appears to have changed, as well as the winter break of season becoming later. There also appears to be more summer thunderstorm activity and longer periods of higher humidity in summer.

Water resources in Perth, particularly public water resources have been affected dramatically. Effective rainfall (precipitation appearing as run-off or recharge) has declined to about 35 per cent of the 100-year running mean. These changes have driven the need to invest hundreds-of-millions-of-dollars to ensure water security for people connected to integrated water supply schemes.

The participants highlighted a number of concerns that industry bodies have in relation to policy and decision making, and planning for climate change. These concerns include:

- Disparity between State and Australian Government approaches to dealing with the impacts of climate change. For example, the introduction of different emissions accounting methods in different States, which companies with operations throughout Australia then need to accommodate.
- On-going access to water.
- Carbon trading may go offshore.
- Planners are not factoring sea level rise into planning for new infrastructure developments. Planners are still talking about 'if' sea level rise occurs but it is already happening.
- On-going access to infrastructure that may be affected by climate change and increasing costs associated with maintenance.
- Smaller companies working on smaller projects lack resources to properly plan for future scenarios.
- Developers with two-year planning/development horizon.

In relation to water supplies climate change has had significant impacts already, including:

- massive increase in capital expenditure to secure water supplies and promotion of a 'Security through Diversity' strategy in response to water shortage in the face of increasing demand;
- adoption of sustainability as the key driver of business, and systematically integrating it into business systems, as well as education and awareness programs; and
- complete re-evaluation of the business, including closure of the water cycle to consider drain water and wastewater as resource, instead of waste streams.

Comments on future climate change and its implications

Infrastructure will be seriously affected by the impacts of sea level rise. This coupled with other climate change impacts will cause increased damage and the need to for repairs to infrastructure that supports industry.

This will cause a lack of capacity to begin new projects if skilled workers and other resources are being diverted toward repairs and on-going maintenance. There is already considered to be a shortage of skilled labour and a diversion of resources will exacerbate this shortage.

Increasing temperatures will have particular implications for the chemical processing and concreting industries.

Industry has a general belief that it will be able to engineer its way around the impacts of climate change when they occur. The life of major projects is around 30 to 40 years after which new infrastructure will be built that can cope with climate changes.

Decreasing water supplies will result in changes to styles of water use such as garden form and watering regimes, and changes to patterns and costs of energy use.

Has the electricity delivery system got the capacity to deal with the impacts of climate change (changing temperatures, higher demand, increased pole-top fires)?

Future information needs to assist with adaptation to climate change

Ensure that policy changes match the needs of industry rather than trying to apply a 'one-size fits all approach'.

It would be useful to develop scenarios that highlight the impacts of increased competition for resources that will occur as a result of climate change, particularly competition for water.

How insurance and superannuation companies are factoring climate change impacts into their planning and premiums.

Future information needs include:

- prediction of frequency of temperature extremes;
- frequency of time spent outside human comfort zones (temperature, humidity and moisture levels); and
- evidence (for sceptics) that climate change impacts will occur;
- Government and private natural resource managers and land users need to be more involved. A major threat of climate change is accelerated extinction of biodiversity. The connecting of isolated fragments of remnant vegetation is a priority involving rural land users and should be supported by all levels of Government.

Bunbury consultation, 16 March

Context

Bunbury is approximately 180 kilometres south of Perth with a population slightly greater than 30,000. It has experienced significant growth in recent times, with increasing development pressure on coastal areas. This is significant given that sea level rise is predicted to have a significant erosion impact on the coastal areas between Mandurah and Bunbury during the next century.

Seven people attended the session and Bunbury, with a good spread of experience in terms of time spent living in the area. There was also a broad range of interests represented. Issues in relation to water availability and quality dominated much of the discussion.

Observations of perceived climate change since the 1970s

Extreme events

There were floods in 1964 and 1974, but none since.

Marine

There has been an increase in rips, changes to the swell, and as a result an increase in coastal erosion. Artificial reefs are not working to off-set these erosion problems.

Swimming on beach in September and October.

There has been a rise in the watertable near coastal areas.

There appear to be fewer crabs in the estuary.

Temperature

There seems to be more hot days in November than before. Summer appears to be lasting longer (so much so you can now play golf until June).

Rainfall and water resources

Soils stay wetter as a result of more intense rainfall events. This leads to an increased need for drainage. It also causes infrastructure impacts such as damage to public pools.

There are now extended dry periods and water restrictions, which has an impact on sports facilities.

There have not been any really wet winters for 30 years. This has seen reduced waterlogging in certain agricultural areas, which has led to improvements in pasture growth. Additionally saline valley floors are showing a reduced rate of ground water rise and as a result a reduced risk of salinity. However, this is leading to reduced experience in management of waterlogging, such as recovery of pastures and dealing with bogs.

There is reduced water quality and availability at East Manjimup. During the drought years of 2000/01 reduced runoff saw a salt build up in dams with insufficient runoff to flush them, causing reduced yields as a result of irrigating using salty water.

Consumption demand for potable water has remained static, although there was a sharp rise in 2005, where household water supply increased by 12 per cent above average (per residential household unit). This is the first real rise in 20 years.

Other

The seasons appear to have shifted at Bunbury. Easter was previously the break of season now it's later in the year.

Comments on future climate change and its implications

Horticulture

There will be a range of impacts on fruit growing as a result of increased temperatures and changes to seasonal aspects of climate such as elevated minimum temperatures. Various aspects of fruit growing have very particular temperature thresholds such as colouration and productivity. Research into new varieties may need to consider additional low chill varieties if the chilling time is reduced.

Sport and recreation

Reduced ability to maintain sports playing surfaces may see greater shift to indoor venues and evening schedules of events. This would also increase demand for infrastructure and energy.

Outdoor recreation is very popular in Australia, which could be affected by reduced areas of bushland and parkland.

Coastal usage will expand, with people seeking access to a greater number of beaches. This will increase the burden on surf life saving resources in the form of clubs, utilisation of risk management expertise, and education and training.

Resources sector

Water is crucial for the mining, minerals processing and energy industries. These industries represent high-value returns on water used. They also generally require less than potable water, and implement high levels of water recycling. A secure water supply is vital for the viability and future growth of the resources sector.

Future information needs to assist with adaptation to climate change

Consideration will need to be given to an assessment of the impacts of climate change on the total water cycle. This includes factors such as:

- reduced recharge;
- reduced return to ocean;
- streamflow;
- water dependent biodiversity impacts; and
- increasing competition for access to resources.

The horticultural industry would require a strategic document that includes identification of threats and opportunities, which can be used as basis for planning and decision making in areas such as research and development needs, and land use planning for agricultural precincts and future agricultural demand for water.

Updates highlighting the linkage between global and South West impacts would be useful.

There will need to be greater education and awareness about the impacts of increasing UV.

Changes to nearshore morphology on sandy beaches will need to be considered.

Demographic information will be needed on any population shifts, for example to coastal areas. This will assist planning for organisations such as Surf Life Saving WA.

Improved educational resources for schools and the general public to assist them to better prepare for climate change.

The development of simple indexes that can be included as part of news and weather broadcasts such as those currently used to highlight UV, temperature, fire, and water-use.

Planning information is needed for schools that would enable them to make decisions about hours of operation, and use and design of ovals and buildings.

Policies are needed to encourage land management change in agricultural areas, particularly in marginal areas where the impacts of climate change may make agriculture uneconomic. Current exceptional circumstances and drought relief payments could be applied in different ways to support farmers in marginal areas to deliver ecosystems services. National policy on carbon trading could support additional revenue streams for farmers (non-government and non-taxpayer sourced funding) on marginal areas for carbon biosequestration.

An assessment of biodiversity impacts and ecosystem change is needed, and the broader public needs to better understand the value of biodiversity.

Case studies on flow-on effects as a result of the changes to particular sectors of the community that are driven by climate change. For example the impacts in the Manjimup community resulting from a shift from forestry to horticulture-based industries.

Geraldton consultation, 21 March

Context

Geraldton is located approximately 450 kilometres north of Perth and has a population of about 30,000. It is the commercial hub of the State's Midwest and as a port city it supports the region's fishing, manufacturing, construction, agriculture and tourism industries. Geraldton is renowned world-wide for the quality rock lobster fishing off our coast and is often referred to as the world leader in this area, a result of the pristine waters along the Batavia Coast.

Three people participated at Geraldton. One participant had been in the area for a little more than 10 years, with the other two being relative new-comers. However, they were able to provide useful anecdotes from other long term residents and suggested several people who would be able to offer further observations of past climate change. These people were followed up and their input is also recorded in the report.

Observations of perceived climate change since the 1970s

Winds

There are no longer consistent high winds around Christmas. Winds seem to come later.

There used to be a mid-morning window of relative calm between an easterly breeze and the wind switching to a southerly each day. Now the wind switches very quickly. Marine tourism operators and fishermen have noticed that the southerly is more pronounced and that you can't head out to sea with an easterly behind you as often any more.

Extreme events

Geraldton experienced two one-in-ten-year storm events last year.

Marine

Winds are reportedly affecting the Leeuwin Current and the ocean is warmer. Tropical fish species are being found much further south than would normally be expected.

Temperature

There appears to be a slow lead up to summer, which then appears to last longer into next year. November and December appear to be cooler.

Rainfall and water resources

Dams seemed to always overflow in the 1970s but they don't any more.

Algal blooms are increasing in the Chapman River as a result of increasing temperatures and decreased flushing.

Other

Mosquito-borne diseases may be spreading further south. The City of Geraldton has increased spraying for mosquitoes in certain areas.

Comments on future climate change and its implications

Agriculture

Limitations to water availability may increase a trend toward mulching and composting in agriculture and horticulture.

Biodiversity

Increasing temperatures will result in coral bleaching, which has consequences for biodiversity, fishing and tourism.

Increasing temperature can affect groundwater dependent organisms that assist in keeping water clean.

Sea level rise will affect the Abrolhos Islands by reducing bird habitat and increasing damage to coral reefs.

Water resources

Less rainfall and drier landscapes will reduce infiltration and therefore groundwater resources. Also drier landscapes become hydrophobic, which increases surface water run-off and erosion.

Waste water treatment plants could see increased algal activity requiring greater management. Additionally, increased blue-green algae may mean that waste water would not be available for re-use. There would be a greater need to disinfect drinking water, which would increase the cost of water.

Shipping

Increased ocean temperatures may provide conditions that are suitable for pest species to survive that are released through ballast water.

Future information needs to assist with adaptation to climate change

Need temperature and evaporation rates for water resource management.

Number of days above particular temperatures.

Need to know when storm events will occur that bring excess rainfall so preparations can be made to make use of surplus water.

The best ways to obtain information would be via a website and through e-mail alerts about local conditions.

Appendix II – Representation at consultation sessions

Katanning

- Department of Agriculture and Food, WA
- WA Farmers
- Local farmers

Ravensthorpe

- Goldfields-Esperance Development Commission
- Department of Agriculture and Food, WA
- South East Forest Foundation
- South Coast Regional Initiative Planning Team
- RAIN
- Local biodiversity consultant

Albany

- South Coast Regional Initiative Planning Team
- Department of Environment and Conservation
- City of Albany
- Great Southern Area Consultative Committee
- Timber 2020
- Department of Agriculture and Food, WA
- Green Skills
- Greening Western Australia
- Department of Consumer and Employment Protection
- Department of Sport and Recreation
- Department of Environment
- ICS Group

Perth

- Chamber of Commerce and Industry
- Chamber of Minerals and Energy
- Water Corporation
- Ernst and Young

Bunbury

- Chamber of Minerals and Energy
- Bunbury Surf Life Saving
- Department of Agriculture and Food, WA
- Department of Sport and Recreation
- Australian Fruit Growers Association
- Aqwest

Geraldton

- City of Geraldton
- Water Corporation
- Geraldton-Greenough Regional Council

APPENDIX III – Consultation questions

Past climate change

1. ***How do you think have weather conditions have changed during the past 30-odd years?***
 - Did you notice unusual or abnormal weather conditions; if so when and why were they abnormal?
 - Were there any specific events that alerted you to the different weather conditions?
 - Do weather patterns appear to have stabilised?
 - Did media/conferences or meetings impact on your awareness?

Future climate change

2. ***Predictions are that it is going to become hotter and dryer in the South West***
 - What will this mean for:
 - you;
 - your family; and/or
 - your business/responsibilities/organisation?
3. ***How do you think you are going to respond to these changes?***
4. ***What information do you think you will need to help you respond?***
 - Information required and when.
 - Information delivery mode (Internet, publications, seminars).
 - Would you like to be involved in an inter-active form of information sourcing?
 - What is the most appropriate way for you to obtain this information?
5. ***Who else do you think should be involved in this project?***

Thank you for your time. Please post form to: Luke Morgan, Department of Agriculture and Food, Western Australia, South Western Highway, BUNBURY WA 6230; or fax to (08) 9780 6229.