Climate Change Science and Knowledge Plan

Cross-sectoral Consultation Workshops
Summary Report

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Contents

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We would like to thank the industry stakeholders who attended the five sector based workshops and to those stakeholders who also participated in interviews prior to the workshops to inform their design and delivery.

1 Introduction

The Department for Environment and Water is developing a Climate Change Science and Knowledge Plan, which will help guide future investment in the science and information needed by the public and private sector in South Australia to build a more climate resilient community, economy and environment.

This work follows from previous investment in building climate resilience in South Australia, such as through the development of regional climate change adaptation plans and the development of the SA Climate Ready climate projections, which are among the most comprehensive of any projections for an Australian State.

Seed Consulting Services was engaged to design and deliver a workshop focused engagement process to inform development of the Plan. Workshops were held with representatives of the following sectors:

- Emergency management;
- Health;
- Infrastructure;
- Primary production; and
- Sustainable landscapes.

It is recognised that each sector has already investigated how climate change will have an impact on how it functions, albeit to varying degrees. In this context, the focus of the workshops was to identify the types of science and information needed to inform priority decisions for each sector. Based on this aim, a consistent structure was followed for each workshop which involved:

- identification of key areas of decision making;
- identification of information needs for each area of decision making;
- characterisation of user needs as being:
    - no awareness of issue;
    - lack of quality information;
    - hidden information;
    - untailored information;
    - too much information; and
- preliminary prioritisation of information needs.

In addition to focusing the workshop discussions on information needs for current and future decision making, the workshops were also conducted noting that some sector decisions have lifetimes that are many decades long and hence require specific consideration of climate change over the longer term. This builds on the work of Stafford Smith et al. (2011), which describes decision lifetimes as the sum of lead time (the time from first consideration to execution) and consequence time (the time period over which the consequences of the decision emerge).

This report provides a summary of the feedback received at the five workshops. Not all issues raised at the workshops are discussed; the feedback has been summarised only where it relates to science and information needs in relation to climate data, impact assessment and response options analysis, which are three key steps in the climate change adaptation planning cycle.

It should be noted that this report does not provide a literature review of what is already understood about climate change impacts for each sector. Where this is of interest, key sector references referred to in this report should be consulted along with the broader literature relevant to that sector.

2 Emergency management

The emergency management sector includes those organisations that provide services to assist with the prevention, preparation, response and recovery from emergencies. The sector is also a key part of the disaster risk reduction sector, which is broader again and includes infrastructure operation, education, natural resource management and telecommunications.

State and national emergency planning has adopted an emphasis on shared responsibility, community resilience, risk reduction and recovery. The focus is shifting from what the emergency management sector does and needs, to what society needs to know to make better informed decisions about risk exposure and consequences. This is communicated in strategies such as the National Strategy for Disaster Resilience, the draft National Disaster Risk Reduction Framework, and the Disaster Resilience Strategy for South Australia. Ensuring that planning and development decisions are based on sound evidence and data will reduce risk and therefore minimise the need for emergency service responses. In view of this, the State Emergency Management Committee (SEMC) has expressed a need for more data to inform the identification of risks, risk reduction, and disaster recovery plans.

The SEMC Strategic Plan 2017-22 sets out the current priority themes and tasks for the emergency management sector in South Australia. Whilst changes to the climate influence much of SEMC's work, there are a number of strategic tasks in the 2017-22 Strategic Plan that will drive the prioritisation of climate information needs for the emergency management sector.

In addition to the SEMC Strategic Plan, the South Australian State Emergency Management Plan (SEMP) sets out the state's comprehensive emergency management arrangements and aims to ensure that the state has effective arrangements in place to protect our communities and people. The SEMP acknowledges that climate change will continue to increase the frequency and severity of extreme weather events, leading to greater impacts upon the South Australian people and government. The SEMP identifies the National Emergency Risk Assessment Guidelines (NERAG) among its supporting documents, which notes the need to identify temporal factors relating to the description of risks, such as how the effects of climate change may alter a risk profile.

Industry stakeholders involved in scoping future science and information needs were from a range of organisations including the Country Fire Service (CFS), Department for Environment and Water (DEW), Metropolitan Fire Service (MFS), South Australian Fire and Emergency Services Commission (SAFECOM), South Australian Police (SA POL), the State Emergency Service (SES) and the Torrens Resilience Institute. It is recognised that a number of other organisations, such as councils, SA Health, and various NGOs, also form part of this sector.

The sector has a well-developed understanding of how climate change can impact emergency management. For example, climate change can cause:

- more frequent and intense fire causing loss of life, injury and damage to property;
- increasing rainfall intensity causing more frequent and intense localised flooding of roads, buildings and property;
- greater risk of sea level rise enhanced storm surge events impacting people and property in the coastal zone; and
- more frequent and intense periods of extreme heat impacting on people, the delivery of essential services and operation of critical infrastructure.

The focus of future work should be on strategic, multi-faceted data needs and uses, such as how climate data can improve risk-based decision-making and develop resilience. Specific needs in relation to climate data are as follows:

- **Tailored information** on extreme weather events – More tailored projections on the likelihood, location, frequency and intensity of fires, floods, storms and extreme heat is needed to support strategic and operational planning, risk reduction and community capacity building. This information can then be combined with other factors that influence the demand for emergency management services such as development and population density. Together this provides a more relevant data set on which to base future planning; and

- **Compounding events** – A compound event occurs when two types of extreme events coincide at a given location and time. Examples of compounding events relevant to emergency services are where extreme heat and fire coincide at a given time and location or where intense rainfall driven flooding and storm surge in the coastal zone intersect. Improved projections of compound events will help with assist with planning and development of risk reduction strategies.

Impact assessments are essential for risk reduction and preparing, responding and recovering from emergency events. In this regard, tailored climate data can be used to inform current operational and strategic planning exercises. Science and information priorities for impact assessment identified by industry stakeholders include:

- **Identifying hazard prone areas** – As part of better planning for emergencies, the sector can encourage urban planners and developers to avoid construction in high risk areas, or construct buildings better suited to potential threats. Further impact assessment can therefore be used to identify areas that will be under greater risk from natural hazards in the future, especially flood, storm surge and fire. This type of analysis can also be extended to determine the vulnerability of a given type of housing stock based on current and projected climate risks;

- **Building community resilience** - Building greater resilience will help communities respond to and recover from extreme events and their consequences. Information is required to better understand communities' risks and vulnerabilities, explore how to communicate the risks and vulnerabilities in an understandable way, and identify effective risk reduction strategies e.g. evacuate or invacuate; and

- **Fire behaviour** – As the climate changes, the factors that influence the behaviour of fire will also change. Information is required to better understand the impact of increased temperature, reduced relative humidity and vegetation changes on future fire behaviour.

Priority science and information needs with respect to understanding risk reduction and response options include:

- **Response and recovery requirements for extreme weather events** – Further analysis is required to understand the response requirements for extreme weather events such as storms and heat waves. Specifically in relation to storms, this will require an understanding of the change in probability of severe storms, when they might occur and the severity of potential impacts and damage;

- **Reviewing bushfire fuel management strategies** – A key strategy to reduce the risk of bushfires is to reduce fuel loads. There are multiple strategies for undertaking this, however, some measures such as prescribed burning may be less appropriate as the length of season available to conduct such burns shortens under climate change. Information needs exist in relation to projected changes in soil dryness, vegetation behaviour before, during and after prescribed burns, landscape scale changes in vegetation and fire weather behaviour; and

- **Managing development in high risk areas** – A proactive way of reducing the increasing demand on emergency services is to avoid development in areas that are at high risk from natural hazards such as floods and fires. Another option is to ensure that new buildings in high risk areas are adapted to the conditions. Information is therefore required to support development assessment and building design, especially in the local government sector.

A broad underpinning message for the emergency management sector was the need for better communication about currently available science and information. This includes the need to develop more meaningful messages that motivate the community to act, develop ways of communicating scenarios and probabilistic risk, communicate the effectiveness of building and planning regulations in risk mitigation, and provide more direct guidance on how individuals should act.

It is anticipated that the climate change data and information needs for this sector will continue to be refined as the National Disaster Risk Reduction Framework and the SEMC Strategic Plan are implemented.

3 Health sector

The health sector includes public and private sector organisations that provide physical and mental health care services in South Australia, including preventative health, primary, acute and aged care services. The sector builds and maintains infrastructure, such as public and private hospitals, and provides services delivered by a range of professionals including medical practitioners and nurses. Combined, the infrastructure and services are essential for individual and community well-being. While some health care services are required in response to short duration natural hazards such as extreme heat and fire, the health sector also builds and maintains infrastructure that typically has an operational life of many decades, and as such initial designs need to consider longer term climate change in order to build infrastructure that is climate resilient.

Sector stakeholders involved in scoping future science and information needs were from a range of organisations including SA Health, Red Cross and the local government sector.

Climate change can impact the health sector in a variety of ways, including:

- extreme heat can cause heat stress and increase the number of hospital admissions, morbidity and mortality;
- more frequent extreme events such as fire and flood can create more demand for primary and acute health services;
- increasing frequency and intensity of extreme heat can increase cooling load requirements for buildings;
- direct damage to health sector infrastructure as a result of bushfire, flood and sea level rise enhanced storm surge events; and
- greater demand for preventative health services. For example, cooler cities with greater amounts of green infrastructure can contribute to preventative health by reducing the impact of extreme heat on physical and mental health.

In addition to this general understanding of climate change impacts, specific knowledge from work undertaken in South Australia includes the following:

- Information on acute health care and heatwaves - Impact analyses of various heatwaves on the health sector have been undertaken and SA Health continues to work with the BOM and SES on the parameters defining extreme heat. The Excess Heat Factor (EHS), which was developed by the BOM, is a new indicator for heatwaves based on gridded data. This forecastable metric has been assessed for suitability in relation to health outcomes in SA which is based on data specific for each location[1];
- Disease patterns - Changes in disease patterns will be an issue arising from climate change. SA Health is already conducting continuous monitoring of changing disease patterns to better inform understanding of this issue; and
- Community vulnerability to heatwaves – Heatwaves cam impact overall vulnerability of the community by impacting a range of health factors. Specific advice is now provided by SA Health in relation to how to stay healthy in the heat[2].

With respect to future science and information needs, the current understanding of climate change impacts needs to be expanded upon with more tailored climate data. This should focus on the potential change in the likelihood, frequency and severity of extreme events, especially extreme heat because it impacts human

[1] http://www.bom.gov.au/australia/heatwave/index.shtml
[2] https://www.sahealth.sa.gov.au/wps/wcm/connect/Public+Content/SA+Health+Internet/Healthy+living/Protecting+your+health/environmental+health/Stay+healthy+in+the+heat/

health and intense rain events and flooding because of their impact on hospital infrastructure. These events are also referred to as surge events and contribute greatly to peak demand for acute care services such as hospital beds.

Generating this tailored information can utilise existing data from SA Climate Ready or Climate Change in Australia, however, the parameters for defining extreme heat in a way that is meaningful for primary and acute health care in particular requires scoping with sector stakeholders.

Science and data on climate projections can be used to conduct more targeted impact assessments for the health sector. Priorities for impact assessment identified by sector stakeholders include:

- **Surge event impact assessment** - Surge events place peak demand on hospitals and provision of acute care services. A surge event impact assessment would use tailored climate data on specific extreme weather events, such as heat waves, to assess the preparedness of hospital infrastructure and other health services;

- **Change in disease patterns and community health** – A priority concern for the health sector is that a changing climate will influence how disease and overall health is experienced across the community. Specific issues of concern include legionella, mosquito-borne diseases, food-borne diseases, and weather-borne asthma events. An increase in these issues will in turn impact where there will be demand for health care services and the type of services required;

- **Health infrastructure risk assessment** – Some of South Australia's most significant infrastructure investment has occurred in the health sector, especially public hospitals. This type of infrastructure has a lifetime of at least 50 years and so consideration needs to be given to the type of climate that such infrastructure will be operating in beyond the middle of this century. A health infrastructure risk assessment would consider more than just surge events in response to extreme weather and will enable the sector to better understand priority areas of vulnerability, the timing of potential impacts and then explore mitigation options; and

- **Characterise vulnerable communities** – While there are general impacts of climate change on the health and well being of the community, some health issues will become more significant, which will drive the need to identify what are the vulnerable communities and how they can adapt and build resilience to climate events. This should include consideration of mental health patients, aged care centres, cardiac patients and medicated community members.

Determining how to respond to climate change impacts on the health sector will play a major role in maintaining the health and welling being of the community. While response options for infrastructure will emerge from infrastructure risk assessments, options analysis in relation to preventative health will also become increasingly important. Priority science and information needs with respect to understanding response options include:

- **Health sector workforce planning** – The impacts of climate change, such as more frequent and intense periods of extreme heat, will place greater demand on health care services and also directly impact those staff employed to provide the services. Strategic and operational health sector workforce planning will help to better understand how the demands on health sector staff will change through time and how this can be addressed; and

- **Green space contribution to preventative health** – The role of green infrastructure in cooling cities and more generally supporting a healthy community is well established. However, the specific preventative health benefits as they relate to planning and building the business case for green infrastructure at a local scale in South Australia, and especially Metropolitan Adelaide, has not been well articulated. This

analysis would help to better define the cost and health benefits of incorporating green space into existing and new developments. There is also strong interest in determining how the health sector can in turn use this information to contribute to green space planning.

As further tailored climate data and impact assessments are delivered, it is anticipated that more specific questions will emerge for different types of health care provision. For example, the impact of climate change on aged care service provision and potential response options warrants further consideration, especially given that this is recognised as a growing part of the health sector in South Australia. This would in part need to ensure that infrastructure is well suited to the future projected climate and that the impact of extreme events, such as heat, are considered in design and operation of aged care buildings.

Aside from understanding the risk associated with climate change impacts, there is also a growing interest in health sector emissions and energy use and how this contributes to the State's overall emissions reduction targets.

4 Infrastructure

The infrastructure sector includes those organisations that develop and maintain public and private infrastructure in South Australia. This infrastructure is essential for the effective functioning of the community and economy and includes water, electricity, transport and building infrastructure. Given that infrastructure of this type typically has an operational life of many decades, initial designs need to consider longer term climate change in order to be climate resilient.

Sector stakeholders involved in scoping future science and information needs for the infrastructure sector were from a range of organisations including the Department for Environment and Water, Department for Planning, Transport and Infrastructure, Electranet, Renewal SA, SA Water, Water Sensitive SA, the Bureau of Meteorology, and the local government sector.

Climate change can impact infrastructure in variety of ways, including:

- rainfall intensity impacting flows through stormwater management systems and water sensitive urban design (WSUD) features;
- storm intensity and frequency impacting the functionality of electricity distribution networks;
- increasing frequency and intensity of extreme heat impacting the condition of road surfaces;
- increasing frequency and intensity of extreme heat increasing cooling load requirements for buildings;
- direct damage as a result of bushfire, flood and sea level rise enhanced storm surge events;
- reduction in water supply reliability of reservoirs due to extended dry periods; and
- changes in water quality control requirements due to algal growth stimulated by warmer weather/water.

A strong theme for the infrastructure sector was the need for more tailored climate science and information, which can then be used to inform subsequent impact assessments. Importantly, this requires working with existing data sets rather than generating new information about climate projections. Priority science and information needs in relation to climate data for the infrastructure sector include:

- **Data for designing climate resilient critical infrastructure** – There is a general understanding of the broad projections and trends for a changing climate, such as increasing temperature, declining average annual rainfall, and increasing rainfall intensity. However, in order to be used for the design of infrastructure agreed data standards need to be developed. This removes the need for assessment of a broad range of scenarios when designing infrastructure. Such an approach already exists with the Coast Protection Board whereby it is recommended that all major coastal developments consider 0.3 m sea level rise by 2050 and 1 m by 2100;

- **Sub-sector specific projections for extreme weather events –** Climate projections to date, such as described in the SA Climate Ready Regional Summaries and the Climate Change in Australia reports and websites, have focussed primarily on the average annual or seasonal projected changes for temperature and rainfall, with some limited insights into changed frequency of, for example, extreme heat and bushfire. However, in order for impact assessments to be undertaken for specific infrastructure types, greater tailoring of current data to generate projections of the changes in frequency or severity of extreme weather events is required to suit the needs of sector-specific applications. This should be pursued individually with relevant stakeholders who develop and maintain the various types of critical infrastructure e.g. water, electricity, transport. For example, the energy sector may require more specific projections in relation to wind speeds, storm frequency, wind event return periods, lightning, low wind speeds on very hot days;

- **Consolidated data on coastal elevation, erosion and inundation** – Understanding the impact of sea level rise in the coastal zone is important for the provision of a broad range of critical infrastructure e.g.

potable water supplies, stormwater management, waste water treatment. In order to undertake such analyses, digital elevation models are required so that erosion and inundation maps can be generated. This information has been procured by a large number of councils across the state and there is an opportunity for this to be consolidated into a single database; and

- **Natural hazard information and mapping to inform urban planning** – Information on natural hazards is important for infrastructure development and planning to ensure that construction does not occur in high risk areas or so that appropriate design standards are met to accommodate potential future impacts. Relevant natural hazard information includes flood and bushfire risk. This information has been prepared in many cases by local government and various state agencies but could be of greater use and impact if it is consolidated.

Climate science capability and regional climate projections can be applied to conduct more targeted impact assessments for the infrastructure sector. Priorities identified by industry stakeholders include:

- **Metropolitan scale stormwater run-off analysis** – This analysis would be multifaceted, requiring an understanding of how run-off will change in response to climate change and urban infill, with the latter impacting the proportion of pervious to impervious surfaces. In turn there is a need to understand how changing quantities of stormwater runoff into the Gulf St Vincent are impacting the coastal environment, such as sea grass communities for which there is growing recognition of their importance in storing carbon;

- **Supply and demand side water security options analysis** – The experience of the Millennium Drought means that South Australia has a strong understanding of the impact of low rainfall on water supplies for cities, industry and the environment. Building on the experience of the Millennium Drought, further modelling and options analysis is required to better understand how climate change may alter the frequency and intensity of drought periods, how this could influence water security, and how this can be best responded to with a range of alternative water supply options; and

- **Critical infrastructure in high risk areas** – Previous studies have identified the broad risks to infrastructure from a changing climate. More site and infrastructure specific analysis is required to determine the risk posed from extreme events that may become more frequent and intense in response to climate change. For example, there are numerous waste water management schemes that are managed by councils or SA Water in low lying areas in the coastal zone. Impact assessments are required to determine which sites are at greatest risk, over what time frame the risk may be experienced, and an estimate of the value of assets at risk.

Determining how best to respond to climate change impacts on critical infrastructure will ensure that public and private infrastructure owners and operators can continue to provide services to support the community and economy. Priority science and information needs with respect to understanding response options include:

- **Infrastructure design for extreme events** – Large infrastructure assets tend to have lifetimes of many decades, ranging from 20-30 years for roads up to 70-90 years for stormwater infrastructure and bridges. This means that the design of such infrastructure needs to consider long term climate change impacts, especially extreme events that are likely to have the largest impact on asset life. While the development of new infrastructure provides an opportunity to build climate resilience into a design at the time of construction, existing infrastructure in many instances will also have several decades of operational life remaining. Further analysis is therefore required to determine how best to design new infrastructure or retrofit critical infrastructure so that they are more resilient to extreme weather events such as storms, intense rainfall and heatwaves; and

- **City scale urban water management analysis** – There is growing understanding of the importance of city greening to improve the liveability of cities and tackle the urban heat island effect. A key to understanding the potential for increasing city greening is to model the interaction between irrigation (using a range of alternative water sources), green infrastructure, and WSUD. This analysis could then be used to better quantify the benefits of irrigation for city cooling and to determine where infrastructure should be located.

- **Location of protection infrastructure** – Protection infrastructure, such as flood levees, provide a way to reduce direct physical damage from floods as well as reduce the cost of insuring property in such zones. Further information is required on the optimal location of protection infrastructure such as along waterways (creeks and rivers) and in the coastal zone.

While the focus of these science and information needs is strongly in relation to water management (stormwater, public water supply, municipal water use), there are a broad range of other types of impact assessment and response options analysis that are likely to emerge once further tailoring of climate data is undertaken. For example, further response options analysis could help to determine the timing at which infrastructure will need to be replaced or retrofitted as different elements of the climate (e.g. rainfall) change.

5 Primary production

The primary production sector covers a range of industries in South Australia, including broad acre cropping, livestock grazing, wool production, viticulture, and almond, apple, cherry, citrus, pear and stonefruit production. Primary production is a cornerstone of the South Australian economy and provides employment directly in regional areas, and in further food processing, logistics and retailing in regional centres and Adelaide.

While consideration of climate is a more recent issue for some sectors, it is the key driver for primary production. As such, the identification of science and information in relation to climate change needs to be in the broader context of the extensive work that has already been undertaken by the sector in relation to climate variability.

While many decisions in the sector are made based on information about the weather (measured over a period of days, to weeks and months) and natural climate variability, there are also decisions that need to consider the long term impacts of climate change. For example, decisions about buying new farms or establishing new vineyards and orchards have lifetimes in the order of 20-30 years.

To scope the future climate change science and information requirements for primary production, input was sought from a range of sector stakeholders including private agricultural companies, peak industry bodies, PIRSA and SARDI.

Climate change can impact primary production in a range of ways including:

- warmer and drier conditions leading to lower yields for dryland cropping;
- warmer and drier conditions leading to lower pasture growth and hence pasture production;
- warmer and drier conditions resulting in lower runoff into rivers and reduced recharge, leading to reduced water allocations for irrigation;
- extreme heat increasing heat stress for livestock;
- warmer conditions changing the ripening patterns for fruit;
- warmer and drier conditions favouring some pest plants and animals while disadvantaging others; and
- increasing risk of fire causing damage to crops, livestock and property.

The science and information needs identified by sector stakeholders were a mixture of those that could be led by DEW on its own or in conjunction with other state agencies (e.g. PIRSA), and those that should be led by the sector itself. Principal amongst the latter were a range of needs in relation to business and financial management, improvements to current best practice, and identification of alternative crops, stock types and farming options.

Currently available climate science and information was considered to be sufficient for industry planning, however, there was a strong view that most of the information is not easy to access or in a readily usable format. Priority science and information needs in relation to climate data include:

- **Access to existing data** – Significant data sets already exist that are relevant to primary production, or that were developed specifically for the sector. This includes the results of research and analysis by SARDI, CSIRO, various research and development corporations and universities. A portal is required to provide easier access to this information and in a user friendly format; and

- **Tailored information** – Although significant amounts of climate data already exists, much of it presents averages, which are useful for understanding broad trends in future climate but not specific impact analyses. Therefore, as awareness increases of potential climate change impacts, there is a growing need for more industry specific and tailored climate data sets, related specifically to aspects of rainfall and temperature.

The primary production sector already conducts impact assessment related to climate variability. Additional science and information needs for impact assessments specifically in relation to climate change includes the following:

- **Water availability and quality** – Water is a primary input for agriculture, especially given the warm to hot and dry conditions across much of South Australia. Climate change is projected to result in a decline in average annual rainfall. Research is required to better understand how water quality, quantity and soil moisture will change in the future, tailored for different industries and production regions across the State;

- **Water demand** – Agriculture in South Australia has evolved through time to respond to variable rainfall and access to water. Increasing average and extreme temperatures will increase demand for water across a range of industries. Further information is specifically required in relation to how water requirements and demands may change with increased temperatures, reduced rainfall, and more frequent and intense heatwaves. This will need to consider the requirements of specific industries and growing approaches (e.g. intensive agriculture versus irrigated crops);

- **Chilling hours** – A range of fruit crops (e.g. apple, cherry) require a minimum number of chill hours in order for a tree to blossom. Climate change will result in lower amounts of chilling hours as the minimum daily temperature increases. There is a requirement for greater sharing of chilling hours information across sectors; and

- **Triggers** – Triggers are important for informing when decisions need to be made or when a different course of action should be followed. While they may inform action against climate change, they can be based on a range of variables such as those that are physical, biological, economic and social. Further information is required to develop triggers related to dry times, market changes and extreme events.

Exploring response options in relation to climate variability is already a significant undertaking for the industry. This covers assessment of alternative crops, livestock breeds and farming practices. However, specific response options that require consideration in relation to climate change are how the sector will respond to extreme weather. This should include consideration of options for:

- management of foliar diseases and mitigating smoke taint as a result of bushfire for the viticulture industry;

- managing the risks of bushfires, including ensuring that information provision is clear such as in relation to fuel load reduction; and

- adapting bushfire preparedness in response to a move to larger farms and smaller rural communities.

In addition to science and information needs, there was also a strong focus in the primary production sector on greater sharing of information, research and case studies on successful examples and options for adaptation. For example, there is widespread interest in which enterprises have coped well with drought and other extreme events and why.

6 Sustainable landscapes

The sustainable landscapes sector relates to natural resources management and covers activities such as coastal zone management, conservation, pest plant and animal management, sustainable agriculture, urban ecology and water management. Sustainably managed landscapes are essential for delivering environmental outcomes as well as supporting the community and economy, such as through maintaining farmland and protecting water catchments. The decisions made in this sector, such as landscape scale restoration and revegetation, have long lifetimes and as a result need to consider longer term climate change in their planning and design.

To scope the future climate change science and information requirements for sustainable landscapes, input was sought primarily from sector stakeholders within natural resource management organisations and the local government sector.

Climate change can impact sustainable landscape management in a range of ways including:

- warmer and drier conditions resulting in lower flows into catchments and less water available for a range of uses, including potable supplies, agriculture and environmental requirements;
- warmer and drier conditions causing a reduction in yield for agriculture and creating other land management challenges such as greater risk from fire and spread of pest plants and animals;
- changing general climatic conditions leading to a change in the types of plants and animals that can persist in the landscape, which is relevant to both conservation of existing species and restoration;
- sea level rise enhancing rates of erosion and inundation in the coastal zone; and
- increasing demand for greater amounts of green infrastructure in cities to address the urban heat island effect and to support urban conservation.

Sector stakeholders were strongly of the view that while climate data may be available, it is often not tailored for specific uses or it is not easy to determine where it is accessible from. Specific climate data related needs include:

- **Geographic consistency** – Some data has been tailored for use in some regions but not others. Further work is required to ensure that tailored information for a range of climate variables is provided for in a consistent manner across regions;

- **Water resource modelling** - Significant work has been undertaken to develop climate projections for temperature and rainfall. Further guidance is now required on how to use climate science for water resource modelling and in turn water planning. Where possible, this should be standardised; and

- **Data for designing water sensitive urban design infrastructure** – The sustainable use and re-use of water in urban development and buildings has been a considerable focus in South Australia, especially following on from the Millennium Drought. The design of many WSUD features requires an understanding of not only average annual rainfall, but also extreme events that impact rainfall intensity, floods and fire at the locality level. Standard data is required for both variables that considers the future influence of climate change.

The majority of science and information needs for the sustainable landscapes sector were in relation to impact assessment. Overall, there is a general need for more information on how different stressors will change under a different future climate. Specific science and information requirements in relation to impact assessments include:

- **Species level prioritisation for climate adaptation** - The South Australian Government is committed to avoiding the extinction of the State's unique native biodiversity, and to this end is developing a Nature

Conservation Program for South Australia. Understanding how South Australia's biodiversity will respond to climate change, in the context of other pressures and our capacity to manage these, will be critical if we are to meet this goal. However, our understanding of the climate sensitivity and adaptive capacity at the species level is restricted to a small number of species. A priority information need is therefore to conduct a more detailed analysis of which species we need to prioritise with respect to climate adaptation, such as those species most threatened with extinction, or whose ecological requirements are not met by landscape-level management.

- **Integrated landscape assessment and predictive modelling** – Landscapes are already experiencing different states and trends independent of climate change impacts. Therefore, there is a need to understand the character of different landscapes as well as their inherent and realised vulnerabilities (exposure, sensitivity and adaptive capacity) to be able to understand the implications of different climate change scenarios and what this means in terms of environmental values and goals. As such, an integrated assessment and predictive modelling exercise is a critical knowledge need to develop a prediction of what will occur under different climate change scenarios in different landscapes, including future ecological communities. This can also help identify anticipatory indicators that can be monitored to determine if the changes being observed are as expected;

- **Predicting future ecological communities** – A key challenge for natural resource managers is to understand the future distribution of native plants and animals as a result of climate change. Information is required on the projected future ecological communities for different regions in the State, which should include guidance on when "new" species will become more common. This could in turn inform development of a framework to select new species for revegetation and help to develop a decision support tool for landscape restoration and management based on an understanding of future ecological communities;

- **Pest plant and animal communities** – A major concern of land managers is that climate change will favour the spread of existing pest plants and animals as well as enable new species to become established. One example is the invasive buffel grass, which occurs in northern parts of the State and is expected to move further south as the climate becomes warmer and drier. Better understanding of the potential distribution and abundance of pest plants and animals is required for regions across the State including when significant changes may occur;

- **Hazard prone areas** – Hazard prone areas can be a focus for natural resource managers for a number of reasons, including building the resilience of ecological communities and to assist with preparing for and recovering from the impact of extreme events. To better identify hazard prone areas, further information is required on those parts of the coastal zone that may be impacted by future erosion and inundation, and areas that may be at future risk from increasing frequency and severity of bushfire;

- **Change in water demand profile** – The demand for water from a range of users such as potable, industrial, agricultural and environmental is expected to change as conditions become warmer and drier across the State. Research is required to better understand how these different types of water demand will increase;

- **Changes to water availability** - Water allocation plans have been developed for key surface and groundwater resource areas across the State. As conditions become warmer and drier, the availability of runoff for surface flows or recharge of groundwater is expected to decline. Information is required to better understand projected changes in the water available for prescribed water resources and how this will impact allocations to different users;

- **Conservation areas** – land based and marine protected areas (including marine parks and conservation parks) exist to protect habitats, animals, plants, cultural heritage and geological formations. Further research is required to determine what strategies are required for protected areas to preserve the conservation function and account for changes in the distribution of plants and animals due to climate change; and

- **Stormwater harvesting** – South Australia has invested significantly into infrastructure to capture and reuse stormwater. The design of these assets was based on historical runoff data. Information is required to determine how much water will be captured in the future by these assets, noting the opposing factors of lower annual average rainfall on the one hand and greater rainfall intensity and increasing runoff from hard, impervious surfaces on the other. This information can in turn be used to determine the extent to which the financial performance of these assets may change.

Further refinement and integration of some of these impact assessment tasks is likely through the development and implementation of the Climate Change Science and Knowledge Plan.

It is noted that while research has already been undertaken into some of these issues, especially the potential changes in ecological communities and the future distribution of pest plants and animals, there is not an agreed understanding of the projected changes across all regions in the State. As such, there is a need for greater facilitation of the process of synthesis and agreement across regions.

Based on input from sector stakeholders, priority science and information needs with respect to understanding response options include:

- **Infrastructure design and operations** – The River Murray, through the locks, weirs and barrages, and the South East through the drainage system, both have significant investment in water resource management infrastructure. Further information is required as follows for both systems: In the River Murray an improved understanding is required of how changes in flow will impact the renewal of river operations infrastructure, while in the South East there is growing interest in how the drainage network may need to change its operations to reduce the flow of freshwater to the sea;

- **Tree canopy mapping** – Creating a green city is a priority action of the State Government and many Metropolitan Councils. Increasing the number of trees and the overall tree canopy is a key target. There are multiple ways of measuring tree canopy at present and information is sought on how to identify a standard tool for canopy mapping; and

- **Recovery options** - Natural resource managers play an important role in assisting with the delivery of emergency management services to protect valuable landscape features, including environmental assets. While emergency service providers often play the lead role in responding to emergency events, more information is required on recovery options for environmental assets.

7 Key findings

The workshop process was conducted with over 100 stakeholders from five sectors. There were a range of industry specific science and information needs, some of which will require further work from those sectors to either scope their needs or to provide the science and information. This is especially the case for the primary production and sustainable landscapes sectors, who have already invested significant resources into research regarding climate variability and to a lesser extent climate change.

There were also a number of common themes that emerged and that warrant further consideration in the Climate Science and Knowledge Plan as follows:

- **Access to existing information** – All sectors were aware that climate projection data has been generated for South Australia, however, there is low awareness of where the information is available from. This indicates that more work is required to build understanding of where to access currently available information. There may also be a requirement in the future to provide a central, user friendly portal through which stakeholders can access information;

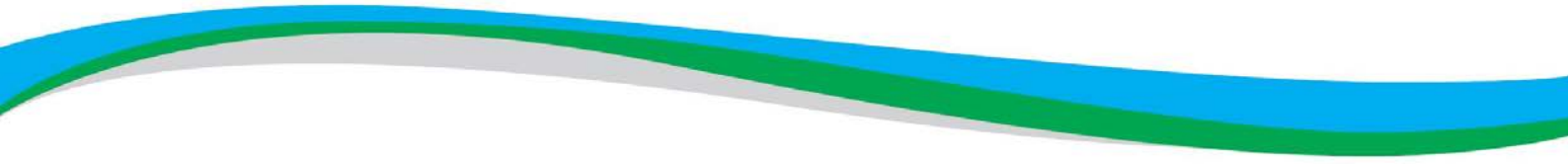
- **Tailoring information** – To date, much of the climate data that has been generated, relates to average temperature and rainfall, or a limited number of additional variables such as the number of consecutive days that will exceed 35'C or 40'C. As awareness has increased in various sectors, there is now demand for more sector specific variables. This requires new work to generate a range of secondary information products that are developed in consultation with key sectors in South Australia;

- **Standard data** – A feature of climate change projections is that there are multiple timeframes, emission scenarios and model outputs to consider when seeking to understand the future climate. While this may be appropriate for capacity building, implementing on-ground actions requires standard approaches to be adopted across a sector. Standards should provide advice to different sectors on which *projection* to use for design of new or retrofitting existing assets, or revising the provision of services, or how to use *multiple scenarios* to inform impact assessment and response options analysis;

- **Extreme weather events** – For many of the sectors consulted there is a good understanding of the broad trends of climate change as they relate to temperature, rainfall and sea level rise. However, the most significant impacts in many instances will be as a consequence of extreme weather events such as heat waves, storms, intense flooding and rainfall, for which only a limited set of projections is available. Work is therefore required to develop improved information on the change in occurrence of extreme weather events, including for concurrent events, that are relevant to multiple sectors;

- **Capacity building** – Climate change science and information is considered to be complex by many stakeholders and requires significant work in some instances to determine its relevance to a sector and then how to respond. All sectors who participated in the workshop process identified some form of capacity building and ongoing communications and outreach as necessary to assist their sector develop appropriate adaptation measures; and

- **Hazard prone areas** – A number of sectors indicated an interest in better understanding where hazard prone areas occur for risks such as bushfire, flooding, storm surge and extreme heat. In part this interest is driven by a desire to reduce development in such areas or ensure that new developments are designed in such a way as to effectively manage potential risks. Improved coordination of mapping hazard prone areas and ensuring that this information feeds into the planning and development systems is therefore strongly favoured.



The Goyder Institute for Water Research is a partnership between the South Australian Government through the Department for Environment and Water, CSIRO, Flinders University, the University of Adelaide, the University of South Australia, and the International Centre of Excellence in Water Resource Management.