

Goldfields-Esperance Regional Mining Climate Vulnerability Workshop Report on workshop outcomes

Climate Adaptation and Minerals Down Under Flagships

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I. Executive summary

The Australian mining industry and its associated communities are likely to be affected by climate change and variability in a number of ways. Direct impacts associated with changes in climatic extremes as well as indirect impacts related to changes in government legislation or flow-on affects from other sectors are expected.

This report details the process and findings of a workshop conducted in Kalgoorlie-Boulder, Western Australia in August 2010 investigating mining industry adaptation to climate change in the Goldfields region. The workshop was conducted by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in conjunction with and supported by the Goldfields-Esperance Development Commission (GEDC). The aim of the workshop was to both deliver and develop a greater understanding of the potential impacts of climate variability and change on a range of stakeholders in the mining industry in the region. Additionally, the workshop aimed to provide a forum where discussion on collaborative adaptation strategies across the stakeholders could take place. Participating organisations included mining companies, mining industry services, utility providers, research organisations, and state and local government agencies.

Western Australia's Goldfields-Esperance (GE) mining region contributed over \$10 billion in 2006-07 to Gross Regional Product (DLGRD 2010) and is an important mineral province for Australia. The regional population of around 60,000 is predominantly located in the major towns of Kalgoorlie-Boulder and Esperance, however many smaller rural and remote towns and settlements in the region also service the mining industry. There is considerable mining infrastructure across the region, from actual mines, through to mineral processing, utilities and transport infrastructure.

Climate projections for the Goldfields region point to warmer (0.6 – 1°C) and drier (5 to 7% less rainfall) conditions by 2030, which will affect many stakeholders in the mining industry, including mining companies, infrastructure providers, local government agencies and local communities.

The workshop identified some major areas of vulnerability in the Goldfields region including availability of scarce resources (principally water and energy), impacts on environment and community, hazards and workforce issues, infrastructure impacts, and mine planning and design. Factors influencing vulnerability to climate change included: the costs, risks and returns associated with adaptation measures; societal expectations that tend to influence government policy and regulation; and, the connections between issues and inter-dependencies between sectors that lead to cumulative and/or compounding knock-on effects across them.

Key adaptation needs identified by participants included: access to relevant, specific and credible information, particularly that related to future availability of critical resources (e.g. water and energy) and future operating conditions for infrastructure, equipment and personnel; knowledge and expertise relating to adaptation methods and technologies; funds to support adaptation; and commitment and policy direction by government to provide impetus for action across the mining value chain, regional communities and society more broadly.

A key finding from the workshop was that while there were differences in sectoral vulnerabilities, needs and capacities, the various sectors were bound by similar issues, with dependence upon critical infrastructure and resources, economic conditions, government policy direction, and societal expectations chief amongst these. With climatic impacts in any one sector likely to have significant implications across most other sectors, it will be beneficial for the different sectors to pursue open communication, interaction and joint-planning as much as possible. While a fully integrated response may not be possible, or even desirable, due to both practical and institutional constraints, a central and engaged regional organisation would seem well placed to facilitate an appropriate integrated approach into the future.

Another finding was the need to embed climate change risk assessment as an additional but integral component of normal planning and risk management processes. In this respect, climate change adaptation needs to be perceived and communicated more as a risk management issue than exclusively an environmental sustainability or 'green' issue. Further, acknowledgement needs to be given to the many uncertainties that still exist around our knowledge of what the exact climate, and therefore, risk (and opportunity) parameters will apply in the future.

2. Introduction

Future climate variability and change is expected to impact on the mining industry and its associated communities in diverse ways across Australia. This may be through direct impacts associated with changes in climatic extremes or via indirect impacts related to changes in legislation or flow-on affects from other sectors (Hodgkinson et al. 2010; Loechel & Moffat, in press). Globally, little work has been performed on ascertaining the impacts of changing climate risk for the mining industry and its associated communities. Of the few reports available (e.g. Pearce et al 2009; Acclimatise 2010; UK Met office 2010), all have identified a general lack of awareness and action within the mining industry in relation to adaptation to the risk of future climate change. To address this gap in relation to Australia, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), through the Climate Adaptation and Minerals Down Under National Research Flagships, is undertaking a project to assess the implications across the whole mining value chain in key mineral provinces around Australia at regional and local geographic scales. As part of this project, the CSIRO is holding a number of workshops around Australia, of which the Kalgoorlie workshop reported here is one, to gain the input of mining companies, technical specialists and industry and community stakeholders.

This report details the process and findings of the workshop conducted in Kalgoorlie-Boulder in August 2010, investigating mining industry adaptation to climate change in the Goldfields region of Western Australia. The workshop was conducted by the CSIRO in conjunction with and supported by the Goldfields-Esperance Development Commission (GEDC). The aim of the workshop was to both deliver and develop a greater understanding of the potential impacts of climate variability and change on a range of stakeholders in the mining industry in the region. Additionally, the workshop aimed to provide a forum where discussion on collaborative adaptation strategies across the stakeholders could take place. Participating organisations included mining companies, mining industry services, utility providers, research organisations, and state and local government agencies.

3. Background

Mining activities in Western Australia's Goldfields-Esperance (GE) region contributed over \$10 billion in 2006-07, representing 19% of the state's Gross Regional Product from mining (DLGRD 2010). The Goldfields-Esperance (GE) region is an important mineral province for Australia, generating significant economic value through resource extraction and contributing to the livelihoods of many individuals and families in the region.

The GE region is vast in area (771,276 km²) and diverse in nature, encompassing desert, temperate eucalypt woodlands and coastal national parks. It is the largest of the state's nine regions and over three times the size of the state of Victoria. The GE region is bounded by the Pilbara Region and Gibson Desert to the north, the Wheat-belt and Mid-West regions to the west, the Great Southern Region to the south-west, the Southern Ocean and the Great Victoria Desert, the Nullarbor Plain and the South Australian border to the east.

With a regional population of around 60,000, the main towns are Kalgoorlie-Boulder (K-B), approximately 600 km east of Perth, (population 30,000) and Esperance (pop. 14,500) approximately 720 km east-southeast of Perth on the coast. The other townships, most of them reliant upon mining, are much smaller, ranging from Kambalda (pop. 4250) near Kalgoorlie, Ravensthorpe (pop. 2,400) closer to the coast, and the more remote towns north and west of K-B with populations of less than 1000. The region comprises nine local government areas (see Figure 1).

While the shires of Ravensthorpe and Esperance on the coast are characterised by higher rainfall and a mix of industries (agriculture, mining, tourism, fishing and forestry), shires further north are increasingly more remote, arid environments, and more dependent upon mining and to a lesser extent tourism for their economic prosperity (GEDC & DLGRD 2006). There is considerable mining infrastructure located across the region, from actual mines that operate in most shires as well as minerals processing, and minerals transport, including roads, rail and port facilities.

The region is home to a significant Indigenous population, particularly in its northern shires of Ngaanyatjarraku, Laverton, Leonora and Menzies. Nearly 10% of the region's population are of Aboriginal descent, which is a substantially higher proportion than for the state as a whole. Many groups reside in small remote community settlements and warrant culturally sensitive approaches to addressing issues that affect them.

Future issues likely to have a major influence on the prosperity and wellbeing of the region include those specific to the region (DEC 2010) and those applicable to the resources sector more generally (Giurco et al. 2009). For example:

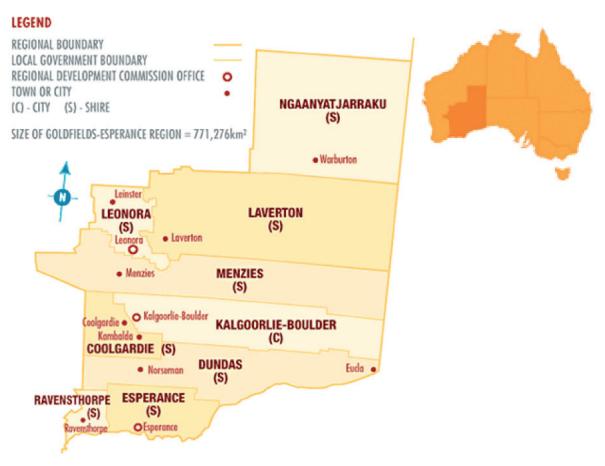


Figure 1. The Goldfields-Esperance region of Western Australia (Source: GEDC 2010)

- the duration of current mines and success of exploration for new mining ventures (linked to the issue of 'peak minerals')¹, and development of minerals processing
- mining investments elsewhere that compete for finite resources (e.g. finance, labour, energy, water)
- skills shortages resulting from the competition for labour
- commodity prices linked to global economic conditions
- corporate globalisation, mergers and acquisitions
- · geopolitical events and shifting economic and political relations
- government taxation and regional investment regimes
- climate change affects, mitigation and adaptation responses including the shift to a less carbon dependent economy
- energy costs and development of renewable resources
- changing societal expectations that influence government regulation, especially those related to environmental and cultural heritage (e.g. Native Title) issues.

This region is likely to experience changes resulting from variations in climate variability and change which will affect stakeholders in the mining industry, including mining companies, infrastructure providers, local government agencies and local communities. Developing a greater understanding of the potential impacts of climate variability and change on a range of interdependent stakeholders in the mineral extraction value chain, and identify strategies to adapt collaboratively to these potential impacts, is therefore an important issue to explore in a systematic manner.

¹ Peak minerals refers to the point in time when the highest amount of production of a mineral occurs, with production declining in subsequent years

3.1 Climate projections for mining Region 4 (WA Goldfields)

Climate projections (changes in monthly temperatures and rainfall) have been developed by CSIRO for 2030 and 2070 for key Australian mineral provinces using novel statistical downscaling methods (Kokic et al. 2010). Figure 2 shows the various mining regions within Australia, including region 4 (corresponding to the WA Goldfields), for which these climate projections have been developed.

3.1.1 Current climate

Region 4 experiences 2 main seasons: namely a hot, dry summer (October to March) and a cool, dry winter. During the summer, this region can experience in excess of 10 days above 40°C and 38 days above 35°C, with a mean summer temperature of around 26°C. Over the winter, average temperatures are around 17°C and the lowest around 7°C occasionally falling below freezing at night. Rainfall is fairly evenly distributed throughout the year and averages about 264mm per annum, although annual figures can vary considerably. The most reliable rains occur in winter and June is typically the wettest month with approximately 29mm of rainfall. Summer rainfall occurs usually as a result of thunderstorms. At such times, annual rainfall can exceed 500 mm (Source: Bureau of Meteorology 2010).

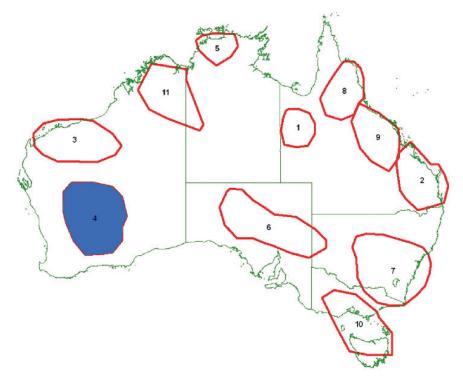


Figure 2. The 11 Australian mining regions for which CSIRO has developed climate projections out to 2030 and 2070 showing WA Goldfields (Region 4) highlighted in blue

3.1.2 Future climate

By 2030 future climate conditions for Region 4 are predicted to be between 0.6 to 1°C warmer and 5 to 7% drier (Table 1). This will have significant effects on extreme events with the number of days above 35°C increasing from its present mean of 38 to between 43 to 53 days. This in turn has significant ramifications for evaporation and water availability.

Projected changes in temperat	ure and rain	fall REGION	4					
SOURCE:	NCAR	NCAR	ECHAM	ECHAM	GFDL	GFDL	HADGEM	HADGEM
	Temp °C	Rain (%)	Temp °C	Rain (%)	Temp°C	Rain (%)	Temp °C	Rain (%)
Novemberto April 2030	1.09	4	1.09	-1	1.16	-5	0.93	-4
May to October2030	1.14	-6	1.09	-6	1.02	-5	0.76	-5
Novemberto April 2070	2.96	10	2.96	-2	3.13	-14	2.52	-12
May to October 2070	3.07	-16	2.46	-15	2.76	-47	2.07	-13

Table I. Projected change scenarios for temperature and rainfall in Region 4 according to four of the best performing climate models available [NCAR = National Centre for Atmospheric Research; ECHAM = Max Planck Institute for Meteorology; GFDL = Geophysical Fluid Dynamics Laboratory; HADGEM = Hadley Centre Global Environmental Model]. (Source: http://www.csiro.au/ozclim/home.do)

3.1.3 What the climate change scenarios mean to the WA Goldfields

In the next 20 years, all the models shown in Table I project an increase in temperature of approximately 1°C and this will increase evapotranspiration² in the WA Goldfields (Region 4). Although one model suggests an increase in summer rainfall by 4%, the remaining models show decreases by approximately 5% across both the summer and winter seasons, which are likely to exacerbate the lack of water availability in the region.

The projections for 2070 show temperatures, compared with those of today, may increase by 2°C to 3°C throughout the year. One projection (GFDL) shows a dramatic decrease in rainfall of 47% during the winter, which is concerning given that this is when the most reliable rains presently fall in region 4. The majority of scenarios show a decrease in rainfall, which, combined with higher temperatures will intensify evapotranspiration in a region that will have already experienced increased dryness since at least 2030.

3.1.4 Summary

The future climate scenarios presented here generally point towards a hotter, drier climate for the WA Goldfields (Region 4), which is already described as hot and dry for most of the year. Where water is already at a premium, reduced rainfall and increased evapotranspiration will put additional stress on the water resources available, suggesting that both mining companies and the local community will need to adapt their practices to use less water and cope in the hotter extremes. What this information does not show, but is projected more generally across Australia and relevant for Region 4, is greater incidence and severity of extreme weather events or storms, including high winds (10 to 15% increase by 2030) and intense rainfall (20 to 30% increase by 2030).

3.2 Mining climate vulnerability

Globally, little work has been performed on ascertaining the impacts of changing climate risk for the mining industry and its associated communities. Of the few reports available (e.g. Pearce et al 2009; Acclimatise 2010; UK Met office 2010), all have identified a general lack of awareness and action within the mining industry in relation to adaptation to the risk of future climate change. To address this gap in relation to Australia, the CSIRO, through the Climate Adaptation and Minerals Down Under National Research Flagships, is undertaking a project to assess the implications across the whole mining value chain in key mineral provinces around Australia at regional and local geographic scales. As part of this project, the CSIRO is holding a number of workshops around Australia, of which the Kalgoorlie workshop reported here is one, to gain the input of mining companies, technical specialists and industry and community stakeholders.

Based on a systematic desk-top assessment across the generic mining process cycle, as well as hosting a recent workshop consulting CSIRO mining scientists and technical specialists, a number of risk areas related to climate are prominent (Moffat 2009; Hodgkinson et al. 2010). These are namely: energy, water, infrastructure and equipment, human resources and safety, and community relations. It is likely that these types of risk areas will also be relevant to the Goldfields-Esperance region.

² A combination of evaporation from soil and transpiration through plant tissue

Energy

Energy supplies appear to be an important issue for a number of reasons. Electricity transmission efficiency rates are reduced in hotter weather, and storm events, including those that cause bushfires, may disrupt supply. On the demand side, hotter, drier conditions and increased storm and flooding events, can increase energy demand for cooling and pumping, while necessitating the use of alternative, local generation. Under these scenarios energy costs could reasonably be expected to increase.

Water

Mining operations tend to be water intensive and a warming and drying climate presents considerable challenges, particularly in remote, arid areas like the Goldfields where supply is already constrained. There is potential for there to be competition for water between mining and communities (Moffat 2009; Hodgkinson et al. 2010).

Infrastructure and equipment

Infrastructure and equipment may be vulnerable in terms of damage and disruption by extreme weather events (storms, flooding) and reduced performance under less extreme conditions (e.g. heat waves). In relation to energy and water supply, flash flooding may have the potential to damage critical energy (such as gas) and water supply pipelines. Transport infrastructure (roads, rail) used to import diesel for local power generation, as well as other supplies, services and freighting of ore, may also be vulnerable. Treatment and disposal of toxic waste in tailings dams would also be vulnerable to increased incidence or severity of flash flooding. Infrastructure and equipment tolerances may need to be increased to deal with conditions such as these.

Human resources and safety

Increased incidence and/or severity of extreme weather events, as well as drier and hotter conditions over all, may also have implications for the working conditions and safety of staff. Research with CSIRO mining specialists suggest that human tolerances under projected future hotter conditions may be a greater limiter to future mine design and operations than equipment and machinery limitations (Moffat 2009). It was suggested that employees will be less willing to work in hotter conditions, and that these conditions may also represent an emergent occupational health and safety issue in the future.

Community impacts and relations

Many of the effects noted above have potential knock-on implications for surrounding communities. For example, infrastructure damage and loss due to extreme weather events are likely to impact on local communities that also use these structures. Increased dust due to hotter, drier conditions is also likely to be of concern to communities. Increased use of groundwater in mining activities, and the potential escape of material from tailings dams due to flooding will be of concern to local communities. Finally, as already identified, as water becomes less available under future hotter and drier conditions, there is potential for conflict between mining, community and other sectoral users of this resource (e.g. environment, cultural heritage, agriculture, manufacturing).

4. Climate change vulnerability and adaptive capacity assessment

This section provides an overview of a general framework for assessing climate change vulnerability and adaptive capacity. Climatic change may bring opportunities and benefits as well as risks, and both need to be considered. However, most analyses tend to take a vulnerability assessment approach. Climate vulnerability is generally expressed in terms of 'potential impact' (derived from exposure and sensitivity), which, when combined with 'adaptive capacity', leads to an estimation of vulnerability (Figure 3).

Exposure refers to the types of environmental stimuli or changes that represent a potential threat, such as heat waves, more frequent and/or intense storm events, rainfall decline and so on.

Sensitivity refers to how great the impact will be on a system for a given change in condition. For example a 1°C increase in average temperatures may reduce production efficiency or increase dust output by a certain percentage.

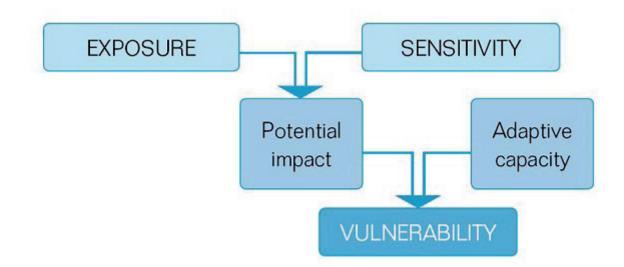


Figure 3. Model for assessing vulnerability (Garnaut 2008 p. 125)

Adaptive capacity refers to the ability of a system to respond constructively to these changes so that detrimental affects are minimised, and any opportunities for improvement are exploited. Adaptive capacity tends to be mainly understood in terms of social, economic and technological characteristics, although biophysical characteristics such as alternative natural resources (e.g. water supplies) can also be important. These factors are sometimes referred to in terms of resource capacity, as expressed in the sustainable livelihoods model developed by Ellis (2000). This model identifies five types of capital available for adaptation: human, social, financial, physical (infrastructure, technology) and natural (biophysical). However, any final assessment of adaptive capacity requires an assessment of adaptation options and strategies utilising these resources (see for example, Nelson et al. 2007; Nelson et al. 2010; Parks et al. 2009; Preston & Stafford Smith 2009).

Finally, while assessments of potential impacts and adaptive capacity will produce a calculation of (net) vulnerability, converting this to an assessment of climate risk requires consideration of the probability or likelihood of the various components that make up the model (Preston & Stafford Smith 2009).

4.1 Dealing with climate change: a process tool for regional assessment of climate adaptation options

It is apparent from the overview above that there are potential implications of future climate variability and change for the mining industry for a broad range of individuals, professions, organisations and groups. Furthermore, there are likely to be inter-connected outcomes as the effects on one party (such as increased costs of energy and transmission infrastructure) potentially have implications for many others. For this reason it is important that any approach to climate adaptation, including vulnerability assessment and strategy development, be undertaken at both the organisational level and at the broader integrated community and/or regional level.

Work within the CSIRO investigating community climate adaptation planning has suggested that any approach needs to consider a range of dimensions (see Figure 4). These include:

- What is being adapted to (e.g. what are the projected future climate conditions?)
- How adaptation can take place (e.g. what resources can be mobilised, what strategies and options are available?)
- What are the objectives of adaptation (is it specific or comprehensive, limited adjustment or transformational?)
- Who is involved in the adaptation process (e.g. will it be autonomous individuals and organisations or broader collective institutions such as regional planning groups?).

In addition to these considerations, lessons for community assessment from various vulnerability, capacity and adaptation studies (Hay & Mimura 2006; Ziervogel et al. 2006; Fussel 2008) suggest that broader, integrated assessments are required that:

• consider a range of major related variables or issues that are likely to affect the area's future; for example, demographic shifts, land-use changes, new technologies, industry trends;

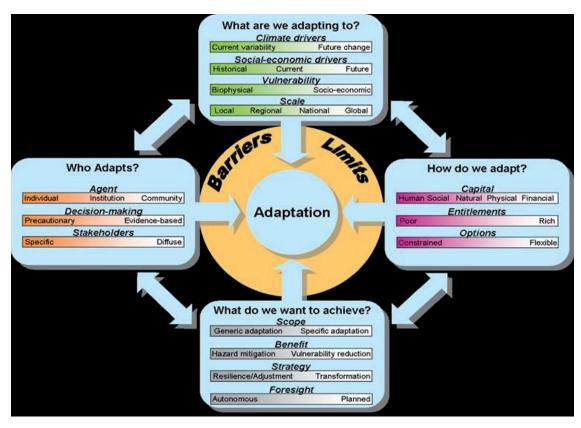


Figure 4. Dimensions of adaptation (Source: Preston and Stafford Smith 2009)

- are integrated into on-going/ pre-existing community development and risk management processes, structures and pathways; and
- help assess not only community vulnerabilities and capacities, but also include risk planning (risk management/ mitigation options).

4.2 Stakeholder engagement for climate adaptation

Work within the CSIRO by Gardner et al (2009) has provided a useful framework for engaging a range of industry, government and community interests, or stakeholders, in relation to issues of climate change. This framework incorporates suggestions from a broad range of literature related to community engagement to establish best practice guidelines. The recommendations provided by Gardner et al (2009:6) are listed briefly below:

- Prior to engagement: set goals and plan; contextualise the issue; define the stakeholders; manage expectations.
- Engagement processes: use group discussion; use varied presentation formats; allow mutual influence; foster trust, respect and ownership.
- Climate change issues: address gaps in knowledge; acknowledge uncertainty; address scepticism; address emotional reactions.
- Engagement follow-up and evaluation: maintain contact and feedback; plan evaluation from the outset; evaluate both process and outcomes; acknowledge other impacts.

The report incorporated a range of features specifically relevant to the issue of adaptation to climate change that have implications for engagement. These features included: the highly contextualised nature of climate change; the complexity of climate science and presence of misinformation and scepticism; people's typical reactions to uncertainty; and variations in the capacity for long-term planning. While some aspects of the climate change issue may make engagement more difficult, other aspects, such as its context specific nature and potential for significant impacts were considered likely to increase desire for engagement. However, the report also notes that communities are not homogenous and different individuals and stakeholder groups within them may require different engagement strategies appropriate to their stage along the pathway to taking action.

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5. Workshop methodology and agenda

5.1 Workshop Aims

The workshop held in Kalgoorlie-Boulder on August 16th 2010 brought together 23 key regional stakeholders from the mining industry, mining services sector, utilities providers, state and local government, researchers and representatives of community to explore the implications of climate variability and change for the GE region (see Appendix A for the list of participating organisations). The workshop was supported financially and logistically by the Goldfields-Esperance Development Commission (GEDC) in collaboration with the CSIRO Climate Adaptation and Minerals Down Under National Research Flagships. It was held as part of the Australasian Institute of Mining and Metallurgy (AusIMM) Sustainable Mining conference program.

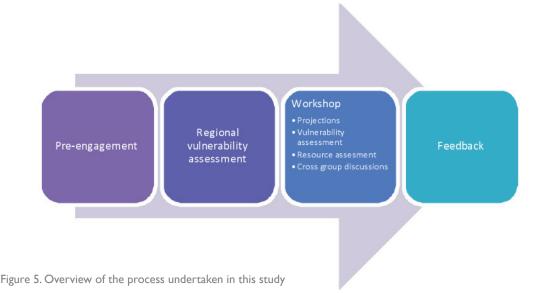
The workshop had three aims:

- I. To provide information and concepts to the participants in relation to climate variability and change, and strategies for adaptation.
- 2. To explore the implications of these data for each of the groups represented and across the mining value chain through structured discussions to inform ongoing CSIRO research.
- 3. To develop a network of stakeholders in the GE region to engage in collaborative adaptation planning in the future.

5.2 Method

The workshop format was adapted from previous CSIRO research in Australian broad acre agriculture exploring adaptation issues for rural communities (Nelson et al. 2010) and in the Pacific exploring adaptation issues with island nations (Park et al. 2009). These research approaches used environmental vulnerability, based on climate projections, and social assessment tools to generate a holistic understanding of community adaptive capacity.

The broad structure of the workshop process is laid out in Figure 5. There were four main components of the process: pre-engagement interviews with attendees, a desktop regional climate vulnerability assessment, the half-day workshop itself, and a follow-up feedback survey to gauge satisfaction with the workshop. The first two components were undertaken prior to conducting the workshop to gain an understanding of the region and issues relevant to the workshop topic to ensure its relevance for attendees. Pre-engagement interviews were undertaken with a representative range of those who had accepted an invitation to attend the workshop (about half those accepting an invitation were interviewed). Additionally, the workshop content was guided by a desktop Regional Vulnerability Assessment (Loechel et al. 2010) a copy of which was provided to participants on the day. This comprised research and analysis regarding the characteristics of the region, prior research on likely impacts of climate change on mining,



including the outputs of an earlier workshop conducted with CSIRO mining experts, and an overview of climate projections and potential implications for the regional mining community.

The third component of the process was the half-day workshop itself. Workshop participants were assigned to their respective stakeholder or sectoral group as defined in Figure 6. Each group was guided by a CSIRO or GEDC facilitator. The workshop included four main stages. First, information regarding past and future climate of the GE region that was developed by CSIRO scientists was presented to participants. The information included global, national and regional climate trend analyses and climate projections for key Australian mineral provinces, including the WA Goldfields.

The second stage of the workshop involved examining the likely vulnerability of the mining industry and community to climate change based on the information provided on regional climate projections. Sessions were structured to allow for sector-specific discussion around key issues before engaging in cross-group discussion to explore the interconnections between sectors.

The third stage of the workshop guided participants through an assessment of the resources available to their organisation and sector for adapting to climate change. The assessment was based on the sustainable livelihoods model developed by Ellis (2000), mentioned earlier, which defines five main resources for adaptive capacity in terms of human, financial, social, physical and natural capital (the model and process is described in more detail in the workshop results Section 6.6).

Finally, the workshop concluded with sector presentations of their resource maps or 'spider diagrams' and a crosssectoral discussion of interconnections between groups.

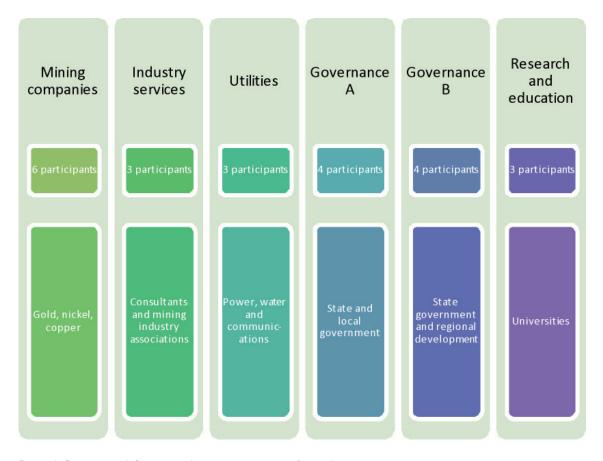


Figure 6. Group type definitions and participants present for each group type

6. **RESULTS**

6.1 Pre-workshop engagement

Prior to the workshop II participants were interviewed to ascertain their main motivations for attending the workshop and their expectations for the day, the major factors or drivers they perceived to be important to the future of their sector, and vulnerabilities, opportunities, adaptation options and strategies they believed to be important in responding to a changing climate.

The resulting comments provided a means to tailor the workshop to their needs and expectations. Common themes that arose during the interviews centred on the mining process, technical issues, utilities, social and environmental issues, governance, information and decision-making, and other general observations and comments.

Rainfall variability and availability of groundwater resources were raised as key concerns for many mining processes. In particular, both flooding and water scarcity caused by changes in patterns of precipitation will need to be considered in adaptation planning. Impacts from hotter conditions were raised as risks to mining processes, as both human and technical resources will be subjected to more intense temperatures and potential failures. This was also linked to the issue of infrastructure integrity, including the ability to transmit power and water effectively to the area under more demanding conditions. These conditions may also reduce the 'liveability' of the area, causing stress in the local population and reducing the attractiveness of the area to mine workers and their families, potentially leading to skills shortages for both the mines and the community. It was also suggested that the availability of credible and situation specific data, together with a supportive political environment, will be crucial for organisations to justify adaptation planning.

More detailed information and discussion on pre-workshop engagement is given in Appendix C.

6.2 Workshop results

In the workshop, participants were provided with an overview of historical climate patterns and future climate projections at a global scale, for Australia, and for the Goldfields regions of Western Australia. Information regarding the variability of future extreme weather events was also presented to participants. Attendees were then given an opportunity to ask questions of the presenter, Steve Crimp, a CSIRO climate applications scientist. The workshop facilitator then asked participants to consider the following four questions relating to future climate variability and change:

- I. What are the key drivers of change or future prosperity for your operation/sector group?
- 2. What are the implications of the climate projections for your operation/sector group?
- 3. What types of factors will influence the vulnerability of your operation/sector group to a changing climate?
- 4. What are the measurable indicators for each area of climate vulnerability in your operation/sector group?

Participants were initially seated with other members of their sectoral group before being asked to share crosssectoral issues and discussion. Participants were grouped into five categories: mining industry and mining services providers, utilities providers, governance (2 tables, included local and state government representatives), and researchers (from universities and West Australian School of Mines).

6.3 Data analysis

A large amount of data was collected during the workshop and analysed for inclusion in this report. Each participant table included a CSIRO or GEDC facilitator to help promote discussion and organise recording of discussions. Table discussions were noted and reported back to the whole group. Conversations at each table were also audio-recorded for later cross-checking to ensure the content of discussions was accurately represented in the workshop outputs.

Following the workshop, CSIRO researchers collated and organised the workshop outputs for analysis. These outputs were analysed for major and minor themes. A theme was considered 'major' based on a judgement of how *extensively* it was discussed, in terms of the number of *different* topics mentioned in relation to it, rather than simply how frequently it arose throughout discussions within the groups. For example, a theme, such as 'hazards' (in Q.2), while only mentioned by three sector groups, was considered a major theme because it was extensively discussed, in

different ways from a range of perspectives, within the mining industry group, and was also mentioned by both the governance groups. In contrast, minor themes were mentioned across few groups *and* had a relatively limited range of topics related to them. For example, in Q.2 again, the theme 'government regulation' was mentioned by as many sector groups as was 'hazards' but because discussion related to it was narrower in its scope than for 'hazards', it was only considered a minor theme.

The major and minor themes for each discussion question are summarised below. A detailed list of the themes generated, with reference to which groups raised them for each discussion question, was tabulated and is included in Appendix D.

6.3.1 Question I: What are the key drivers of change or future prosperity for your operation/sector group?

Following presentation of the climate projections, participants were asked to list the key drivers for their operation or sectoral group. The aim of this question was to explore the broader context within which climate adaptation will take place for each sector group, to understand how these drivers related to climate change, and to explore any differences and similarities across groups.

Across all of the groups, the most common drivers mentioned related to:

- the economics of doing business and the costs of adaptation,
- · certainty around government policy on climate change, and
- societal pressures.

Other drivers mentioned related to workforce availability, infrastructure costs and regulatory requirements of utilities providers, climate change adaptation and technology. There was considerable overlap in the drivers discussed, as reflected in Figure 7. Each coloured area in figures 7-10 represents a sector group while the numbers represent the various drivers of change identified within each group; the positioning of the numbers thus indicates which drivers were common to which groups. (The *shape* of the coloured areas is immaterial and only reflects the need to provide clear labelling of sector groups).

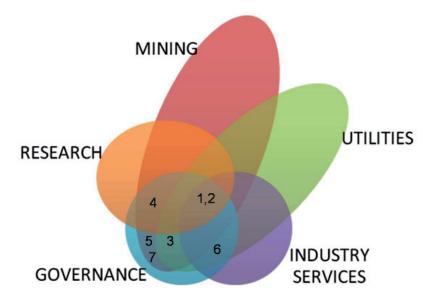


Figure 7. Key Drivers of change or future prosperity by sector group. [I=Economic factors; 2=Policy; 3=Society; 4=Workforce; 5=Adaptation challenges; 6=Infrastructure; 7=Technology (See also Appendix D)]

Economic issues: for the mining sector, this driver related to future commodity demand and prices, in addition to resource input costs (water, energy) and access to capital in a competitive global environment. While these market-economy factors were less broadly discussed by other sectors, references to economic factors across the governance and research sector groups were typically related to the government's provision of funding. The utilities sector mentioned economics both in terms of demand by industry and economic regulation by government, both of which affect their future growth and profitability, including the need to improve infrastructure.

The second major theme across all sectors was the **influence of government**, and the effect of policy uncertainty on activities such as adaptation planning. For the mining company and service sectors this typically related to regulation and taxation issues (e.g. a future carbon tax), for the governance sector this related to environmental regulation and local government reform, while for the research sector the concern was around future levels of government funding.

Societal perceptions, expectations and pressures were another series of drivers and issues commonly discussed across the groups. Heightened societal sensitivity and expectations of resource use by the mining industry (e.g. water, energy) and environmental and social impacts on communities were seen as a challenge. In many cases they were linked to comments about government regulation of mining, as they manifested through the political process or the media to pressure government to make changes to the way mining is regulated.

Workforce and staffing issues were mentioned principally by the mining company, governance and research sectors. The types of issues raised related particularly to high turnover and skills shortages. Infrastructure was discussed in terms of being able to adequately meet future demands, and changing requirements to access more sustainable resources. A variety of climate adaptation challenges, including the pace of climate change and legacy issues were raised, as was the need for rapid technological advancement to meet these challenges.

6.3.2 Question 2: What are the implications of the climate projections presented for your operation/sector group?

Moving from thinking about the broad range of issues affecting their sector, to those more specifically related to climate change, a broad range of 'major' themes were evident. The theme areas identified within each sector group are displayed in Figure 8. The major themes identified by the groups included:

- use of scarce resources (principally water and energy),
- impacts on environment and community,
- hazards and workforce issues,
- · infrastructure impacts, and
- mine planning and design.

The main issues raised by the **mining sector** related to the effects of extreme weather events, such as: damage to infrastructure; the need for greater onsite storage of supplies such as diesel, reagents and water in the case of loss of access flooding; and hazards and safety issues such as flooding, slope instability, and wind-blown debris. Improved mine planning, design and technologies to deal with extreme events were also mentioned.

The **industry services group** focussed on issues to do with: business analysis and reporting; complying with regulations; dealing with the increased need for, or community expectations of, improved management of scarce or costly resources such as water and energy; and, attracting workers to mining communities.

Utilities representatives mainly focussed on implications for infrastructure, in terms of its location, damage from extreme weather events and design requirements. They also mentioned that additional infrastructure and/or different types will be required to provide resource security (e.g. energy, water).

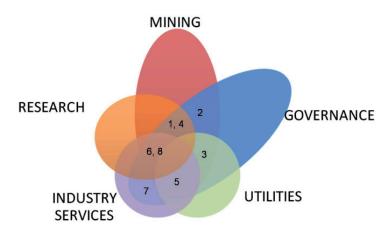


Figure 8. Implications of climate projections by sector group: I=Economic factors; 2=Hazards; 3=Infrastructure; 4=Mine planning and design; 5=Resource use; 6=Workforce issues; 7=Policy; 8=Impacts on environment and communities. (See also Appendix D)

The **governance A group** considered impacts on the mining industry, the community and the environment. They included increased water costs due to access and scarcity issues, broader national economic and population health impacts of climate change, and the combined effect on the environment of land clearing and climate change.

The **governance B group** focussed on how governments typically interested in city and coastal issues may neglect regional areas, and that this could have major implications for mining community adaptation to climate change. Key limitations were seen as inappropriate policies and lack of funding. A potential (partial) solution was seen in industry being willing to assist local government in terms of provision or funding of infrastructure. Other issues raised by this group included: the difficulty of attracting and retaining the mining workforce in regional areas with increasing temperatures and preferences for coastal climates; understanding the impact of changing mining practices, such as increased automation; and, the affect of more extreme heat waves on infrastructure maintenance.

The **research sector group** mentioned the need for mining education, training and research organisations to incorporate consideration of climate change impacts in their programs. This included knowledge about risk assessment, and technical design and costings of current and future mines to improve their resilience.

Looking across these different sector groups, a prominent 'meta-theme' emerging was the need for development of infrastructure and technologies that could more efficiently utilise resources, such as water and energy, as they become increasingly scarce or costly under a warmer and drier climate. An interesting aspect of this issue, mentioned by a number of groups, was that water scarcity may lead to increased energy costs. This is because accessing new sources and/or desalinating water may be energy intensive and require additions to the current energy infrastructure. In relation to this, other groups stated that adaptive capacity is strongly related to the costs of adaptation measures, or conversely, funding limitations.

The impact of climate change on the mining workforce was mentioned in terms of both safety issues and the potential difficulty in finding suitably skilled staff. Safety concerns were mainly related to the hazards posed by extreme weather events, such as cyclones, storms and flooding. An issue that was raised principally in relation to the impacts of climate change on the community, but equally relevant to the mine workforce, was health risks from shifting geographic occurrence of disease. Difficulty finding suitably skilled staff was partly seen as an impact of less amenable working conditions and partly related to a lack of relevant education and training.

Impacts on the environment and community were discussed in relation to protecting the environment from fire under hotter and drier conditions (mining sector), heightened community expectations for responsible mine management of scarce resources (industry services), national economy and population health impacts from climate change (governance A), perceptions that hotter/drier conditions will exacerbate coastal/ regional tensions (governance B) and expectations that mining education provision should incorporate climate change aspects (research sector).

Interestingly, economic factors and government regulation, two major themes in the preceding discussions, were mentioned far less. In relation to government regulation, this is possibly because it was emphasised in the introduction to the workshop, and in the explanation of this specific question, that the focus should be on direct climate change impacts, rather than those brought about by government policy responses to climate change (e.g. emissions mitigation). Further, in regard to economic factors, although many items related to issues that could arguably ultimately have a financial cost, such as infrastructure 'damage' and 'changes', 'new technologies', 'increased renewable energy use' and 'attraction & retention of workforce', this cost was often not explicitly mentioned.

Overall, it is evident that participants felt that climate change would require adaptation within both the mining industry and its communities to more efficiently use scarce resources, upgrade and/or modify the infrastructure serving them, as well as mine designs and operations, and to safeguard employees and the surrounding communities and the environment.

6.3.3 Question 3: What types of factors will influence the vulnerability of your operation/sector group to a changing climate?

While the previous question identified those areas where each group were vulnerable to climate change, question three sought to identify the types of factors that would affect each sector group's vulnerability. The main issues or factors affecting vulnerability that recurred across the sector groups were (see Figure 9):

• access to the essential resources (e.g. water, energy, funds) and infrastructure needed to adapt to climate change;

- access to necessary information and knowledge (which can be seen as another form of resource); and,
- the degree of behaviour change required across all sectors of society (businesses, government and community) to address the challenges of climate change and increase adaptive capacity.

Although access to key resources, infrastructure and knowledge, and acceptance of behaviour change were the dominant themes across sector groups, a broad range of additional factors were seen as influencing vulnerability to climate change. These included: government policy leadership (linked to the issue of behaviour change); the costs, risks and returns associated with adaptation measures (emphasised under Q.2 above); society-wide impacts, pressures and expectations that tend to influence government policy and regulation; availability of appropriately skilled workers (who, again, can be seen as another form of resource); and the connections between issues and inter-dependencies between sectors that lead to cumulative and/or compounding knock-on effects across them.

The main factors identified by the **mining sector** were:

- the availability of detailed and credible information and knowledge (e.g. vulnerability thresholds, location specific climate projections, the availability of scarce resources, and adaptation methods);
- acceptance of the need to adapt within the business community; and
- understanding the interacting effects of climate events across the supply chain.

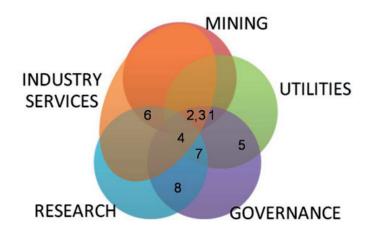


Figure 9. Factors that will influence vulnerability to climate change by sector group: I=Access to resources; 2=Behaviour change; 3=Knowledge; 4=Costs and risk/return; 5=Policy and leadership; 6=Cumulative impacts; 7=Society; 8=Workforce. (See also Appendix D)

Factors mentioned by the industry services group included:

- unwillingness to change within the government and business community;
- maladaptive responses such as poorly thought out solutions (for example selecting insufficient emergency power sources);
- risks related to investing in new technology under conditions of uncertainty; and,
- global climate change impacts that have a knock-on effect to local industry (for example damage or disruption to the supply chain or change in demand for commodities).

The **utilities sector** nominated their main influencing factors as:

- a lack of agreement at the federal or state government level regarding climate change policy, which made it difficult for utilities companies to justify the cost of adaptation measure to their regulators; and,
- change of culture in society regarding the way utilities are used and valued, affecting capacity requirements and the ability to source alternative supplies, and therefore the ability of companies to provide a service.

The types of factors the governance A group identified included:

- government leadership or political will on the issue, which affects funding levels to address it;
- the speed with which the climate changes, which affects time available to adapt and the costs of doing so;

- the scarcity of resources such as funds, human capital, essential services and infrastructure to apply to the problem (which is again linked to government leadership and priorities); and,
- societal issues such as increased population pressures, consumerism, unemployment and increasing health needs of an ageing population.

The **governance B group** focussed focussed on the ability of state and federal government to provide practical policy solutions to adapt to climate change as a key factor contributing to the overall mining community vulnerability. They mentioned issues such as:

- the need for improved assessment processes;
- alternative funding systems for public infrastructure;
- policy, methods and technologies to better manage scarce resources such as water; and,
- the need to meet increased demands for information, including baseline environmental monitoring.

Factors seen as affecting the capacity of governments (and communities) to respond to climate change included declining resources, lower volunteerism and the increased power consumption required to manage infrastructure. The point was made that infrastructure was designed for optimum performance under current climatic conditions and any change in conditions would inevitability reduce the performance and increase the cost or maintaining this infrastructure.

The **research group** focussed on the factors they saw as influencing the vulnerability of the mining sector and identified that hotter working conditions in the mines, together with the problems of work-life balance brought about by fly-in fly-out work schedules, may reduce the capacity of the mining sector to attract the human resources they needed. They also discussed greater risks and costs involved in mining under new climatic conditions that could reduce returns; and knock-on effects between mines and other stakeholders, as well as the cumulative impacts of multiple mines, which could create community tensions.

6.3.4 Question 4: What are the measurable indicators for each area of climate vulnerability in your operation/sector group?

This question sought to identify the types of specific, measurable indicators that could be used to identify vulnerability for each sector group represented. The most commonly identified indicators across all the sector groups fell into three major categories (see Figure 10):

- <u>economic indicators</u>: for example, input costs for mining such as overheads and materials costs, commodity prices, insurance premiums, a potential carbon price being implemented, and the consumer price index (CPI) in relation to prices generally being driven higher as a result of climate change effects;
- infrastructure capacity measures: such as load demands, supply disruptions or faults, and maintenance schedules; and,
- <u>social indicators</u>: particularly those related to behavioural change and political support for addressing climate change problems.

Other indicators mentioned included: mine production measures; natural resource availability, particularly water; weather and climatic conditions; and workforce or human capital related indicators (e.g. health and safety, skills gaps).

The **mining** sector focussed on natural resource indicators such as water availability and production measures such as the number of days lost to wet weather. The **mining industry services** group nominated policy and behavioural change measures and economic indicators such as commodity prices and technology costs. The utilities group focussed on infrastructure related indicators such as load demands and faults related to weather events, as well and natural resource (water) measures.

The two **governance** groups nominated social indicators relating to behavioural change and support for new policy measures, and indicators that measured the demand for, and ability to provide, public infrastructure. The **research sector** first sought to define vulnerability, viewing it as the risk of adverse events, including the costs once these had occurred. In terms of measures of vulnerability relevant to their sector, they nominated the number of people that would be needed to be trained to plan for and develop the solutions to adapt to climate change, which had implications for funding requirements for their sector.

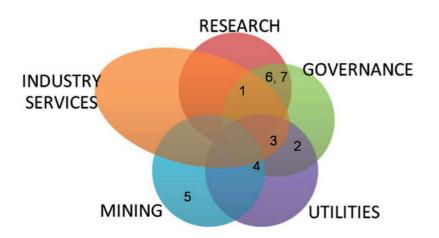


Figure 10. Measurable indicators for each area of climate vulnerability by sector: I=Economic indicators; 2=Infrastructure change; 3=Social/behaviour; 4=Natural resources; 5=Production indicators; 6=Weather/climatic indicators; 7=Workforce/HR indicators. (See also Appendix D)

6.4 Climate change implications: mixed-group discussion

One of the key aims of the workshop was to explore climate change implications and adaptation strategies across a range of stakeholders in the mining industry. Following the sector group discussions, each sector group presented a summary of their findings across the four questions to the entire group. Workshop attendees were then asked to move to different tables and form cross-sectoral groups to discuss the common issues and interactions that were emerging, as well as any differences. Attendees were asked to consider three questions:

- Was your group thinking about vulnerability differently to other groups?
- Do you have different definitions or indicators of vulnerability?
- Which issues are common to multiple groups and which are unique to specific sectors of the mining industry?

A diverse range of themes emerged from the cross-sectoral table discussions. These have been divided into major, medium and minor themes, based on the frequency of occurrence across the discussions, and summarised in Figure II (see Appendix D for a more detailed list of the discussion points generated).

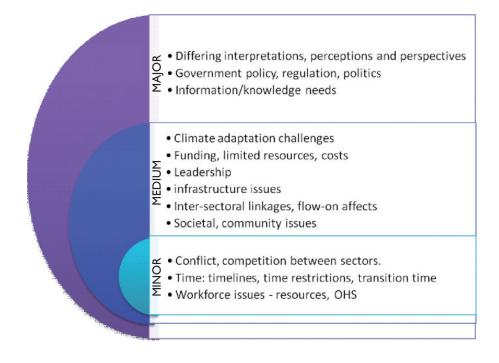


Figure 11. Relative incidence of discussion points for each topic raised. (See also Appendix D)

Many comments by the mixed sectoral groups referred to the **diversity of interpretations, perspectives and focus** across the various sectors. As could be expected, participants noted that each sector group emphasised different aspects or had a 'different slant' on the same issue or question. These differences in perspective were sometimes related to comments about potential conflict and complexity in dealing with issues. However, some groups noted that similar themes ('governance' and 'societal') arose across the different groups and that there were 'no violent disagreements' between sectors.

A second major theme related to the importance of **government policy and regulation**. This was tied to the issue of leadership; namely, the need for a political resolution and policy direction that would provide impetus for action on climate change adaptation by business, community and government entities across Australia. It was also linked to the issues of the need for better information and of funding or resource allocation to support climate change adaptation. Comments such as "waiting for government (and) credible data" and "need to influence government to obtain funding to respond" exemplify some of these sentiments. Without a definitive policy direction, as represented in legislation and regulation for a collective national response, and credible, situation-specific information, it was considered difficult for some organisations to justify allocating resources to take action. For mining companies, while they were less dependent upon government leadership to take action, they also wanted better climate projection information and certainty around a range of policy issues related to climate change action, although the driver for decisions (cost-benefit analysis for taking specific actions) was different. However, on issues such as water efficiency the mining industry representatives felt that immediate benefits may be realised through action independent of other decisions.

While the diversity of sectoral perspectives was emphasised, another prominent theme was the inter-dependencies between sectors. Many issues, such as water, energy and infrastructure, were considered to be critical inputs to a range of sectors. Additionally, the flow-on effects of impacts and vulnerabilities in one sector leading to consequences for other sectors was often mentioned. Similar to the differences in sectoral perspectives, these inter-sectoral linkages and interdependencies were likewise seen as contributing to the complexity of the climate vulnerability issue and were another reason cited for the need for governance leadership. One group mentioned the need for "taking leadership to bring together different stakeholders to seek common purpose" while other groups noted "everything is dependent on everything" and "vulnerability is more complex than we tend to think".

Issues related to the **workforce and human resources** ("inability to attract and retain people"), **infrastructure** ("previous design/specs versus future conditions") and social and **community perceptions and impacts** ("socially – everyone's affected"), were similar to those mentioned within the sectoral group discussions summarised above. These were often related to a broader range of adaptation challenges or barriers, such as the need to "figure out what climate change actually means practically to operations", which is also related to the need for specific and relevant information, and to be "innovative and creative" in dealing with the potential challenges under conditions of uncertainty and limited funds.

Another issue occasionally cited, typically in terms of a challenge to adaptation, was that of **time**. This included the view that "different (sectoral) perspectives (of) timelines" could exacerbate vulnerability. The time potentially wasted "waiting for government" to show leadership was contrasted with the capacity for early organisational leadership which could reduce the transition time to a more resilient condition.

6.5 Summary of the vulnerability session

Reviewing responses to all the vulnerability questions, including the inter-sectoral session, a number of key themes are apparent. These are:

- economic factors supply and demand, costs, risks and returns;
- government policy, leadership, funding;
- societal, community and environmental issues expectations, pressures, behaviours and impacts;
- workforce and human resources labour supply, skills gaps and health and safety;
- infrastructure, technology and technical concerns;
- information and knowledge needs.

As is the case across society, the place of economic factors, government policy and community expectations are fundamental to climate change vulnerability and adaptive capacity within the mining industry and its associated stakeholder groups. In addition, it is evident that the availability of a range of 'resources', broadly defined, that support mining businesses and communities, such as water, energy, labour, infrastructure, technology and knowledge, will be critical considerations. Considering the important role that mining plays for the GE region, the impacts of future climate variability and change on these 'resources' have implications beyond the mining value chain. Specifically, the relationship between local populations and workforce availability, implications of climate change for mining and public infrastructure, and the need for quality information to inform decision making regarding adaptation options, illustrate the deeper connection between mining and communities in the GE region.

Industries, services and communities dependent upon mining are vulnerable should mining suffer from climate change and similarly, mining may suffer if these groups were not there to support them due to non-adaptation. Sufficiently adapted and maintained infrastructure such as roads, railways, water and power would reduce both mining and its communities' vulnerability to climate change just as technical and technological solutions would assist with adaptation and reduce vulnerability.

Importantly for future strategic and collaborative adaptation planning, the major issues were mentioned by all of the sectoral groups, although their prominence differed depending on perspective. For example, the themes that tended to recur across the various questions for the mining sector were issues around economics, managing scarce resources, technical and production concerns, and the workforce. These themes can be seen as having direct relevance to the business of mining. In contrast, the governance groups continually emphasised government leadership, policy and funding priorities and the societal, community and environmental issues that government bodies are tasked with managing, as could be expected. However, the governance group also consistently raised economic factors (although this typically related to government funding) and mining workforce issues, while the mining sector group often referred to societal, community and environmental issues. This emphasises that all of the dominant themes had implications for each sector, although the specific way in which they were manifested differed in each sector. Importantly, the recurrence of themes across sectors is also a reflection of the inter-dependencies between sectors, with issues in one sector having implications for others, as was emphasised in the mixed group discussions.

The findings suggest that climate adaptation in mining regions will not only require a focus on these major themes, but also that substantial interaction between sectors will be required to effectively deal with the challenges. While a fully integrated response may not be possible, due to both practical and institutional constraints, it may be beneficial for the various sectors, and for the region as a whole, to pursue multi-sector engagement, interaction and joint-planning as much as possible.

6.6 Defining the resource availability for successful adaptation

The next task for workshop attendees was to assess the availability of resources to support adaptation to the implications identified for their specific sector groups. Participants moved back to their original sectoral tables and were provided with information regarding a framework for categorising and assessing resource availability.

The framework used to assess resource availability for adaptation was derived from the sustainable livelihoods framework applied in other recent CSIRO research on community climate adaptation (Nelson et al. 2010; Park et al. 2009) and originally developed by Ellis (2000) to construct an adaptive capacity index. This framework conceptualises adaptation resources as five primary organisational assets: human, social, natural, physical and financial capital (see Table 2 for examples within a mining context).

Resource type	Description	Indicators	Mining industry examples
Human capital	Education, skills, health	Qualified, experienced	No. of qualified engineers
		staff; labour availability	
Social capital	Social networks &	Connections to other	Membership of mining
	associations (claims	human and organisational	industry associations;
	& obligations)	resources; institutions;	community organisations;
		governance entities	connections to
		and processes; culture	political figures
		and heritage	
Physical capital	Means of production	Infrastructure, machines,	Roads, ports, energy
	and goods derived from	technology;	supply lines, earth-moving
	economic production		equipment, mine housing
Financial capital	Financial assets, income	cash, shares; profit/loss	Cash reserves; share
	streams, access to credit	statements; lines of credit	price/ equity position;
			mine income
Natural capital	Land, water, vegetation	Geographic features;	Exploration leases;
		land area; access to	groundwater availability;
		water; biodiversity	revegetation seedstock

Table 2. Description and examples of five capitals for adaptation

First, each individual was asked to think about how to define each type of capital for their sector and to individually assess the availability of each resource type in order to adapt successfully to future climate variability and change. Attendees were also asked to generate two to three indicators for each type of capital that they could use to evaluate the availability of these resources on a scale from 0 (unavailable) to 5 (full availability) on a 'spider diagram' template provided to participants (see Appendix E for an example). Sector resources were then mapped onto the 'spider diagram' displaying relative resource availability across the five capitals. The group then discussed their individual assessments and developed a consensus group position on the indicators and an average score for each type of capital through discussion. This consensus position was recorded by the groups on a larger version of the 'spider diagram' template (see Figure 12 for an example). Four groups were formed for this exercise: governance (combining both tables), mining industry and services, utilities, and researchers.

6.6.1 Governance sector

The governance group rated their resource capacity as moderate across the different types of capital, with slightly stronger ratings for social capital (Figure 12). They suggested this reflected a strong drive in government agencies to be geared towards the development of social skills and capabilities internally. They stated that human capital availability varied between agencies, with some having much more capacity than others.

With regards to natural capital, the group again selected a moderate value because while most agencies are not overly reliant upon natural capital to fulfil their roles, some do work with this form of capital in the daily execution of their tasks, such as environmental and agricultural agencies. Physical capital (e.g. machinery) was rated quite low as many activities are now outsourced or outside of the domain of local agency control and therefore must be contracted back in. Financial capital received the lowest rating by this group, because although it was mentioned that "governments have all the money", they noted the difficulty in gaining funding for specific local projects. This group did not identify key indicators for each type of capital.

6.6.2 Industry sector

The key finding from this sector's discussion was that even within companies individuals with different roles had different opinions, as did other industry and mining services members. Those in management positions identified that they have to think about adaptation from two points of view: existing businesses and new businesses. It was suggested the latter of these would be easier to adapt than existing businesses because of the sunk cost of deployed infrastructure and technology. In contrast, those consultants present felt they were able to view adaptation from one view point on behalf of a client. Figure 13 thus displays a range of resource positions for the sector.

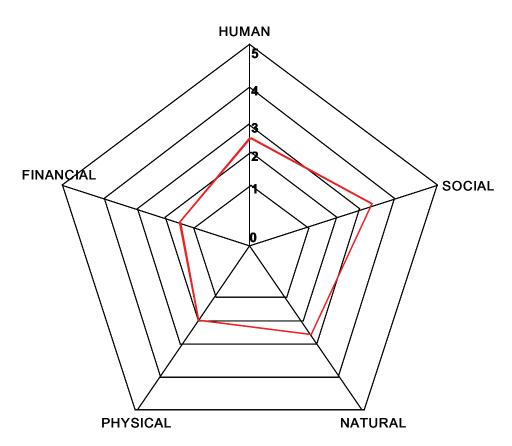


Figure 12. Spider diagram produced by the Governance sector group where '0' represents unavailability of a resource type and '5' represents full availability

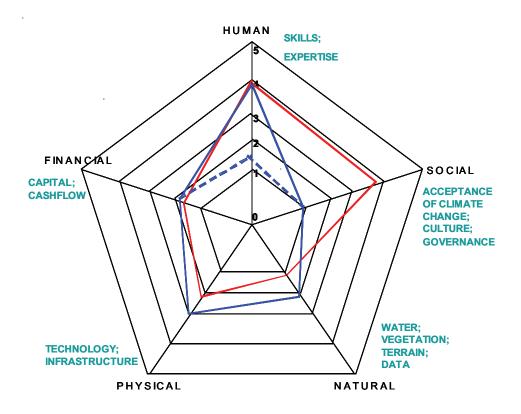


Figure 13. Spider diagram produced by the Industry sector group (blue line: industry [general expertise]; blue dotted line: industry [specific climate adaptation expertise]; red line: consultants to industry).

It was agreed that there is sufficient human capital in both industry and consulting although some parts of industry may lack the sufficient skill sets to follow through with adaptation. In regards to social capital, they reported that consultants are suited to the work of climate change adaptation as their skill set is geared towards social interaction and engagement: a key route to action on adaptation. However, it was felt that industry presently lacks the requisite business structure and culture to drive the concept of adaptation forward, as reflected by the lack of acceptance of the issue in many parts of industry. Natural and physical capitals for both groups were identified as moderate to low and focussed on water, vegetation, terrain and data, as well technology and infrastructure. Financially, it was reported that there is a general lack of cash-flow and capital to drive climate change adaptation, particularly for existing mining operations.

6.6.3 Research sector

The research group could not reach consensus on four of the five capitals as each institution represented had a different set of needs and perspective on adaptation in the mining industry (Figure 14). They also suggested that by "...influencing one of the aspects (capitals) you can then change one of the others" and that there is a strong connection between the capitals. Human capital was rated relatively strong and they suggested that people's skills and numbers of people available would be key drivers/indicators.

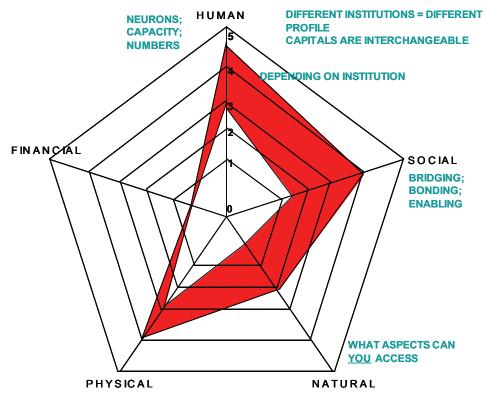


Figure 14. Spider diagram produced by the Research sector group (coloured area represents variation in group members' scores for each capital)

Financial capital was identified as a particularly weak area for all research institutions, while physical capital was identified as being relatively strong. The research group felt social capital was mainly related to bridging, bonding and enabling of people in order to meet the requirements for climate change adaptation. Finally, from a natural capital perspective, the group felt this depended on physical access to different forms of this capital to deploy for adaptation and that this was a contextual question.

6.6.4 Utilities sector

The utilities sector group included power and water providers for the region. Their responses suggested they do not see a particular capital as either lacking or leading, although social and natural capital were the least available relative to the other capitals discussed (Figure 15). Human resources or skills were seen as being somewhat available with skills and being able to work together considered the main drivers for adaptation. Social capital was seen as fairly weak and community engagement was suggested to be the way forward in this area. From a natural capital perspective, also seen as somewhat weak, the utilities companies identified that distance from water source and connection to renewable energy may be of significance.

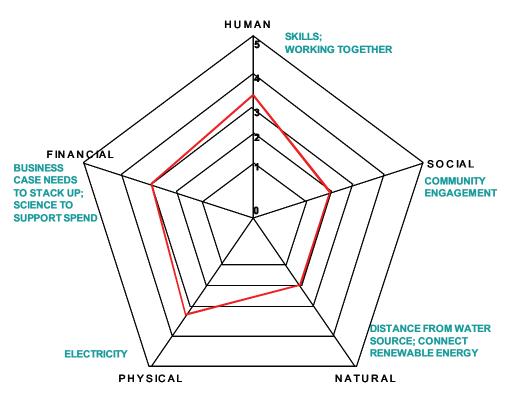


Figure 15. Spider diagram produced by the Utilities sector group

Physical capital was identified as being stronger but electricity was identified as a primary concern considering the climate change implications discussed by this group (e.g. lower transmission efficiency under hotter and drier conditions, capacity increases due to population growth). Finally, financial capital was moderately strong although it was noted that for a business case to be accepted by regulators and investors (e.g. expansion or increases in costs) it must be supported by science, as without credible data the money wouldn't be made available for adaptation to take place.

6.6.5 Summary

Human capital was identified as high by all sectors, suggesting that capabilities are available to find solutions. In contrast, financial capital was nominated as limited in all but the utilities sectors. Physical capital does not appear to be a limiting factor except in the government groups. There were clearly some common strengths and weaknesses between the groups, however where differences exist there may be an opportunity for collaboration and joint-planning.

It was also suggested that although the utilities appear to have money and governments do not, the utilities' funds may essentially stem from a government source or largely be under the control of government. Social capital varied somewhat from group to group, and may be an area where a focus on improved communication and interaction and cross fertilisation of experiences and ideas will be useful. Additionally, utilising social capital resources to influence people and businesses to use less water and energy may reduce demands on financial capital. This is an example of how the different capitals inter-relate in a complex system, as well as of the interdependencies between different sectors.

7. Summary and discussion

7.1 Summary

Overall, vulnerability to climate change and adaptive capacity were viewed within a **broader context** dominated by economic, regulatory and societal pressures that affected each sector's prosperity or functional capacity. Alongside these pressures were a range of resource constraints, such as water, energy, labour, technology and infrastructure that impinged on the capacity of the various sectors to achieve their goals.

Looking at the **impacts of projected regional climate change** more specifically, the main areas of concern were: use of scarce resources (principally water and energy), impacts on environment and community, hazards and workforce issues, infrastructure impacts, and mine planning and design. It is apparent here that a major concern about climate change is its impact on the various resource constraints that currently impinge on sectoral capacity. For example, as heavy rain and intense heat can cause both down time and long-lasting effects on mine equipment and staff, participants identified that processes and affected equipment would require adaptation. Additionally, effects on recharge to water resources would be of concern to those in the region who use dams and groundwater so real time data on rainfall, recharge and evapotranspiration would be of benefit. The increasing need for cooling people and equipment would impact on energy use and costs, both within and external to mines and its operations. Also, external and critical infrastructure such as power lines, water pipelines and roads have been known in the past to suffer from extreme weather events which may become more prevalent in the future.

With regards to **factors that influence vulnerability to climate change**, most groups again identified access to key resources such as water, energy infrastructure, funds, labour and knowledge as being critical. In addition to these, the issue of leadership was viewed as an important factor in enabling future action. Specifically, the need for a political resolution and government policy direction to provide impetus for action across society was emphasised. It was apparent that participants felt that, without a definitive policy direction, as represented in legislation and regulation for a collective national response, and lacking credible information, some organisations will find it difficult to justify allocating resources to take action. Although mining companies may be considered less dependent upon government leadership to take action than other sector organisations, they are similarly dependent on good information.

Other important factors influencing vulnerability to climate change included: the costs, risks and returns associated with adaptation measures; societal expectations that tend to influence government policy and regulation; and the connections between issues and dependencies between sectors that lead to cumulative and/or compounding knock-on effects.

Despite many apparent constraints to action, it was recognised that organisations can be proactive on some issues that would currently provide benefits, such as improving water and energy use efficiency. For mining companies, although it may be easier and less costly to bring 'adapted' methods and processes to new mines than to existing mines, adaptation of the latter may still be effective for health and safety, community and environmental aspects.

Turning to **specific measurable indicators of climate vulnerability**, the dominant measures suggested by participants were economic indicators, infrastructure capacity measures and social indicators. Other measures included mine production figures, natural resource levels, climatic conditions and workforce metrics. The types of indicators suggested differed significantly by sector however, which suggests that at this level of vulnerability assessment quite specific measures are required according to the type of operation or organisational function.

In the **cross-sectoral discussions of vulnerabilities**, both the divergence of perspectives and similarities of concerns between sectors became more apparent. The orientation of each sector or stakeholder group to their particular business or function was recognised, such as the production and business focus of mining companies, and broader community or 'public good' focus of the governance groups. However, also apparent was the similar dependency of different sectors on common resources (e.g. water) and influencing factors (e.g. government policy), and of the inter-dependency between sectors. The flow-on effects of impacts and vulnerabilities in one sector leading to consequences for other sectors was recognised as having far reaching consequences. Both the differences and interdependencies between sectors contribute to the complexity of the climate vulnerability issue.

In relation to the issue of **resources available for adaptation**, it was apparent from the 'spider diagram' assessments that although there may be sufficient human capital capabilities generally across the sectors, lack of balance in the other capitals may need management and collaboration. Requirement for the different capitals within each sector will depend upon the specific nature and scope of adaptation activities required by the particular sector. This highlights the importance of assessing both vulnerability and adaptation strategies, as it is really the latter – "what needs to be done" – that determines the resources or capitals that need to be applied.

It was apparent that the different capitals are interrelated, for example social capital can enable access to, or influence behaviour that may reduce the need for other capitals; while financial capital may be able to purchase some of the others outright, such as skilled labour (human), water and land (natural) and machinery and technology (physical capital). This flexibility of capital use means that some organisations have considerable capacity to change the balance of capitals they hold in order to address different types of tasks, which is important for adaptation. However, while different capitals may be transferred or rebalanced internally within an organisation, the key to regional adaptation may be to enable this to occur between different organisations or sectors. For example, it was mentioned that in some places there are already agreements in place between mining companies and local government authorities to share resources or undertake specific tasks for one another. Proactive planning to determine the types of capitals available in a given region and agreements on how they could be shared to adapt to a changing climate would therefore appear beneficial.

7.2 Discussion

Through the appraisals of both the broader context that influenced sectoral prosperity as well as the various factors that influence their vulnerability to climate change, it was apparent that policy leadership (government and/ or corporate) regarding climate change; 'credible', situation-specific information; and, access to key resources were considered the main ingredients required to instigate preparations for climate change by organisations within the region. Current uncertainties around future government climate policy as well as what climatic conditions will actually eventuate in the region, and therefore what this will mean to individual organisations, were viewed as undermining decisive adaptation responses. While it was mentioned that addressing some issues, such as improving efficiency and security of future water and energy supplies would be beneficial to the region regardless of climate change, it was apparent that other areas such as preparing for more extreme weather events are reliant on convincing high level decision-makers that these measures are necessary.

Regardless of high-level leadership and perceptions of information credibility, a further major constraint affecting vulnerability and adaptive capacity was identified in access to key resources such as water, energy, funds, skilled labour, infrastructure and technology. (The review of the resources available to enable adaptation in the latter part of the workshop organised these according to the five different types of capital). Apart from funds, which may only require authorisation by an organisation's high-level decision-makers to supply, many of these resources may not be readily accessible. Security of essential water and energy supplies, including the infrastructure that underpins them, typically relies upon cooperative action between multiple sectors (different levels of government, utility providers and mining organisation) to develop agreements around supply, demand and price. The availability of appropriately skilled labour, expertise and technology may be constrained by competitive factors (multiple mining developments at the same time) or a lack of specific training and knowledge in the existing labour market and institutional arena (e.g. mining companies, education and research organisations and consultancies may simply lack the experience and knowledge to deal with, and train people for, the new conditions and situations arising). Additionally, it was noted that as climatic conditions changed, people may be less inclined to work in remote inland areas, or due to extreme events, may be unable to access these areas due to disruptions to transportation. For both the security of essential resources and access to skills and technology, supply lags may be considerable. This issue was identified by a number of participants who mentioned the importance of time as an issue in relation to adaptive capacity, particularly with regards to the 'time to transition' compared to the speed at which climate change is taking place.

The issue of access to scarce resources points to the dependencies between sectors, although there were many other examples of common reliance on resources and of 'knock-on effects', as vulnerabilities and adaptation responses in one sector impacted on other sectors. In particular, the discussion about the five capitals underpinning adaptive capacity highlighted commonalities in resource reliance; as well as the possibilities and constraints to sharing capitals between sectors and organisations, and the capacity for behaviour change in one sector to influence vulnerability in others. Another example of interdependency was that of utilities companies regulated by government. Utilities may find it difficult to justify costs for adaptation measures to their regulators and it was suggested that higher government leadership on climate change would greatly assist them in making their case. Further, if communities that surround mining operations are slow to prepare for climatic change (or vice-versa) it may be difficult for the forward thinking mining companies (or communities) to get the other to buy-in to their own plans, increasing the vulnerability of both. These interdependencies also suggest a mix of bottom-up and top-down leadership would appear important to create effective change.

A final issue that merits discussion is the evidence here that climate change, in affecting fundamental aspects of operations (energy, water, infrastructure, labour etc), may usefully be constructed partly as a matter of interconnected business risk assessment and management. In this framework, first, climate adaptation is not simply a 'green' environmental or sustainability issue but, as suggested by Rogers (2010:14), encompasses, and may be best communicated as, an issue of ''risks, costs, service continuity, duty of care, liability, insurance and... reputation''. Second, interdependent organisations are best served by broadening their individual risk assessment processes to encompass a collaborative approach to adaptation as part of their normal management plans.

However, an orientation to risk management should not blind organisations to opportunities to capture any benefits or strategic advantages that arise from climate change. Adaptation and resilience is more than just risk management as it derives from capitalising on opportunities as well as dealing with threats. Overall then, climate adaptation planning may be most effectively implemented through being embedded in the normal risk and broader management planning of the organisation, rather than being a separate 'add-on' to these core activities. Finally, acknowledgement needs to be given to the many uncertainties that still exist around our knowledge of what the exact climate, and therefore, risk (and opportunity) parameters will apply in the future and the likelihood that these will shift over time as our knowledge develops (White and Etkin 1997).

8. Future work

While the findings from this workshop suggest that future action on preparing the region for climate change may be somewhat affected by uncertainties surrounding higher level government and/or corporate leadership in this policy area, there are nevertheless possibilities for advanced preparation to commence immediately. Apart from the specific assessments and planning by individual organisations, which is possible with currently available information (including that provided in this report), it would appear highly beneficial for a more integrated multi-stakeholder response to be initiated.

Involvement of all the major sectoral groups would enable detailed mapping of key vulnerabilities for the region, including tracing the specific linkages or 'cascading effects' between sectors under different scenarios, and identifying specific measures and indicators to facilitate adaptation. Importantly, it would enable development of integrated responses to climate change, in terms of what adaptive measures are required by which sectors, and how the various resources held by each can be utilised in efficient and effective ways to improve the preparedness of the region. Of importance here will be gaining a realistic understanding of, and ideally, agreement upon, practical resource sharing measures by the various sectors. We would also encourage future work in climate change adaptation planning to be integrated into on-going and/or pre-existing regional development, risk management and planning processes and structures, rather than being an isolated activity.

Practical measures to consider in climate change risk assessment and adaptation planning include:

- Continuing to identify opportunities to engage stakeholders and build momentum to prepare the region for climate change (e.g. initiatives by individual organisations may be able to be expanded to consider a broader range of stakeholders)
- Work with, and build upon, current or pre-existing mechanisms and processes to improve the regional adaptive capacity (e.g. include consideration of mining aspects in any general assessment of climate vulnerability and adaptive capacity that is initiated in the region; and/or encourage the embedding of climate risk assessment in normal planning and risk management processes of organisations)
- Establish a multi-stakeholder regional climate adaptation initiative, perhaps hosted within a relevant and credible local organisation to engage the various stakeholders
- Identify regional 'champions' for climate change adaptation within any of the stakeholder groups who can assist in influencing others and providing resources to support the process at different points
- Set an overall goal for a desired outcome (e.g. an integrated multi-sectoral regional climate adaptive capacity report) and the various milestones required to get there (e.g. individual sector reports).

9. Conclusion

The Goldfields-Esperance region is currently a prosperous mining community. Nevertheless, the mining industry upon which it depends faces a range of future challenges including climate change. The region's climate is expected to become warmer and drier with increased incidence and severity of extreme weather events. These changes are expected to pose a range of challenges to the region in terms of water, energy, infrastructure, human resources and mining-community relations. Dealing with these issues will require careful assessment of vulnerabilities, opportunities and adaptation options by individual organisations. The greatest value for the region will be achieved through engagement processes that integrate climate adaption planning across a broad range of regional stakeholders.

The workshop identified some major aspects of climate vulnerability in the Goldfields mining region, from a range of sectoral perspectives. The results have provided an insight into the broader contextual drivers of future sectoral development, specific climate change impacts expected or perceived, factors that are likely to influence sectoral vulnerability, and specific, measurable indicators of vulnerability for each sector. Significantly, it has illuminated many of the cross-sectoral vulnerabilities and interdependencies that exist. In addition, the examination of the capacities of each sector in terms of the five capitals, together with the adaptation challenges and options identified in the course of this vulnerability analysis, has increased our knowledge of the adaptive capacity of the region.

A key finding that is common across both the vulnerability and adaptive capacity sessions was that while there were differences in sectoral vulnerabilities, needs and capacities, the sectors were bound by inter-dependencies. Not only were different sectors largely influenced by similar issues, with dependency on critical infrastructure and resources, economic conditions, government policy, and societal pressures chief amongst these, but climatic impacts in one sector appeared likely to have significant implications across most other sectors. This would suggest that it will be beneficial for different sectors to pursue communication, interaction and joint-planning as much as possible. While a fully integrated response may not be possible, or desirable, due to both practical and institutional constraints, a central and engaged regional organisation would seem well placed to facilitate an optimally integrated approach into the future.

This report is the first of a series of regional CSIRO reports on perception, attitudes and adaptation requirements for and within the whole of the mining value chain. The Goldfields mining industry climate change adaptation workshop reported here is an important step along this journey and has provided valuable information on perceptions in the mining sector of this region.

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Appendix A: List of participating organisations

360 Environmental AMIRA International AngloGold Ashanti City of Kalgoorlie-Boulder Department of Environment and Conservation, WA Department of Mining & Petroleum, WA Gold Fields Australia Goldfields-Esperance Development Commission HAC Consulting Main Roads WA Nickel West, Stainless Steel Materials, BHP Billiton Oz Minerals Telstra Country Wide WA Chamber of Minerals & Energy WA Country Health Service - Goldfields, WA Dept. of Health Water Corporation Western Australian School of Mines, Curtin University of Technology

Western Power

Appendix B: Workshop partner organisations

Goldfields-Esperance Development Commission (GEDC)

The Goldfields-Esperance Development Commission (GEDC) is a Western Australian State government agency committed to encouraging and promoting economic and social activity in the Goldfields-Esperance region of Western Australia. The GEDC aims to maximise job creation, improving career opportunities in the region and development of the region's economic base. The Commission also aims to provide information and advice to promote business development within the region. Receiving an annual budget from the State Government to carry out its activities the staff are located in Kalgoorlie-Boulder, Esperance and Leonora and coordinate the day-to-day activities of the GEDC.

Supported logistically and financially by GEDC, this workshop provided a forum for local companies, governance bodies and community representatives to learn more about climate change in the region and discuss potential effects and requirements for them to adapt to the new conditions in the future. This report is available to the commission, local businesses, and the general public through the GEDC website and CSIRO publishing.

Australasian Institute of Mining and Metallurgy (AusIMM)

The Australasian Institute of Mining and Metallurgy (The AusIMM) represents the interests of professionals associated in all facets of the mining, exploration and minerals processing industries. It has a focus on 'Enhancing Professional Excellence', providing professional development opportunities for its members. The AusIMM represents and supports a 10,000-strong membership base which is located in a network of Branches throughout the Asia Pacific region, and with a growing international member base.

The Sustainable Mining conference was the first AusIMM Conference to focus on operational aspects of meeting sustainable development challenges. The CSIRO/GEDC mining and climate adaptation workshop was held on the first day of this conference.

Appendix C: Pre-Workshop engagement interviews

Prior to the workshop, interviews were performed with 11 workshop participants to ascertain the following:

- their professional and organisational background;
- why they are attending the workshop and their expectations of it;
- the major factors or drivers they perceive important to the future of their sector, and;
- the vulnerabilities, opportunities, adaptation options and strategies they see as important in responding to a changing climate.

The resulting comments made by the participants were able to be divided into common themes around the mining process, technical issues, utilities, social and environmental issues, governance, information and decision-making, and general observations and other general comments. Each set of responses is presented below, although there were clear overlapping themes within the data. Where an adaptation option was suggested by a participant this has also been included.

Mining process

Interviewees discussed four specific themes related to the mining process and climate change:

- water (rainfall variability and groundwater availability),
- · heat impacts on energy requirements and availability,
- infrastructure integrity (e.g., tailings dam tolerances, transport routes),
- the constraints of mining where ore bodies are found.

Participants identified that if climate change impacts on water, both in the forms of precipitation and as a resource (surface or groundwater), then the mining process will be affected and adaptation may be a requirement. If groundwater becomes an unviable source, piped-in water may be too expensive to use as a replacement, even if it is available. Exposure to heat may impact on both human and technical resources in a two-fold manner: the heat will directly cause additional stress to people and equipment causing potential failure more frequently; increased heat may result in the mine using more energy for cooling. For the mining process itself, adaptation was seen as particularly important for the industry as mining operations are constrained in their location by the ore bodies they are seeking to exploit. Relocating processing infrastructure was also viewed as too expensive to be economically viable, again highlighting adaptation as a necessary strategy for continued success in the industry.

Technical

Themes within a discussion of "technical" implications of climate change included:

- equipment efficiency under future climate conditions
- impacts of infrastructure (e.g. road) failure on mines and communities
- resource conflict (e.g. water)

Equipment including power transformers, vehicles and mining equipment that is currently stressed under expected 'extreme' conditions may cope less as such conditions gradually become more frequent with such failures causing productivity losses. Changes to the climate can cause infrastructure degradation causing a mine site or town to be cut off and resources in or out of a mine to be stranded or delayed until repairs are made. If recharge decreases and/ or evapotranspiration increased, groundwater resources presently used will become even more stressed as they are accessed by more mines, industries and communities. Building of gravel roads for example, in remote areas, may become a costly exercise if current water resources used for that activity become severely depleted and external supply must be transported in. Additionally, more stress will be experienced by people in hotter, drier or more flood-prone pits and equipment maintenance will be increasingly more difficult.

Utilities

The role and implications for utility providers under future climate conditions was discussed. Specifically:

- power transmission is less efficient under hotter conditions and extreme weather events (e.g. storms) may increase the risk of infrastructure failure and consequences such as bush fires
- an increase in population in some mining centres will increase the demand for water and power

With the GE region hoping for growth in population and business activity (GEDC & DLGRD 2006), utility providers will need to cope with increased demand under more difficult operating conditions.

Social and environmental

The GE region contains globally significant ecological areas (e.g., western woodlands) that may be under threat in future climate conditions from higher temperatures and increased risk of bushfires. Local liveability under future conditions, particularly for the Goldfields area, was also a concern.

Governance, information and decision-making

Finally, taking action to address the impacts of climate change in the GE region centred around the relationship between governments at all levels, mining industry stakeholders, and local community attitudes. Decision-making about climate adaptation measures appears strongly dependent on good quality information (credible and situation specific) and a supportive political environment. The political aspects are more important to organisations more closely linked to government, such as local government bodies that rely on constituent support and may be heavily influenced by politically powerful local identities; and utilities companies who answer to government regulators. However, it is likely that government policies and regulation related to climate change, or the lack thereof, influence mining company adaptation planning to some extent as well.

Other observations and issues raised

Participants also made a number of observations regarding the GE regions and raised the following issues that they wanted to see addressed in the workshop or future discussions:

- Changes in climate and natural systems had been observed in recent years by interviewees local to the GE region (i.e. summer and winter beginning a little later, storm events becoming more severe, changes to some bird populations)
- There is a strong relationship between adaptation and mitigation responses to climate change, and the capacity of stakeholders to adapt may depend on the impacts of mitigation policy from the federal government
- Climate induced pressures on local populations will have direct impacts on the ability of mines to source local staff, and increase the level of fly-in, fly-out (FIFO) workforces
- Adaptation to climate change must be dealt with sooner rather than later "...cheaper to do it now than to add it later".

Appendix D: Workshop results tables

Q.1 What are the key drivers of change or future prosperity for your operation/sector group?

What are	e the key drivers of change	or future pros	perity for you	r operation/se	ector group?						
			Sectors/ table groups								
Themes		Mining	Industry services	Utilities	Governance A	Governance B	Research				
Major	Economic factors: commodity markets, supply & demand, financial resources	~	~	~	~	~	~				
	Government policy, regulation, taxation	~	~	~	~	~	>				
	Societal perceptions, expectations & pressures	~		~	~	~					
	Workforce issues – human resources, turnover, OHS	~				~	>				
Minor	Climate adaptation challenges	~				~					
	Infrastructure		~	~		~					
	Technology advances	~				~					

Q.2 What are the implications of the climate projections for your operation/sector group?

	Sectors/ table groups								
Themes		Mining	Industry services	Utilities	Governance	Governance B	Research		
Major	Impacts on environment and communities	~	~		~	~	~		
	Infrastructure	~		~		~			
	Hazards	~			~	~			
	Mine planning & design	~				~	~		
	Resource use (water, energy)	~	~	~	~				
	Workforce issues – human resources, turnover, OHS	~	~		~	~	~		
Minor	Economic factors: funds, financial resources, costs	~			~	~	~		
	Government policy, regulation		~		~	~			

		Sectors/ table groups								
Themes		Mining	Industry services	Utilities	Governance A	Governance B	Research			
Major	Access to essential resources (water, energy, human, finance)/ utilities/ infrastructure	~		~	~	~	~			
	Behaviour change	~	~	~	~	~				
	Information/ knowledge	~	~	*		~				
	Costs, risks & returns		~	~	~	~	~			
Minor	Government policy, leadership			~	~	~				
	Interacting, cumulative, knock- on affects	~	~				~			
	Societal issues - pressures, expectations, impacts			~	~	~	~			
	Workforce issues – human resources, turnover, OHS				~		~			

Q.3 What types of factors will influence the vulnerability of your operation/sector group to a changing climate?

Q.4 What are the measurable indicators for each area of climate vulnerability in your operation/sector group?

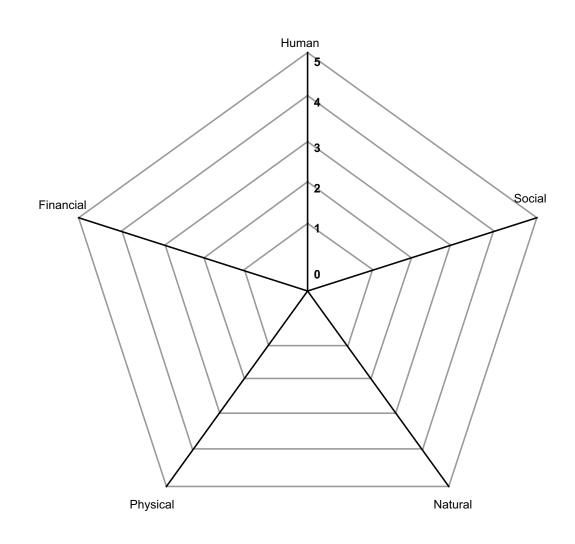
Themes		Mining	Industry services	Utilities	Governance A	Governance B	Research
Major	Economic indicators		~		~		~
	Infrastructure			~	~	~	
	Social indicators, changing behaviour		~	~	~	~	
	Natural resource indicators	~		~	~		
	Production indicators	~					
	Weather/ climatic indicators					~	~
Minor	Workforce/ human resource indicators				~		~

Mixed sectoral group discussions

Q. Discuss common issues and interactions that are emerging

- Are you thinking about vulnerability differently?
- Do you have different definitions or indicators of vulnerability?
- Are there clusters of sector groups around specific issues, or interdependencies in dealing with them?

	ommon issues and interactio							
		•	D		D E F			
Themes		A	В	С	D	E	F	
Major	Differing interpretations, perceptions & perspectives	~	•		~	V	~	
	Government policy, regulation, politics	~	~	~	*	~	~	
	Information/ knowledge needs	~	~	~		v	~	
	Climate adaptation challenges		~	~	~	¥		
	Funding, limited resources, costs	~		~	~		~	
	Infrastructure issues		~	~		~		
	Inter-sectoral linkages, flow- on affects	~			~		~	
	Leadership	~		~	~	~		
	Societal, community issues	~			~	~		
Minor	Conflict, competition between sectors					v	~	
	Time: timelines, time restrictions, transition time	~				V		
	Workforce issues – human resources, OHS		~	~				



Appendix E: Spider diagram used by workshop participants

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