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Extractive resource development in a changing climate

Learning the lessons from extreme weather events in
Queensland, Australia

Vigya Sharma, Shashi van de Graaff,
Barton Loechel, Daniel Franks



Extractive resource development in a changing climate

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FINAL REPORT

Centre for Social Responsibility in Mining

Sustainable Minerals Institute

The University of Queensland

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The role of NCCARF is to lead the research community in a national interdisciplinary effort to generate the information needed by decision makers in government, business and in vulnerable sectors and communities to manage the risk of climate change impacts.

Disclaimer

The views expressed herein are not necessarily the views of the Commonwealth or NCCARF, and neither the Commonwealth nor NCCARF accept responsibility for information or advice contained herein.

Cover image

January 21, 2008: Emerald, QLD. Aerial view of flooding in the town of Emerald, showing a submerged drag line at a coal mine (photo by James Laws/Newspix.)

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ABSTRACT

Australia is not only a location of extreme climate variability but is one of the world's most vulnerable regions to anthropogenic climatic changes. The dependence that national and regional economies have on mining-led export earnings, combined with the resource sector's potential to impact significantly on environments and communities during extreme weather events, makes the minerals sector an important area of focus for climate adaptation research. This project examines extreme weather events in Queensland and the direct and indirect impacts of these events on the mining industry, governments and dependent communities. The project is funded by NCCARF's Synthesis and Integrative Research Program.

This report presents findings from our research project that investigates the nature and scope of climatic extremes experienced since 2000 in Central Queensland's coal mining region. It examines the direct and flow-on impacts of extreme events on the mining industry and other stakeholders, and the response mechanisms employed by these stakeholder groups to address key impacts. By doing so, the project's overarching objective is to highlight both climate-influenced drought (water quantity) and flooding (water quality) challenges relevant to the future viability of the industry and local communities. Key outcomes from this research include: a better understanding of the range of existing barriers and challenges – both within and outside the mining industry – that currently prevent the resources sector from developing a coherent adaptation policy for future climatic events; improved knowledge on how lessons learnt from past experiences can inform future research directions to enhance the resilience and adaptive capacity of the resources sector to address current and future climatic perturbations; and directions for future research on climate adaptation in the resources sector based on lessons learnt from these experiences.

Data for this project has been drawn from a variety of sources, including a systematic review of literature (academic sources, newspaper and other media articles, government and industry reports, and reports published from the Queensland Floods Commission of Inquiry); targeted interviews with representatives of state and local governments, industry, and peak regional bodies; and a series of workshops with a mix of representatives from relevant stakeholder groups active in the region.

EXECUTIVE SUMMARY

This report summarises key findings from an NCCARF-funded study that examines the implications of climatic variability and extreme weather events for coal mining industry and associated communities over the past decade. The geographic area examined incorporates the Bowen Basin coal mining region in Central Queensland, with a particular focus on the Fitzroy River catchment. The Bowen Basin hosts over 50 operational open-cut and underground coal mines.

The project involved a two-phase methodology, and was guided by a project steering committee that comprised members of key stakeholder groups in the region. The committee was established to ensure strong end-user engagement and future uptake of the project's findings.

Phase 1 of the project drew together information from existing literature and targeted interviews conducted with key stakeholders to identify:

- significant climate-related extreme *events* experienced by the region since 2000;
- the main *impacts* of these events on key stakeholder groups;
- *responses* of affected groups to these events; and
- *Key lessons* learnt from these experiences.

Phase 2 of the project involved reviewing current literature on adaptation barriers and challenges, drawing lessons from the experiences of a particular mining operation in Central Queensland, and conducting workshops with relevant industry and regional stakeholders. This phase focused on identifying:

- how have *previous experiences* with floods influenced both corporate and operational decision-making on adaptation to climatic changes within a particular mining organisation active in Central Queensland;
- the main *barriers, challenges, motivators and enablers* influencing the development of long-term adaptation options for the resources sector to address future climatic events; and
- potential *avenues for collaboration* across key stakeholder groups to learn and share experiences, and better manage future climatic impacts on resource development at a regional and national level

Stakeholders consulted in both phases of the project included coal mining companies, local government authorities, state government departments, regional researchers and consultants with expertise in local development and risk and disaster management, and peak industry bodies.

Besides competition over water use during droughts and flood-related direct impacts on production and revenue generation, several **key issues** emerged through this research:

1. Difficulty switching industry mindsets between extreme 'dry' and 'wet' conditions

There is an inherent contradiction in industry mindsets between encouraging water conservation during the dry season, and managing excess water resulting from extreme floods. This contradiction, accompanied by lack of preparedness to deal with sudden intense changes in the natural climate and short-lived industry memory due to high staff turnover, has exacerbated the physical and psycho-social vulnerability of the industry and regional stakeholders to climatic disasters.

2. Economic and psychological impacts on the community

Production time lost as a result of flooding impacted royalty revenues to the state government, thereby resulting in losses in excess of \$5 billion to Queensland's gross state product (QFCI 2012). Curtailed employment and extended periods of isolation due to inundated properties during floods, combined with increased energy prices due to reduced power production caused by severe water scarcity during droughts impacted socio-psychological wellbeing of communities throughout the region.

3. Community perceptions of the mining industry

Managing community expectations during periods of extreme climatic events can be a challenge for the mining industry. While community members recognise mining companies as a source of assistance in the immediate aftermath of climatic events, community concerns around mine water discharge during floods, and competition over water scarcity during droughts, can have negative reputational impacts for the mining industry. In the past, incomplete, or misplaced knowledge about mining activities in the region has led to a series of negative perceptions among local communities. The reputational costs associated with underlying community–company mistrust increasingly influence disaster management and enable more informed corporate decision making on climate adaptation.

4. Lack of available and useable climate data

Mining companies only have a small window of opportunity available (no more than 3 months) to act on projections of a climatic shift from extreme dry to extreme wet conditions. In addition, currently available climate data is not considered useful enough by the industry as it is perceived as lacking localised information and other micro details that enable focused pro-active planning and management of risks. Lack of sufficient time available prior to the onset of extreme events further disables mining operations from rallying internally within their respective organisations to seek additional financial, technical and human resources to build effective risk management plans.

Based on these findings, the research has identified a number of lessons for improving adaptation to extreme climatic events within the resources sector. These lessons emphasise, *inter alia*, the importance of:

- flexible and robust arrangements to ensure ongoing monitoring, evaluation, review and feedback to enable *methodical learning* and timely adjustments to plans and strategies;

- early and timely *planning* both by governments and industries – long-term water resource management and planning for droughts and preparatory planning for floods;
- a better understanding of local and regional *contexts*, including of floodplain hydrology and the socio-ecological landscape that hosts mining operations;
- *engagement and communication* across different stakeholder groups – to facilitate timely information exchange, build cooperative relationships and address community anxiety about the socio-ecological impacts of mining vis-à-vis other industries;
- *collective knowledge management, transfer and training* – to develop a common pool of regional and catchment-wide expertise in preparing for and managing both real and perceived impacts from climatic changes; and
- greater *flexibility* in resource management plans – to accommodate abrupt changes in climatic conditions.

The research findings highlight a number of issues that have particular relevance for policy making across all levels of government. This project suggests four key implications for policy and decision makers that are vital to assessing current adaptation efforts in the sector, as well as identifying opportunities that can help improve these efforts to deal with future changes more effectively:

1. Role of government

Clear articulation of the roles and responsibilities between state and local government is vital to preventing service gaps or overlap, and to prevent a top-down governance approach without consideration for local priorities, capacities and aspirations. The regional expertise and experience that local governments hold should be capitalised in developing climate change adaptation policies and strategies.

2. Role of communication, cooperation and collaboration between and among various stakeholders

Extreme events resulting due to climatic variability requires stakeholders to consider climatic challenges as a ‘common’ concern that can be best addressed by pooling available resources, exchanging information on climate data, sharing knowledge, skills and expertise in managing risks and disaster events, and rallying together at a local and regional level to demand improved services from state government agencies. Policy makers at the state level can play a key role in encouraging and coordinating stakeholders to operationalize effective partnerships for climate adaptation.

3. Acknowledging extreme events as opportunities to drive innovation

Extreme events provide a unique policy opportunity to trigger innovative thinking, problem-solving, and a more resilient set of entrepreneurial skills. Policy makers at the state level can systematically encourage long-term innovation and creativity in building new relationships, networks, and knowledge for improved local adaptation to changing climatic conditions.

4. Learning the lessons from past climatic variability to inform future adaptation to climate change

Past attempts at responding to extreme events and climatic change can be examined to evaluate what worked, what did not work, and what adaptations or past approaches are necessary to better respond to a future repeat of similar events. Lessons from past climatic disaster experiences can generate organisation-level appreciation for proactive planning and flexible risk management strategies to deal with the underlying scientific uncertainty about future climate change.

1. INTRODUCTION

1.1 Establishing the connection between extreme weather events and extractive resource development

Resource extraction is inherently tied to the natural environment in which it takes place. The industry maintains both direct and indirect dependence on suitable natural conditions – including a habitable climate, access to water resources, and presence of supporting infrastructure – to extract resources from the ground as well as process these resources for future domestic and or international use. Unlike other economic activities that may be relocated elsewhere should the environment become unsupportive, strategic decisions with regard to operating in the mining industry are almost exclusively based on the location of the resource to be mined. It is therefore pertinent that stakeholders associated with the resource extraction process recognise the significance of changes to natural environmental conditions and how the latter may impact not only immediate operations but also the long-term viability of the mining industry (Pearce et al. 2009).

Changes to the natural climate manifest themselves in three important forms of weather events: droughts, floods, and cyclones and storms. Owing to the availability of better scientific models, improved knowledge of weather systems, and robust monitoring tools, it has now become possible to record the frequency and intensity of these events and identify ‘extreme’ events in particular. The nature of impacts of such extreme events on the mining industry is highly complex, demonstrated by the underlying multi-causality that takes effect across varied scales and dimensions. Despite this exposure there appears to have been little research investigating the effects of extreme weather events or climate adaptation in the mining industry in Australia or elsewhere (for a review see Hodgkinson et al. 2010a). Further, understanding these impacts necessitates a whole-of-region approach that encapsulates not only the impacts felt by the industry but communities and the wider ecological landscape that may both influence, and be influenced by the presence of extractive industries in the region.

Appendix 1 provides a typology of impacts of extreme events on various stakeholders associated with the mining industry. As can be noted, the impacts are not always direct and easy to ascertain. Over time, these impacts interact among themselves in myriad ways to potentially result in new and more complex arrangements of second-order impacts that are both difficult to anticipate and manage in the absence of adequate experience, foresight and knowledge of the local context. To this extent, Appendix 1 is not exhaustive; instead it only points towards fundamental impacts that the literature suggests may be expected when climatic changes interact with resource development activities. It is important to note that not all impacts experienced by different stakeholders are negative; impacts mentioned in italics are opportunities – rather than threats – that can better strengthen relationships between stakeholders, thereby enhancing mining’s contribution to sustainable development at both regional and local levels.

- In this project, we apply the lens of extreme weather events experienced in Australia’s Central Queensland region over the last decade to examine a) the

nature and scope of impacts on mining operations as well as resulting flow-on effects on the socio-ecological health of the wider region, particularly on areas that bear close interaction with the mining industry either socio-economically or spatially by virtue of their location downstream, b) what actions, responses and measures were undertaken by different stakeholders in the region to address these impacts, and c) what lessons have been learnt on the way that may better inform future pathways in developing adaptation plans to build greater resilience and adaptive capacities in resource-rich regions.

The report is organised as follows: the following section outlines the central objectives of the research.

Section three then describes the research methods and design employed to seek answers to the questions raised above.

Section four, the literature review, provides insights into the study area, including its climatic characteristics and the role of mining. It also details challenges to climate adaptation (barriers and enablers), as well as lessons for the mining industry from adaptation research in other natural resource-based industries.

Section five then provides an outline of the results and project outputs, through three sub-sections. The first subsection includes a timeline of key extreme events witnessed in the past decade, an examination of local and regional impacts as relevant to the mining community, and actions and responses undertaken to address these impacts. The second sub-section details a case study of a mining operation's experiences of – and lessons from – flooding in 2008. The third sub-section outlines barriers, motivators and enablers to climate adaptation currently existing within the mining industry, and also across multiple stakeholders in the broader Central Queensland region.

Section six goes on to discuss how lessons learnt from Central Queensland's experiences of extreme events may shape our future thinking on resilience and adaptation planning within the resources sector.

Section seven concludes the report with a summary of the project's key findings, and finally, the report ends with recommendations for future research directions in section eight.

1. OBJECTIVES OF THE RESEARCH

Extractive resource development requires a direct and immediate dependence on the natural environment, it is therefore important that this inter-relationship is better understood (Pearce et al. 2011). The significance of this relation for Australia can hardly be underestimated. Not only is Australia considered one of the world's most vulnerable regions to climatic changes due to its unique bio-physical environment but its national and regional economic structures also maintain a strong reliance on mining-led export earnings. For these reasons, climate change and variability are “emerging concern[s] for the mining industry ... [yet] limited action has been taken to plan for or adapt to changing conditions” (Pearce et al. 2011, p.350; Tyler and Chivaka 2011).

- This research project aimed to address this gap by applying the lens of Queensland's recent flood events to strengthen the adaptive capacity of the mining industry to climate variability and climate change. By doing so, it proposed to a) develop a better understanding of the range of flood-related impacts on mining operations *and the wider region (including impacts on the socio-ecological landscape of areas further downstream)* and, b) identify barriers and challenges – both within and outside the mining industry – that may prevent the resources sector from developing a coherent adaptation policy for future climatic events.

Research on mining sector adaptation to climate change in Australia is still emergent, however a number of reviews (Hodgkinson et al. 2010a,b) have been complemented by industry and community surveys (Loechel et al 2012) and studies of specific regional issues (Loechel et al 2010, 2011; Sharma & Franks 2011). However, thus far there has not been a significant study of the lived experience and responses of mining regions to a particular climatic crisis or pattern of extreme weather events. This type of study is valuable because it can examine in-depth the actual experience of those involved in the crisis. The research findings reinstate the urgent need for industry and governments to consider climatic changes in planning and management of the resources sector in both Queensland and Australia. Further, by identifying current and potential barriers and challenges, the research provides directions on how different stakeholders can work together to better adapt to changing conditions and ensure that mining remains consistent with the principles of sustainable resource development.

In addition to several challenges intrinsic to mining, such as income inequality, socio-economic dependence on mining, housing shortage etc., the devastating impacts of extreme weather events on mining operations in Queensland demonstrate significant implications of a changing climate for sustainable resource development. As an example, the floods of 2010-2011 alone cost Queensland more than AUD 2 billion in export earnings (ABARES 2011) while several other socio-ecological impacts continued to be felt for several months after the events. The enormity of the impacts illustrates not only *how* a changing climate can stretch the socio-economic and institutional capacities of all stakeholders but it also generates an opportunity to inform our understanding of *what* measures need to be undertaken to both assist recuperation of impacted operations and develop suitable adaptation options to prevent (or limit) impacts from such events in the future across Australia.

For the purposes of this project, the focus was on coal mining operations across Queensland. We believe that results from this research provide useful pointers towards what barriers various mining stakeholders – representatives from state government agencies and local councils, community groups, mining corporations and regional peak bodies – currently face in working together to build collective economic, technical and social capacities to address impacts from climatic changes. In saying this, we hope that the project findings provide a strong basis to initiate a dialogue between and within these stakeholders to firstly, understand the kinds of impacts that may be manifested in a resource development setting due to a changing climate and secondly, develop effective ways to pre-emptively consider these impacts in strengthening resilience and adaptive capacities in resource regions across Australia.

In particular, the project had three main objectives:

1. Identify the nature and scope of flood- and other climate-related direct impacts on mining operations and resulting flow-on effects on the socio-ecological health of the wider region with particular emphasis on areas located further downstream,
2. Draw lessons from the case of one mining operation in Central Queensland that experienced almost-total inundation and devastation in 2008 and subsequently developed successful adaptation measures that, in turn, limited the impacts of the 2010 floods. The learnings will include, inter alia, the implications of the 2008 flood events both for the mining company and regional council in which the operation was located and what the latter meant for both immediate and downstream socio-ecological landscape, and
3. Identify factors that enable or impede the development of adaptation options for the resources sector – the mining industry and relevant communities – to address future climatic events.

2. RESEARCH ACTIVITIES AND METHODS

To achieve the aims and objectives outlined above, as a first step in the project, the research design included establishing an advisory body – Project Steering Committee (PSC) – to maintain strong end-user engagement and ensure smooth uptake of the project's findings. The PSC met once every two months and entailed representation from the region's peak environmental agency (Fitzroy Basin Association; FBA), peak industry body representing the interests of Queensland's minerals and energy resources sector (Queensland Resources Council; QRC), Central Queensland Local Government Association (CQLGA), a large regional council, and senior researchers with extensive knowledge of the study region and expertise in natural resource management during extreme events.

It was expected that a diverse group of interests in the PSC would ensure not only greater end-user engagement but also encourage future research uptake by both the industry and state and local governments. In addition, the committee provided valuable insights to the core research team by helping in the development of useful networks within the industry, participation in relevant forums in the region, and helping the project team demonstrate both practical and theoretical significance of this research to appropriate stakeholders.

Further, the project methodology consisted of two phases to align with the key research questions identified earlier:

Phase 1 examined and documented the nature, scale and scope of impacts of climatic events upon Central Queensland's coal mining operations, locally and regionally, in the past decade. In this phase, the focus remained on building knowledge around the following issues:

- Creating a comprehensive inventory of when and how variability in climatic conditions has positively or negatively impacted Queensland's resources sector and dependent socio-ecological systems in the recent past;
- Identifying impacts from key climatic events on various stakeholder groups operating in the region;
- Understanding how these impacts were responded to; and
- Identifying key lessons based on these past experiences that can better inform future planning and management of climatic disasters in a mining region.

Two primary data sources informed the first phase. First, a desk-based systematic review of peer-review published research, relevant industry documents available in the public domain, news articles and media releases, policy documents sourced from government agencies, and information available from the QRC and the FBA. The literature review primarily focused around the themes of climatic variability, extreme weather events, and mining operations, with a particular focus on the Central Queensland region. Key search terms used for locating relevant literature included different combinations of 'mining', 'resources', 'industry', 'Queensland', 'Bowen Basin', 'flood', 'drought', 'cyclone', 'impact', 'climate', 'climatic event', and 'extreme weather'.

1. Second, information compiled from the literature review was complemented by undertaking open-ended, in-depth interviews with representatives from a range of stakeholder groups, during April 2012. The interviews had a two-fold purpose: a) to corroborate the findings of the literature review with regard to identifying the nature, scale and scope of impacts from extreme events on mining operations and communities, and b) to obtain detailed accounts of responses undertaken by various actors and lessons learnt over the past decade to inform future adaptation planning.

Given the sensitivity surrounding a number of these impacts both for the industry and relevant communities, there was a clear dearth of data available publically. As a result, it was particularly important to source first-hand information from experts who had been actively involved in discussions around climatic variability, extreme weather events and impacts on mining operations and communities. Eleven interviews were conducted in total; one with each of the elected representative of the three relevant local councils, senior representatives from three major mining companies operating in the region, senior managers from the Queensland Government's then Department of Environment and Resource and Management (DERM), and one senior representative each from the QRC, and another peak body representing the interests of agricultural land users, AgForce. As much as possible, the research team aimed to maintain an equitable representation of stakeholder groups consistent with their presence in the Central Queensland region. Appendix 2 provides a list of organisations whose representatives were interviewed during this first phase.

The average length of the interviews varied from one hour to ninety minutes. Interviews were conducted either telephonically or, where possible, in person. All discussions were recorded (digitally and in note form), after receiving explicit permission from the participants. Data collected from the interviews was compared with the findings from the literature review through a thematic analysis. The latter informed the project's findings during the first phase, thereby, providing responses to the first key research objective/ question identified in the previous section.

The outcomes from the first phase of the project informed and influenced the second phase.

Phase 2 focused on exploring what barriers, challenges, opportunities and motivations exist that inform current thinking – within the industry, regulatory authorities and other state and local government agencies – on adaptation to climatic changes in Queensland's resource regions. To do this, the phase involved two sub-components:

Firstly, it investigated the case of one mining operation adversely impacted by the 2008 floods to deconstruct what factors defined a change in the corporate strategy to address climatic changes, thereby limiting the degree of impacts to the same operation from the 2010-11 flooding events. At the time of developing the research proposal, the idea was to engage directly with this particular organisation and seeks answers to questions such as:

- What factors led the company to incorporate climatic variability as a key consideration in its decision making process at both corporate and mine operational levels?
- Which organisations and factors, if any, provided them support to operationalise the transformation in their thinking about addressing climatic changes?
- What barriers and challenges did the company face – from within its industry counterparts, or from regulatory or financial perspectives – with regards to identifying and implementing adaptation measures?
- What information and/or support networks could have further helped the company achieve better adaptation outcomes?
- What further actions is the company currently undertaking in this space in planning for both current and future operations?

However, our efforts in establishing contact with the organisation were not successful primarily due to the processing of the company's flood-related insurance claims at the time. The associated sensitivity with information related to past floods thus impacted the company's willingness to engage with us. In light of these developments, and according to advice received from members of the Project Steering Committee, an alternative solution was agreed upon, to develop a case study of the mining operation based on information available in the public domain, that would include information on the impacts, experiences, responses and lessons learnt at the organisation level from these past extreme events. The case study undertaken here has therefore not been verified by the mining company. While the research team has strived to maintain the accuracy of data, flood impacts and responses, since the case study is largely drawn from media-reported information available in the public sphere, we acknowledge that there is the potential of some details being over- or under-represented.

The idea of including this case study – as will become clear in the latter sections of this report – is to provide an example of how extreme events can successfully transform organisational thinking around resilience and adaptation. Facts and figures in the case study should therefore be analysed in the larger spirit of 'learning from examples'. In addition to the case study, Phase 2 identified more broadly, what barriers and challenges – real and/or perceived – currently exist that constrain the industry's efforts to incorporate climatic changes into future planning and management of mining operations. In essence, the particular objective in this phase was to create a platform for dialogue between all stakeholders to foster end-user engagement and collective action towards developing capacity to address these barriers and challenges.

Data collection for this component in Phase 2 included:

- Reviewing current literature on adaptation barriers and challenges more broadly, but also those related to natural resources-based industries such as forestry, agriculture and grazing in Australia. Relevant overseas studies were also included through a focussed approach.
- Organising and conducting two group workshops.

- The first workshop brought together representatives from the industry, consultancy organisations, service providers and QRC, to discuss industry-specific barriers and challenges that may be sensitive enough to prevent a robust discussion in a more open environment.
- The second workshop was a multi-stakeholder consultation exercise that brought together a diverse mix of representatives from local governments, regional environmental and agricultural peak bodies, community organisations, industry (including site managers), CQLGA, regional service and infrastructure providers, state government agencies, private consultants active in the region, and academic researchers with knowledge of the local conditions and interest in the broader research topic of climate variability and adaptation in Central Queensland.

Appendix 3 provides a list of all organisations represented across the two workshops conducted during this second phase of the project.

The first workshop was conducted in Brisbane on the 19th of June 2012. The QRC kindly agreed to share their existing contact database to invite suitable attendees and also hold the workshop at their office in Brisbane City. For the second workshop, held on the 6th of July 2012 in Rockhampton, we engaged with the FBA and CQLGA to use their contacts in the region to identify appropriate stakeholders whose understanding of both policy and practical issues related to extreme events and adaptive management could provide useful insights to address key objectives in this phase.

Key outcomes from these workshops included:

- Better knowledge and understanding of the nature of challenges and barriers – theoretical and practical – that currently exist within the Central Queensland region, and therefore, hinder a holistic response to climatic impacts
- Better knowledge and understanding of how some or all of these challenges and barriers could be best addressed across the whole range of stakeholder groups – public, private and non-government sectors.
- Identification of potential avenues for collaboration across key stakeholder groups to learn about and share experiences, data and success strategies in order to better manage, monitor and report climatic impacts on resource development, both regionally and nationally.
- As a final outcome, the issues identified above have guided the recommendations that the project team proposes – as part of this report – to NCCARF to better enable Queensland's mining industry and relevant stakeholders to pro-actively engage with future climatic changes and make suitable adaptations to ensure long-term regional sustainability.

Undertaking these workshops in close association with peak bodies such as the QRC, FBA and CQLGA that maintain a solid reputation within the region generated greater awareness about the project within the region and instilled greater credibility and stakeholder confidence in the project's findings. Engaging a wider audience from the region will hopefully encourage local and regional stakeholders to uptake the research findings for policymaking within their organisations. This will, in turn, further contribute to the existing set of regional skills and expertise in adaptation planning in resource-

rich Central Queensland. The latter also aligns well with NCCARF's key objective of ensuring extensive end-user engagement to maximise uptake of findings from research funded by the Commonwealth.

In summary, the research design included triangulating data from a multitude of sources: an advisory body of representatives from key stakeholder groups from the region was established to provide practical guidance to the research team, and a comprehensive literature review of published material, policy documents, reports of the Queensland Floods Commission of Inquiry, media and news articles, information from mining companies available in the public domain and documents from local and state government agencies and civil society groups active in the region. Information collected through this literature review was corroborated with a number of targeted phone and in-person interviews with key representatives from state and local governments, mining organisations, and peak industry bodies. The project also included two consultative workshops – one with industry representatives and the other with significant multistakeholder representation from regional Central Queensland.

3. LITERATURE REVIEW

3.1 *Characterising Australia's (and Queensland's) climatic variability and changes*

While globally, there are strong arguments in favour of anthropogenic climate change increasingly influencing the frequency and intensity of extreme weather events, in the Australian context, the relationship between extreme weather events and human-induced climate change is not often as clear. This is largely due to several characteristics inherent to Australia's climatic and oceanographic conditions which have traditionally contributed to greater natural climatic variability across the continent (Henessey et al. 2007; BOM 2012a).

Two important forms in which natural variability is experienced in Australia include: the Southern Oscillation (SO) and the Interdecadal Pacific Oscillation (IPO). IPO is a low-frequency event occurring every one to three decades and results from an oscillating ocean-atmosphere system influencing sea surface temperature (Geoscience Australia 2012) and thereby, the climate around the Pacific basin. With IPO switching phases from positive to negative and vice versa, shifts in average climatic conditions across Oceania have been observed (Salinger n.d.). SO, on the other hand, commonly categorised into El Niño and La Niña events, occurs more frequently over three to eight year timeframes. The strength and phase of the SO is indicated by the South Oscillation Index (SOI) which measures the air pressure difference between Tahiti and Darwin (BOM 2012a). Sustained negative SOI values suggest El Niño, indicating extended periods of high temperature and reduced rainfall across northern and eastern Australia, while La Niña is a result of continued positive SOI experienced over long periods of time and relates to warmer sea temperatures north of Australia, resulting in cooler than average daytime temperatures accompanied with high rainfall patterns in northern and eastern Australia (BOM 2012a).

With SO and IPO affecting rainfall patterns across eastern Australia, including Queensland, natural climatic variability is considered the primary force behind a series of extensive drought and flood events experienced across the state in the past decade (see Figure 1 below) (QFCI 2011a). Furthermore, considering Australia's established vulnerability to anthropogenic climatic changes (Palutikof 2010), discussions are ongoing as to whether or not climate change may have had any influence on aggravating the intensity of these events – thus far largely considered a result of natural climatic variability (Climate Action Centre 2011; Fogarty 2011). Currently however, it remains premature to draw any conclusive arguments that may strengthen the relationship between anthropogenic climate change and extreme floods and droughts experienced across eastern Australia in the past several decades.

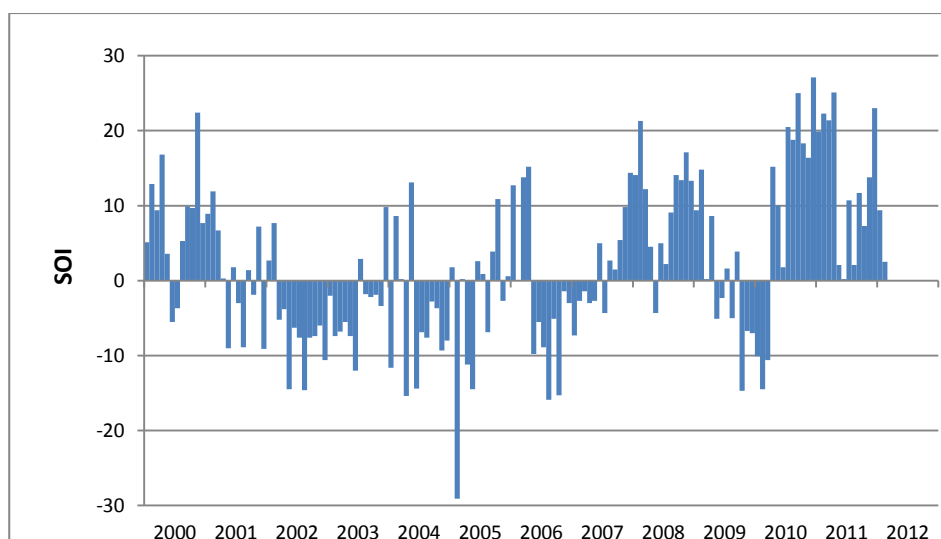


Figure 1: Australia's Southern Oscillation Index (SOI), 2000 – 2012

Source: BOM 2012b

Irrespective of the causes behind changes in climatic conditions – natural or anthropogenic – several Australian industries and dependent socio-ecological systems remain highly vulnerable to a changing climate. The severity of climatic changes manifested in extended drought and flooding events, demonstrated in the past decade by a suite of long- and short-term impacts on the Australian mining industry, is a case in point. The experience of the mining industry and communities in the region raises several important considerations with regard to preparation, planning and adaptation to address future changes in local and regional climatic conditions. The rest of this report provides further insights on these issues.

3.2 Prior research on climate adaptation and mining

The effects of weather events as such on mining operations in Australia have been assessed by a limited number of researchers (Colls 1993; Anaman and Lellyett, 1997). A recent review by Hodgkinson and colleagues at the CSIRO (Hodgkinson et al. 2010a) described they face a range of hazards posed to mine operations in Australia by intense rainfall, drought, heat, cyclones and storms, which also affect the operations of other components of the mining value chain such as utilities, industry services, transportation infrastructure and processing facilities. With regard to climate change more specifically, a number of industry-oriented reviews and reports have assessed mining industry vulnerability to climate change at the international level (Acclimatise 2010) and within Australia (Hodgkinson et al. 2010a,b; Loechel et al. 2010, 2011). However, peer-reviewed studies of climate change adaptation in the mining industry are relatively limited, with the main body of work examining the Canadian industry (Ford et al. 2010, 2011; Pearce et al., 2011), while Australian studies are still emerging (Loechel et al. 2012; Sharma & Franks 2012). While these reviews have found a range of climate change risks pertinent to mining operations and their associated communities, they have generally found only a limited degree of adaptation planning taking place across the industry.

3.3 Challenges to climate adaptation – barriers and enablers

Adapting to climatic changes necessitates alignment with existing risk management processes that include ‘identifying, evaluating and responding to changes in risks faced to minimise damage from harmful events and maximise gains from new opportunities... [thereby] enhancing the wellbeing of the community’ (Productivity Commission 2012, p.5). Despite numerous calls for proactive adaptation to climatic changes, several factors influence the extent to which effective adaptation outcomes can be planned and or executed. A number of studies have already been undertaken that highlight a diverse array of possible barriers to climatic adaptation. This section serves the purpose of bringing together a systematic assessment of adaptation barriers and challenges from mining and other natural resource-based industries that are particularly relevant to the present study.

Extreme events provide a useful ‘window of opportunity’ in terms of drawing lessons from these events to plan for adaptation towards future climate change – natural or anthropogenic (Amundsen et al. 2010; Kates et al. 2012). In most cases, there is a high degree of certainty associated with the timing and nature of risks resulting from existing natural climate variability. As a result, it is argued that adaptation to these risks should be prioritised in the short-term, as developing successful adaptation strategies to deal with extreme events are also ‘likely to build capacity to adapt to future [anthropogenic] climate change’ (Productivity Commission 2012, p.10-11, p.245).

In a number of cases, it has been reported that although adaptation planning may have occurred in the past, it is the extreme events and resulting loss of infrastructure, and economic and socio-ecological disruption that often provides the necessary ‘trigger’ to execute long-established adaptation plans (Leszczynska 2012). A study of Norwegian municipalities revealed a direct correlation between local areas that had experienced extreme events, such as flooding in the past and had undertaken some degree of adaptation planning compared to other municipalities that had no experience dealing with extreme events.

To a large extent therefore, adaptation to climatic changes is primarily incremental and involves ‘doing slightly more of what is already being done to deal with natural variation in climate and with extreme events’ (Kates et al. 2012, p.7156; Productivity Commission 2012). Over an extended period of time, risk management strategies will progressively need to factor in a declining ratio of gains to losses, which will eventually require these incremental, largely reactive measures to accumulate and deliver more fundamental or ‘transformational’ adaptation outcomes. In doing so, transformational adaptation may even help address other co-existing multiple stresses that are environmental, socio-cultural and economic in nature (Kates et al. 2012).

Similarly, identifying potential links between natural climatic variability and anthropogenic climate change can also positively influence the success of adaptation plans (Amundsen et al. 2010). On the one hand, greater recognition of climate change does not necessarily lead to better adaptation outcomes as the latter also calls for knowledge and tools to translate theoretical recognition into practical implementation. Yet, on the other hand, the awareness around possible links between natural and

human factors influencing climate can deliver sound vulnerability analyses that may well enhance adaptation efforts over time (Leszczynska 2012).

Further, it is argued that the presence of extreme events – in the Australian context, often a result of natural climatic variability – alone does not determine the degree to which implementing adaptation plans may be realistically possible. The presence – or lack thereof – of a number of factors can either motivate or impede adaptation success. These factors, resulting in a number of *adaptation barriers* are often context-specific and may exist as ‘a constraint because of the way a society is organised or because of the values it propagates...organisational arrangements and social values are likely to vary widely within and between societies and are likely to change over time’ (Hulme et al. 2007, p.3). Broadly speaking, there are four main types of factors that may initiate a number of barriers to climatic adaptation (Productivity Commission 2012). These are:

- Market failure;
- Regulatory frameworks;
- Governance and institutional arrangements; and
- Social and individual behavioural characteristics.

Based on the above factors, common examples of adaptation barriers include, *inter alia*, the nature of institutional frameworks; interdependence across various tiers of governments; financial constraints; technological innovation; stakeholder awareness and appreciation of climatic externalities; acknowledgment of local indigenous knowledge; lack of, or unfamiliarity with interpreting and synthesising climate data; willingness to embrace new learning; pre-conceived behavioural norms and privileges; individual and collective cognition determined by traditional values, goals and social choice; and other external market drivers beyond the direct control of national or local governments (Hulme et al. 2007; Amundsen et al. 2010; Aslaksen et al. 2012; Kates et al. 2012; Leszczynska 2012; Productivity Commission 2012). Underlying many of these factors is the particular relevance of the ‘role of capacity building in education, risk management, and scientific and political participation’ that may further strengthen adaptation efforts towards both natural and anthropogenic climate change (Aslaksen et al. 2012, p.139).

Although not exhaustive, the above examples of common adaptation barriers highlight three issues that need further consideration. Firstly, as impacts from any disturbance in the natural climatic conditions are most severely manifested at the local level, it is particularly important that local governments are actively involved in shaping adaptation programs and policies (Productivity Commission 2012). To that extent, there is a much greater need for clarity from regional and national institutions on the specific roles of local governments (Amundsen et al. 2010). An informed division of responsibilities between regional and local governments complemented with the provision of adequate resources can play an important role in bringing about effective change in planning for and adapting to both present and future climatic changes (Amundsen et al. 2010).

The recently released report by Australia’s Productivity Commission on adaptation barriers further highlights the need to better clarify local government’s role, and strengthen its capacity to develop pro-active adaptation measures (Productivity Commission 2012). It argues that a clear institutional system alone that identifies the

most appropriate level of authority to manage climatic risks is necessary, but not sufficient. Timely and adequate access to resources – financial, human, and guidance on climate information – are equally important in enabling ‘how’ to deliver effective adaptation outcomes (Productivity Commission 2012, p.122-4).

Secondly, multi-level governance arrangements that facilitate optimal information exchange play a particularly important role in addressing adaptation barriers (Hulme et al. 2007; Amundsen et al. 2010; Aslaksen et al. 2012; Productivity Commission 2012). Vertical as well as horizontal integration across various sectors and institutional scales is important both to help clarify institutional roles and create avenues for coordination, communication and knowledge exchange that can, in turn, build capacity to develop successful adaptation measures (Leszczynska 2012; Productivity Commission 2012). In the case of climatic changes where impacts are often experienced variedly across groups, improved deliberation and dialogue among stakeholders can further help address uncertainties ‘arising from conflicting values and interests’ (Hulme et al. 2007; Aslaksen et al. 2012, p.136).

Finally, there is a need to recognise that sharing responsibility between stakeholders is a useful way forward in addressing climate risks and facilitating proactive adaptation to changing climatic conditions (Productivity Commission 2012, p.197). Governments, in consultation with business and community organisations can facilitate effective adaptation by creating knowledge flows, improving economic and regulatory flexibility, and creating policy environments that are able to address the range of adaptation barriers discussed above despite looming scientific uncertainty regarding the nature and impacts of climate change (Productivity Commission 2012).

3.4 Lessons for mining from adaptation research in other natural resource-based industries

Apart from mining, the main natural resource-based industries include various forms of agriculture (cropping, horticulture, livestock), forestry, and fisheries (including aquaculture). While it is likely there are lessons that can be drawn from climate adaptation research in these other primary industries to inform mining adaptation, there are a number of differences and similarities between the two types that are noteworthy. At a fundamental level, mining is an industry which exploits physical, geologically-based materials or non-living systems, as compared to the other natural resource-based industries that are reliant on harvesting and or cultivating living or biological systems. This makes the latter inherently more sensitive to variations in climatic conditions. For example, in the case of dry-land agriculture often wide fluctuations in productivity and or profitability are experienced from one year to the next due purely to seasonal (intra- and inter-annual) climatic conditions (Howden and Stokes 2010). Mining production systems by contrast are much more independent of, and/or less sensitive to, seasonal weather patterns and thus potentially, to shifts in climate.

Mining operations are however, typically less mobile and more strongly constrained by the location of the resource they are exploiting, than the biologically based industries which have a greater capacity to move their operations to other more suitable locations (with perhaps the exception of forestry). Indeed, an explicit strategy some large agricultural firms use to deal with natural climatic variability is to own properties in

multiple locations around Australia, diversifying their operations and/or shifting stock between them as conditions warrant (Campbell 1980; Henzell 2007).

The relation of mining operations to surrounding communities is also often qualitatively different. Mining operations are fewer but larger in terms of scale, numbers and often, economic significance. They employ many workers, and in most cases, the ultimate ownership and control is located in a distant urban centre, either within the national borders or, overseas. This compares to the typical agricultural or fishing community where the operations are more numerous and their owners have not only been residents within the community for many generations but also feel a strong sense of belongingness to the local region. The separateness of mining operations from their host communities is also increasingly exacerbated by long distance importation of the workforce, in fly-in, fly-out (FIFO) arrangements and the masculinised, semi-skilled and highly paid demographics of this workforce (Lockie et al. 2009).

There are however, some similarities between mining and other natural resource-based industries, including their location in rural, regional and remote locations as opposed to urban and metropolitan areas (although intensive agriculture and downstream minerals processing are often found in outer, industrial or 'peri-urban' areas). This leads to a number of other similarities such as their importance to, and impact upon, relatively small communities, their geographic distance from supportive social and industrial services and infrastructure, and thus reliance on extensive transportation routes. Both types of natural resource-based industries are highly reliant on land and water for their production systems, which can also have major effects on water quality and other environmental assets. For these reasons, both are important for inclusion in regional natural resource management (NRM) planning and governance systems (Lane et al. 2009). Similar to mining, the other natural resource-based industries are highly reliant on international commodity prices and tend to experience cyclical swings in fortune (Taylor et al. 2003).

3.5 Climate change adaptation findings from agriculture, forestry and fishing

Considerable research has been undertaken on the adaptation needs of the primary industries (Stokes and Howden 2010a) and some of the findings may hold lessons for the mining industry. While climate change impacts on specific areas such as plant growth, animal production and fisheries may have little relevance to mining operations, other more generic areas such as water use efficiency, dealing with extreme weather events, risk-management and decision-making under uncertainty, and broader strategies to approach adaptation, will have greater applicability. This section therefore outlines findings from agricultural adaptation research that are likely to have relevance to climatic adaptation in mining.

3.6 Water

Climate projections suggest reduced rainfall and surface water supply in many parts of Australia. The hydrological cycle is also expected to intensify, largely due to increased atmospheric water vapour from evaporation, leading to heavier rainfall events and flooding (Howden and Stokes 2010).

Some useful adaptive responses to the likelihood of increased drought across Australia include (Jones 2010):

- improved water resource planning and regulation (e.g. appropriate resource allocations relative to supply);
- integrating surface and ground water in resource planning;
- initiatives to improve water-use efficiency, expand and diversify water harvesting and supply, and increase storage capacity;
- improved seasonal forecasting of rainfall and/or water supply to enable better planning; and
- improving farm management and planning systems to improve flexibility and responsiveness to altered water supply conditions.

Further, there has been an ongoing focus on improving risk management by considering:

- longer-term planning horizons;
- being responsive to the transition between different levels of risk, including a 'whole of climate' approach that combines historical observations as well as climate projections, and guarding against maladaptive responses such as increased water trading between regions based on short term commodity market price signals resulting in long term industry and community damage and stranded infrastructure;
- At an institutional level, there have been attempts to move towards:
 - more market-based approaches that increase water pricing and trading as well as other market-based risk management strategies such as hedging, forward selling and 'banking' water where appropriate;
 - an integrated catchment management approach that incorporates multiple supply and demand sources and drivers beyond agriculture and climatic influences; and
 - incorporating flood risk planning into long-term water supply planning.

3.7 Extreme weather events

Extreme weather events expected to increase in intensity and/or frequency around Australia, albeit with regional variation, include heatwaves, bushfires, destructive storms, tornadoes, severe winds, dust storms, intense rainfall leading to flooding, hailstorms, severe and prolonged drought, frosts, oceanic storm surges and cyclones.

However, due to their exposure to the elements, and the relatively harsh nature of the Australian climate, the natural resource-based industries have been successfully dealing with severe climatic conditions and extreme events over time. Further, climate adaptation is not new to the managers of the natural resource-based industries in Australia. In historical terms, agriculture in Australia was developed by people who emigrated from overseas, principally Europe, and have therefore, had to adapt to a very different operating climate. Even within Australia, newer agricultural areas have often been developed by farmers moving in from different climatic zones, often seeking more favourable climatic conditions and/or cheaper land (Henzell 2007; Campbell 1980). Thus, suggestions for adaptation to extreme weather events include learning from past experiences and experience across a broader geographic range (Stokes and

Howden 2010b). This may include increasing awareness of and planning for types and magnitudes of events that occurred earlier in the historical record than are currently included, broadening existing knowledge-sharing networks, and considering events that have traditionally occurred beyond one's own district or region.

3.8 *Risk management and decision-making under uncertainty*

There are inherent uncertainties in future climate change scenarios, particularly as they apply to specific, more localised geographic scales (Stokes and Howden 2010b). These uncertainties are likely to persist for some time due to a lack of baseline climate data or knowledge in some areas, the complexity of climate systems, including cascading impacts between sectors and issues, and the dynamic nature of anthropogenic climate change given unclear future global greenhouse gas emissions. Thus adaptation risk-management and decision-making needs to be undertaken while regional, and particularly local, climate scenario outcomes are still far from certain. However, similar to dealing with a new climate, high uncertainty is not an unusual decision-making context for the natural resource-based industries in Australia. A host of relevant factors have traditionally rendered these enterprises fraught with uncertainty such as pest and disease outbreaks, reliance on international export markets, fluctuating domestic economic conditions, and changing government policy and regulations.

A key lesson from these experiences is that future adaptation should employ and improve upon those risk-management and decision-making strategies that have proven successful in the past. These can be expected to be flexible, risk-based approaches that account for high uncertainty, while preparing and equipping managers to be able to cope with a range of foreseeable scenarios, including improving their capacity to implement, monitor and adjust as needed (Stokes and Howden 2010b). These strategies will also need to be integrated or synergistic with broader institutional settings and government policies, which themselves will need to display flexibility, responsiveness, and iterative, social learning characteristics (Martin et al. 2009; Stokes and Howden 2010b).

Some areas and industries, particularly those with currently marginal profitability, will be more vulnerable to climate change than others, and can be expected to reach the limits of their adaptive capacity. In such cases, strong policy intervention will be required not only to support affected communities in their transition to new types of productive activity (Stokes and Howden 2010b), but also along a number of human aspects of adaptation (Marshall et al. 2010). The latter include psychological, social, cultural, institutional and governance dimensions important to building adaptive capacity. Adaptive capacity relies on capabilities at different levels and/or scales including those of individuals, organisations, social networks, communities, regions, institutions, different forms and levels of governance from local through regional, state and federal, and broader social, political and economic arrangements and systems.

Finally, a number of specific issues have been identified as important to building industry and enterprise adaptive capacity (Marshall et al. 2010). These include, but are not limited to:

- personal beliefs about climate change
- availability of practical adaptation options
- enterprise knowledge of vulnerability and adaptation options
- the operating context of the industry/ enterprise
- availability of resources, in terms of human, social, financial, physical and natural capital
- access to broader supportive systems, policies and structures to enable change
- research and education systems for adaptation knowledge development and dissemination
- the presence of incentive structures that encourage adaptation, and
- the ease with which climate change may be mainstreamed into current systems of risk management and long-term development planning.

3.9 The study region: socio-economic role of mining and the environment in Central Queensland

Queensland is the world's largest coal exporter, contributing to approximately 52% of the total coal exports worldwide (ABARES 2011). Mining contributes to more than 20% of Queensland's economy and 13% of both direct and indirect employment (QFCI 2011a).

The Bowen Basin in Central Queensland is the largest coal-reserve in Australia, and produces Queensland's high-grade coking coal, along with most of the exported thermal coal. Figure 2 provides an account of the total coal production in the Basin since 2000. Covering an area of approximately 60,000 km² and a length of 650km, the Bowen Basin comprises seven major local government authorities (Queensland Places 2011). However, for the purposes of this research, the focus within the Bowen Basin is limited to the three primarily mining-intensive regional authorities: Isaac Regional Council (IRC), Banana Shire Council (BSC), and Central Highlands Regional Council (CHRC). Prior to amalgamation of Queensland's local authorities in early 2008, the Shires of Belyando, Broadsound, Nebo, Bauhinia, Duaringa, Emerald, Peak Downs and Banana comprised the coal producing belt in the Bowen Basin. The total economic output from mining for the Central Queensland region amounted to approximately \$8,406 million in 2010 (RDAFCW 2012, p.29).

Mining is the predominant industry in the region and contributes to approximately 37%, 22% and 15% of the total employment in IRC, CHRC and BSC respectively (Isaac Regional Council 2011; RDAFCW 2012; Banana Shire Council 2010). Consistent with the increase in coal production and resulting socio-economic contribution made by mining to the region, population within the Bowen Basin has also been on a constant rise since 2000 as shown in Figure 3.

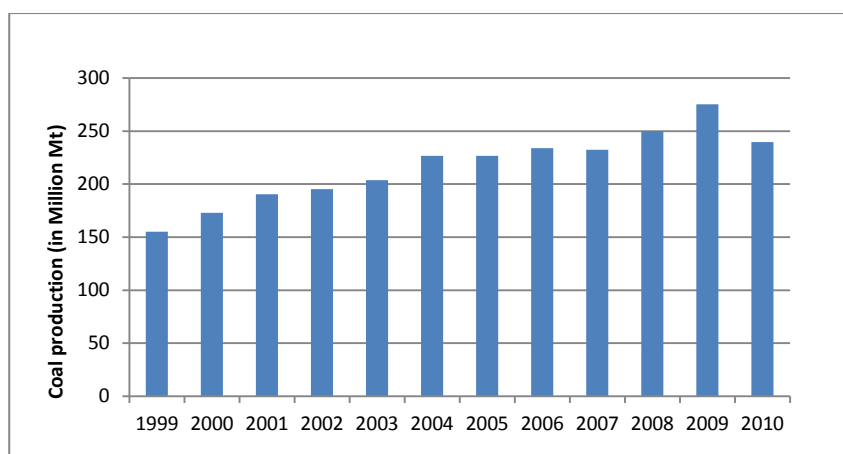


Figure 2: Total coal production in the Bowen Basin of Central Queensland (since 1999)*

Source: DEEDI 2012

*Note: reduced 2010 production due to flooding events

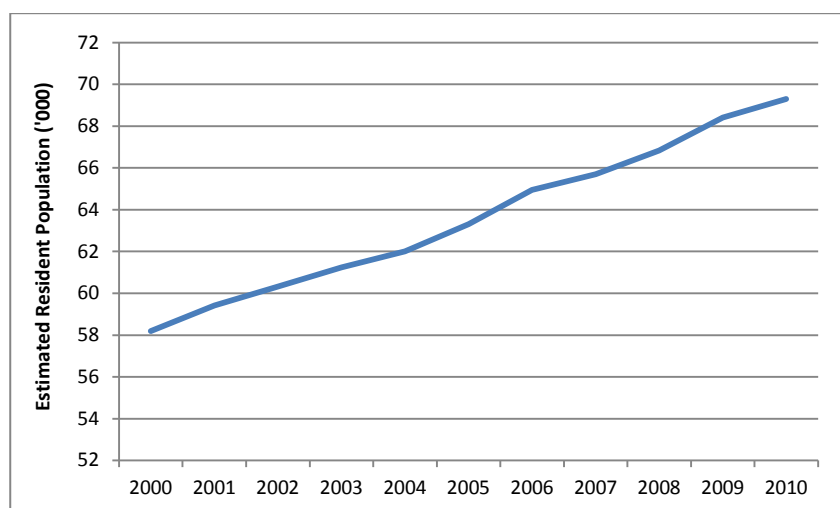


Figure 3: Population increase in the Bowen Basin since 2000¹

Source: Population figures for 2000 from ABS 2011a. Population figures for 2001-10 from ABS 2011b.

¹ To maintain consistency, the above figures only include data for the three major local government areas in the Bowen Basin – Isaac Regional Council, Central Highlands Regional Council, and Banana Shire Council.

Note: figures for *Central Highland* population in 2000 are compiled from Bauhinia (S), Duaringa (S), Emerald (S) and Peak Downs (S). Figures for *Isaac* population in 2000 compiled from Belyando (S), Broadsound (S) and Nebo (S).

The town of Collinsville is not included in this analysis of the Bowen Basin Population.

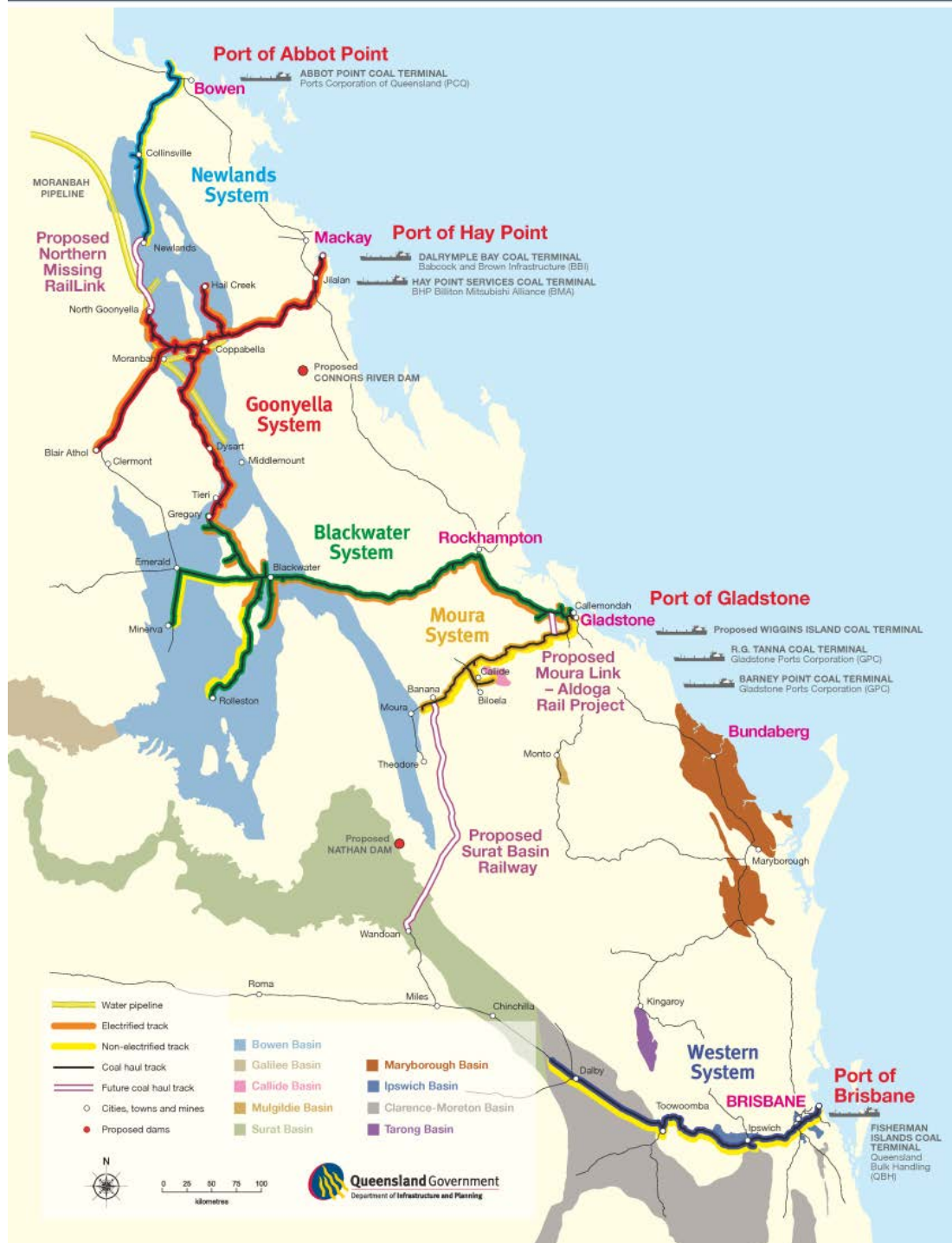


Figure 4: Map of Queensland Coal Systems

Source: Department of Infrastructure and Planning 2010

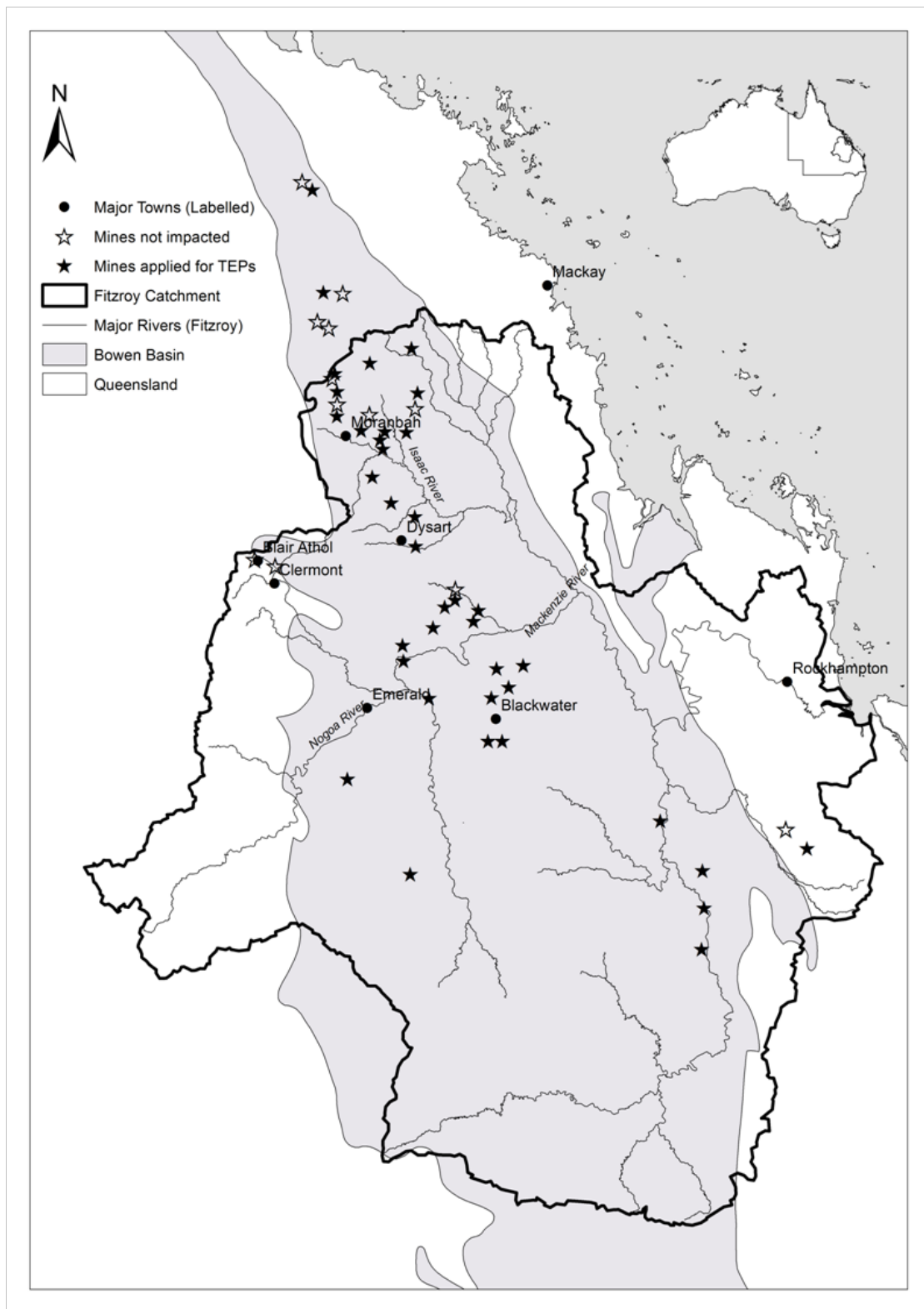


Figure 5: Map of Fitzroy Basin Catchment

Source: Map prepared by L. Sonter and V. Sharma 2012

In 2010-11, the Bowen Basin hosted 56 operational open-cut and underground coal mines with a large majority of the mines located in the north (DEEDI 2012). Coal is exported primarily through the Hay Point and Dalrymple Bay terminals, located approximately 30km and 25km south of Mackay. The Bowen Basin's main coal-based townships are Moranbah, Moura, Collinsville, Dysart, Middlemount, Blackwater, Glenden, Capella and Tier. In addition, the four major service hubs of Rockhampton, Mackay, Gladstone and Emerald are important centres within the region (see Figures 4 and 5).

With further expansion plans scheduled for coal mining operations in the region (DEEDI 2011), not only will mining activities continue to shape the social and economic profile of the Bowen Basin but their location within the ecologically-sensitive Fitzroy Catchment also raises concerns for the long-term health of associated river systems and potential downstream impacts on local communities. The catchment primarily hosts mining and agriculture as key industries. In the presence of these landscape-transforming activities and their exhaustive use of water and land resources, Fitzroy Catchment has undergone significant changes over the past decades (Jones and Moss 2010). With a high degree of ongoing climatic variability across eastern Australia, there is increasing pressure on all stakeholders operating within the region – government, industry groups, civil society – to devise improved adaptation plans to both better manage existing resources and address future changes in climatic conditions.

Covering an area of approximately 14 million hectares, the Fitzroy Catchment is the largest river system on the east coast of Australia, and the second largest catchment in Australia. Stretching from the Carnarvon Gorge National Park in western Queensland, to the rivermouth in Keppel Bay on the central coast, the system then empties into the southern end of the Great Barrier Reef (Calvert et al. 2000). The system consists of six major sub-catchments: the Nogoa, Comet, Mackenzie, Isaac-Connors, Dawson, and Fitzroy River systems (see Figure 6 below). A sub-tropical, semi-arid climate with high rainfall variability characterises the region. Rainfall predominantly occurs in the months of December to March, and varies annually from around 800mm at Rockhampton near the coast to around 516mm further inland, near Emerald. The majority of the annual discharge of approximately 5000 gigalitres occurs in this period, and several of the streams in the region are ephemeral in nature, thus flowing only during the wet season (Hart et al. 2008).

The catchment is prone to severe flooding following heavy rainfall events. Of the major rivers in the sub-catchments, the Dawson and the Connors-Mackenzie are particularly prone to flooding. The highest flooding event on record occurred in January 1918, reaching 10.11 metres recorded near Rockhampton. The flooding event experienced in 2010-11 came close to this record with a height of 9.2 metres, and resulted in the largest floods recorded for several important towns of the Bowen Basin, including Emerald, Rolleston, and Theodore (BOM 2011).



Figure 6: Fitzroy Catchment and River Systems

Source: Department of Natural Resources, Mines and Energy 2004

4. RESULTS AND OUTPUTS

4.1 Climate-mining nexus in Central Queensland: identifying the nature and scale of impacts and responses

4.1.1 Events in the past decade

Owing to Queensland's high natural climatic variability and associated ecological vulnerability of the Bowen Basin to climatic changes, several extreme weather events have been witnessed in the past decade. Climatic events affecting Central Queensland mainly included droughts, cyclones and flooding, and resulted in a range of impacts on a variety of stakeholders. Sporadic information about these events currently exists in the public domain, however this report marks the first comprehensive attempt to identify and document the nature, scale and scope of extreme climatic events experienced by Queensland's coal mining operations, locally and regionally in the past decade. This inventory of events will contribute to highlighting when and how variability in climatic conditions may have positively or negatively impacted Queensland's resources sector and dependent socio-ecological systems in the recent past. Appendices 4 and 5 provide a detailed account of these extreme weather events, including the type and intensity of event, the date of occurrence, the region affected, and the nature and scope of these events from a catchment-wide perspective. While the tables may not detail every extreme climatic event that has occurred over this time period for the study region, it is the closest approximation that could be developed based on publicly available information.

Droughts

From June 2002 to late 2010, a strong negative SOI, resulting in an extended El Niño state (refer to Figure 1) caused severe drought conditions across several parts of the Bowen Basin. Of the Basin's three local government authorities focused in this paper,

- Isaac Regional Council experienced drought from June 2002 to April 2008;
- Banana Shire Council experienced drought from October 2006 to late 2010; and
- Several parts of Central Highlands Regional Council region faced drought conditions of varying intensity intermittently between June 2002 and April 2010 (DERM 2012).

Appendix 4 draws together a timeline of drought affected parts of the mining-intensive Bowen Basin. The events are classified as 'Drought' or 'Partial Drought' to reflect the intensity of changed rainfall conditions. Whereas 'drought' indicates all of the individual properties in designated areas as drought-affected, 'partial drought' suggests that in most cases, more than 40% of all individual properties were affected by long-term drying conditions (DERM 2012).

4.1.1.1 Floods and Cyclones

While parts of the Bowen Basin have experienced intermittent flooding since 2000, major flood events occurred between the summer periods of 2007-08 and 2011-12 due to a positive Southern Oscillation along with a strong switch in the IPO detected in the Pacific Ocean (refer to Figure 1). Several towns – both mining-intensive and larger

service hubs – in and around Central Queensland were flooded and it took a long time before normal services and mining operations could be resumed. As mentioned earlier, record peak levels were observed for many towns and rivers in the region.

Through this extended period of extreme wet conditions, the flooding and cyclone events of 2010-11 were particularly noteworthy in that the La Niña effect observed in 2010 was one of Australia's strongest since 1917 (Nicholls 2011). Consequently, the summer period of 2010 surpassed all rainfall data ever recorded on the continent, thereby resulting in 'flooding of historic proportions' (QFCI 2011a, p.32). Almost 80% of the entire state of Queensland – with more than 2.5 million people and several thousand kilometres of road and rail infrastructure – was declared flood-affected. It is estimated that the reconstruction and rehabilitation of the 2010-11 flood-affected regions alone would cost the state of Queensland more than \$5 billion. Thirty-three deaths were recorded with three people reported still missing at the time of writing (QFCI 2011a, p.32). The state's agricultural and mining sectors in particular, suffered huge losses both directly and indirectly due to prolonged floods experienced in the region (ABARES 2011; Queensland Reconstruction Authority 2011; Sharma and Franks 2011).

In addition to floods, Central Queensland is also highly vulnerable to cyclonic events. During the period of 2000 to 2011, four cyclones were recorded that resulted in significant impacts on coal mining operations in the Bowen Basin. These were Cyclone Beni (February 2003), Cyclone Ului (March 2010), Cyclone Tasha (December 2010), and Cyclone Yasi (February 2011). Appendix 5 provides further detail on the nature and scale of these events and regions affected in Central Queensland.

4.1.2 Impacts of extreme events on stakeholders in Central Queensland – implications for long term sustainability

It is important to note that different stakeholders in Central Queensland experience extreme weather events differently. Each stakeholder group undertakes activities with varying vulnerability to changing climatic conditions. The list below suggests some examples of key activities divided across stakeholder groups operating in Central Queensland that are particularly vulnerable to changes in water quantity and quality, owing to extreme droughts and floods as experienced in the past decade. It highlights that on the one hand, a number of these vulnerabilities impact different stakeholders simultaneously, for example: infrastructure, including road, rail and telecommunications network are fundamental to the smooth functioning of all tiers of government, industry and communities.

On the other hand, several activities are specific to stakeholder groups and can result in multiple implications for their future sustainability, example: optimum quality and quantity of water availability is a pre-requisite for the smooth operations of the mining industry. Too little or too much water can impact production, thereby resulting in losses across economic (reduced export), social (reduced employment or OH&S issues for its staff) and ecological (stringent water regulation scrutiny) fronts. A thorough understanding of impacts resulting from these varied vulnerabilities to changing climatic experiences is therefore important in planning for improved response mechanisms in the future.

Examples of regional activities vulnerable to a variable climate, as drawn together from stakeholder interviews, include:

- Local government authorities (LGA) - LGAs traditionally play an important role in maintaining roads and other infrastructure including town water supply and sewerage. A variable climate can disrupt basic infrastructure with long-term consequences. Wider community safety – another LGA responsibility – is also vulnerable to changing climatic conditions due to health concerns, among others;
- State government agencies - Water planning and management, addressing mine rehabilitation and legacy issues, overseeing environmental impact assessments, ensuring industry compliance with regulations, and responding to reported incidents – all rely on a supportive natural environment. The functioning of several other state government departments such as Main Roads, Rail and Emergency Services is also affected by a variable climate.
- Mining industry – The viability of several activities such as underground and open cut coal production and extraction, dust suppression, maintenance of mined pits, tailings dams and road and rail accessibility for resource transportation to ports and supply of machinery and other equipment to the operation sites is predominantly influenced by supportive local and regional environmental conditions (Pearce et al. 2009). Furthermore, water scarcity limits power stations from operating to full capacity – the latter can influence energy prices and thereby impact both residential and commercial users.
- Farming community – those employed with the agricultural sector depend upon suitable climatic conditions both to maintain agricultural output as well as livestock. Climate-influenced potential pest infestation, as an example, could result in the loss of long-term farm output, thus creating financial hardships for those involved in farming and livestock sectors
- Local residential community – standards of public health and wider mental and socio-economic wellbeing depends on the smooth functioning of climate-sensitive industries such as mining, tourism and agriculture – dominant in Central Queensland. Regional and remote communities rely extensively on well-functioning road and rail infrastructure to ensure basic service provision.

In light of this knowledge about differentiated sectoral vulnerabilities to a changing climate, interviews conducted with key representatives from these stakeholder groups, identified three most significant impacts for their sectors resulting from several years of drought experienced in the Central Queensland region over the past decade. The interviews also discussed how, if at all, the presence of mining in the region may have influenced and or exacerbated these impacts. Key points emerging from the interviews included, but were not limited to:

- Local government authorities (LGA) – reduced water supply to community and businesses; impact on utilities due to reduced power supply and enhanced energy prices; and reduced council income from local rate payers' inability to pay taxes. The latter was a direct result of low farm incomes due to ongoing drought, which subsequently affected most other local businesses.

- Besides the presence of mining leading to greater competition amongst water users for water allocations, groundwater extraction for use by the mining industry in a time of extended drought caused local groundwater levels to drop further.
- State government agencies – serious implications for ensuring long-term water security region-wide, causing forced supply restrictions for multiple sectors – agriculture, mining, other industry, and local towns; haphazard execution of water management plans, calling for greater improvements in long-term water planning strategies and initiatives; negative impacts on the degree of success achieved with mined land rehabilitation and revegetation processes; and mines provided a positive alternative source of employment in drought-stricken farming-based communities. Enhanced competition for water allocations was again highlighted as a particularly significant influence of the mining industry during droughts experienced in the past decade.
- Mining Industry – water scarcity led to direct impacts on production; competition for water use negatively influenced – and damaged – industry's relations with downstream water users, including communities; extended operations in a water scarcity mode limited industry's adaptability to post-drought sudden change in climate to extreme wet conditions; several instances of failed mined rehabilitation efforts for lack of water to support vegetation were reported; increased energy prices as curtailed power production due to extended water scarcity raised industry's operating costs.
- Farming community – direct impacts on farm production and profitability; several short- and long-term land management issues; and mining industry's efforts to obtain greater water allocation quotas during the drought by buying more land led to a steep rise in land prices.

As mentioned previously, the size and topography of the Fitzroy Catchment – Central Queensland's primary water supply system – influences its vulnerability to climatic variability differently across the catchment (Jones and Moss 2010). This vulnerability is most clearly exhibited in flooding conditions. Although Central Queensland as a region has had several flood events in its past, the intensity, and resulting impacts of the floods in 2007-08 and 2010-11 were particularly severe for two primary reasons: a) the floods occurred after several years of drought conditions and therefore, for government, communities and industries based in the region, there was a visible lack of region-wide awareness of the implications of a sudden change from dry-to-wet conditions over a period of weeks and or months (Sharma and Franks 2012); and b) due to a small window of opportunity available (generally, not more than three months) in which extreme wet conditions due to a variable climate can be predicted, limited time was available to make anticipatory changes to 'business-as-usual' practices (QFCI 2011a). As a result, the enormity of the impacts observed during these floods raised important questions about the region's preparedness towards extreme wet conditions.

Significant flooding and cyclone impacts identified during interviews with key stakeholder group representatives highlighted several concerns with regard to the future planning and management of climatic variability as follows:

- Local government authorities (LGA) – widespread damage to roads and other infrastructure; and serious economic and psychological impacts on the community due to lost revenues, curtailed employment, physical isolation and inundation of houses and properties. Not only did infrastructure damage result in direct costs to LGAs in repairs and reconstruction but also isolated several rural communities and properties.
- Potential town and farm water supply contamination due to mining was suggested as an important perceived impact of floods largely influenced by the presence of mining in the region.
- State government agencies – direct impacts on regional water quality due to mine dewatering; damage to infrastructure, particularly transport and telecommunications; resulting real and or perceived social, economic and environmental impacts led to serious repercussions upon the relations between communities and other government and industry stakeholders.
- With regard to the mining industry's presence in the region influencing flood and cyclone impacts, it was highlighted that while the floods in 2008 clearly impacted the quality of water available in towns and communities downstream, the more recent flooding event of 2010-11 had no significant impacts on water quality.
- Mining Industry – impacts on revenue generation both due to flooded pits limiting production, and road and rail damage resulting in limited coal supply reaching ports for export to international markets; additional costs borne by the industry due to hiring of pumping infrastructure for dewatering pits, and repairing and upgrading mine site infrastructure damaged by cyclones and extended floods; concerns over mine water releases – although regulated – caused long-term damage to industry's relationships with communities located in the immediate vicinity of mining operations but also those further downstream; and finally, lost time in production impacted royalty revenues to the State Government, thereby resulting in losses in excess of \$5 billion to Queensland's gross state product (QFCI 2012, p.350). Appendix 6 further deconstructs the effects of the 2010-11 floods as experienced particularly by the region's mining industry. It captures details about flood-related water management and compliance issues and subsequent impacts for six specific mine sites operating in the Bowen Basin.
- Farming community – besides direct financial costs to farmers, floods and cyclones also resulted in significant bio-security risks both for cropland as well as livestock; and heavy rain-influenced large volumes of grass and vegetation growth make the region much more prone to fire risks in the near future. The presence of abandoned mines still waiting to be rehabilitated pose further threats of land and water contamination due to inundation caused by extensive flooding (QFCI 2012, p.350). Potential metal contamination extending into streams and the spilling of tailing dams remain constant threats for the wider socio-ecological health of the system in which the mines are located.

Despite several negative impacts of floods, a number of interviews also highlighted a significant positive development observed during past extreme events. Mining operations provided valuable resources – such as, additional State Emergency Service (SES) volunteers, helicopters, fodder drops for livestock in isolated communities,

evacuation centres and help with road infrastructure reconstruction – to affected communities and local governments, thereby contributing to an expedited response to floods and cyclones.

4.1.2.1 Implications for regional sustainability

In the process of identifying impacts of droughts and floods on different stakeholders operating within the Bowen Basin, including the mining industry, several other important issues are raised that may bear consequences for the future sustainability of the broader Central Queensland region. The fact that climatic variability may influence a number of these issues adds further complexity to their future management and development:

Region-wide liveability and affordability – for a region hosting several mining operations, liveability is to a large extent, influenced by the attraction and retention of staff in other industries besides mining; the ability to provide adequate infrastructure and services such as dams to maintain long-term environmental flows; the presence of governance arrangements and strategies that are able to manage and address the diversity of socio-ecological and or mental health impacts arising due to climatic influences on the interplay between mining and other industries such as agriculture in the region.

- ***Conflict between mining development and impacts*** – the presence of mining often creates conflicts not only with the operation of other industries but also in terms of having implications for communities based in the region. Maintaining balance between mining-led development and environmental impacts, particularly those relating to water quality and quantity (water supply); potential conflicts over resource-sharing in times of resource constraints such as droughts; and undertaking initiatives that ensure long-term success in rehabilitating closed mines offer useful pointers towards potential causes of conflict. In addition, managing community expectations from mining development has implications for regional sustainability in two important ways: a) ensuring that socio-economic contributions of mining are commensurate with regional and local impacts, and b) addressing community opposition to further expansion of the industry, thereby upholding their concern for ‘balanced development’
- ***Water management and regulation*** – developing improved mechanisms for a) flood management, including mine water discharge, b) water scarcity management during droughts, including sustained water supply and efficiency; and
- undertaking thorough assessments of mining impacts on groundwater may further influence sustainability outcomes at the regional level.

4.1.3 Stakeholder responses to extreme events experienced in Central Queensland

Not only are there significant differences between impacts eventuating from extreme weather events, the response processes employed to address these impacts also vary to a large extent. This is largely due to varied temporal dimensions associated with different climatic events. While droughts occur over a much larger time period and the intensity of drought impacts increases over time, extreme floods and cyclones are more

short-lived but sudden and intense in nature. As a result, in relative terms, in cases where droughts extend over many seasons, there is better scope for making adjustments and responding 'on the go' unlike floods and cyclones which – due to their sudden nature – necessitate either comprehensive pre-emptive planning and adaptation or reactionary learning from previous experiences to inform future response processes.

In examining how stakeholders operating in Central Queensland responded to extreme climatic events over the past decade, a number of important observations may be made:

1. In the case of droughts, the approaches adopted by different stakeholders to address water scarce conditions were focused primarily on developing and maintaining water efficiency measures (Department of Natural Resources and Water 2006).
 - a. Improved water resource planning to better manage and strategise water use across different users underlined efforts to restore water efficiency.
 - b. The introduction of water trading schemes, altered water allocation regulations and water harvesting strategies, employed mainly by the mining industry, provided valuable opportunities to ensure water security and long-term sustainability.
2. Another key response priority identified during the interviews related to increased investments in infrastructure and resource management to support water efficiency measures.
 - a. Important steps undertaken to achieve the above included: improving water supply networks by upgrading existing infrastructure, enhancing efforts within the mining industry to access greater water supplies by purchasing more farmland, redesigning mine layouts to minimise water evaporation while capturing runoff, training communities and industry workforce on the importance of water saving initiatives, improving communication channels for better flow of critical information between and within different stakeholder groups, and identifying opportunities for collaboration amongst stakeholders, including industry and state and federal government to lobby and better address water security issues for properties and businesses affected by drought.
3. While securing long-term water supply – quantity – for communities and key industries, such as agriculture and mining remained the key institutional priority during the drought years, the intense wet seasons experienced in Central Queensland in 2007-08 and 2010-11 raised concerns of a contrasting nature. With several towns isolated due to these extreme events, other key priorities for local and state governments included the establishment of disaster planning and emergency management programs, and

4. Strategies to deal with region-wide concerns with regard to excess water management and ensuring a reasonable quality of water for both domestic and commercial consumption.
 - a. Tools and mechanisms were subsequently put in place to undertake further studies on local and regional hydrology, including flood monitoring and modelling techniques.
5. The active presence of mining in the region compounded the anxiety about mine-affected water entering regional waterways, resulting in potentially irreparable damage to public and ecological health. Owing to large socio-economic costs from the floods, the industry's call for an expedited response from the state government authorities, mainly (then) Department of Environment and Resource Management (DERM) to authorise Transitional Environmental Programs (TEPs) – to allow for rapid mine pit de-watering and water discharges outside of the regulated Environmental Authorities associated with each mining operation – further led to heightened public outcry over water quality (Sharma and Franks 2012).
6. In addition to changes in environmental regulations advocated by the mining industry to better respond to future flooding and cyclone events, the experience gained during the floods in the past decade has called for a systematic re-assessment of a broader range of measures.
 - a. These include: managing excess water, revising structural design parameters for water storage dams to prevent overtopping, maintaining a steady availability of equipments such as additional pumps to enable prompt water discharge, improving collaboration and coordination internally as well as externally, thereby strengthening communication channels to better prepare for flood impacts; and investing in additional infrastructure to manage excess runoff and or water captured on mine sites.

The above investigation into key response mechanisms employed to address extreme events in Central Queensland through the past decade highlights the role that effective *collaboration* among the industry, community and local governments play in addressing these extremes. Collaborations enabled individual stakeholder groups to bring together their resources – human, financial and infrastructural – to respond to both water security issues during drought and flood-related disaster and emergency situations. In particular, interviews with mining industry representatives observed how the establishment of timely and effective consultation processes, such as the Fitzroy Water Quality Advisory Group and more recently, the Fitzroy Partnership for River Health, following past climatic extremes have enhanced regional communication channels.

Better communication has, in turn, encouraged multi-directional exchange of knowledge, information and experience among regional stakeholders, including local and state governments, utility providers, indigenous groups, academic researchers, industry partners from mining, agriculture and other businesses, environmental peak bodies and community groups, thereby better preparing for and managing impacts from past and present changes to the natural climate. Furthermore, in doing so,

collaborative arrangements have helped establish improved regional environmental monitoring strategies and community infrastructure programs, which have played an important role in minimising the risks and impacts of climatic extremes on the wider socio-ecological landscape in Central Queensland.

Another important argument that resonated across a number of interviews was the idea of 'sharing responsibility' among stakeholders to address future climatic events. Co-sharing responsibility with other actors to develop suitable response mechanisms positively influences both the degree of collaboration and the quality of communication channels considered vital in strengthening Central Queensland's capacity to adapt to a changing climate. Past experience in dealing with the region's climatic extremes have demonstrated a high level of collaborative planning and a sense of collective responsibility across stakeholders to condition goals, make decisions and execute plans in order to maintain long-term regional and local social, economic and ecological integrity.

Finally, observations made above do not in any way suggest that there is no scope for further improvements in the way the system currently operates. While broadly speaking, Central Queensland benefits from a comprehensive NRM program, strong regional relationships and a rich experience of dealing with extreme events, the sheer scale of mining and its complex non-linear interaction with non-mining industries makes the task of transitioning to long-term sustainability region-wide far greater to achieve.

Several concerns continue to exist; some of the key challenges over the short-term include: ongoing attention to establishing and sustaining efficient and effective communication; developing further collaborative arrangements to review and implement recommendations made by the Queensland Floods Commission of Inquiry (QFCI; see section 5 for more detail); improving upon current agricultural practices and mine rehabilitation strategies; developing a concerted approach that values and respects divergent skill sets available in the region; empowering local governments with greater access to resources to deal with extreme events; improving technical expertise in catchment-wide flood modelling and hydrological assessments and ensuring consistency in data collection and storage; developing a region-wide approach to precautionary rather than reactionary planning and response to climatic extremes; and finally dealing with the loss of organisational and collective memory associated with extreme events as a result of high staff turnover typical of the mining industry.

4.2 *Learning from the past: a case study of Ensham's experiences of flooding in 2008*

4.2.1 *The event – 2008 Floods*

In January 2008, unprecedented rainfall occurred over a short period of time in the Nogoa River and Theresa Creek catchments within the Fitzroy Basin, in Central Queensland. The rainfall led to severe flooding in the region, inundating the township of Emerald and causing serious infrastructure and economic damage to mines located in the Bowen Basin region, particularly the Ensham and North Curragh mines (EMQ 2008). The flow down from the northern Theresa Creek system reached a peak of 157,000 megalitres (ML) of water per day, a rate that continued for more than a week. Yet this figure is only around half of the inflow that reached Fairbairn Dam from the southern Nogoa River System, which peaked at 350,000 ML per day (with a rough average of 300,000 ML per day) (Ensham Resources 2008a).

The Ensham Mine, an opencut coal mine located 40km northeast of Emerald and operated by Ensham Resources Pty Ltd, suffered the full force of these flows, particularly as the Nogoa River ran through the middle of its mining operation. In the week from 19th to 26th January 2008, 1.5 to 2 million ML of water streamed through the Ensham mine (Ensham Resources 2008b). Estimates place this figure at roughly five times the volume of water present in Sydney Harbour (Australia's Mining Monthly 2008). The peak flow in the Nogoa River passing through the Ensham Mine was approximately 250,000 ML per day (Ensham Resources 2008a), equating to one thousand times the normal water flow (Ensham Resources 2008b). The surge of water breached the levee banks that had been constructed to withstand a 1-in-100 year flood, filling two of Ensham's six coal pits (B Pit and C/D Pit) with 110-150,000 ML of water (Lewis 2010).

An initial extreme weather warning, released on 18th January 2008, prompted Ensham staff to move two of the operation's four draglines to safety. Efforts to move a third dragline (the Marion 8050) were thwarted, however, when rising flood waters forced the crew to vacate the dragline and shut off power for safety reasons (Australia's Mining Monthly 2008). This dragline, the second biggest dragline in the world at the time, was consequently submerged in water 15 metres deep (Australia's Mining Monthly 2008; Porter 2008). In the aftermath of the event, Ensham Resources CEO John Pegler complained that "there was no effective warning and little or no real-time information about the likely severity of the flood, which was unprecedented" (Australia's Mining Monthly 2008).

4.2.2 *The response*

Following the initial impact, Ensham employees were placed on flood alert, and any employees living in the affected area were sent home to care for their properties and families. Initially, employees were transported to and from the mine site by helicopters, until water from the Nogoa River receded and light vehicles could enter the mine from a haul road (Australia's Mining Monthly 2008).

Once the rain subsided, Ensham faced the difficult task of draining water from its flooded pits, as well as recovering its submerged dragline. Ensham was allocated a “Prescribed Project” status by the Queensland Government in order to both assist with flood recovery, and to expedite the process of government approvals required to return the operation to full production as quickly as possible (Australia’s Mining Monthly 2008).

Ensham successfully applied for a permit from the then Environmental Protection Agency to release the water trapped in its pits as part of the “Transitional Environmental Program” (TEP). From February to September 2008, Ensham released approximately 138,000 ML of water, at 2000 ML per day, into the Nogoa River (DERM 2010). The extended discharge of mine-affected water elevated salinity levels as far downstream as Rockhampton (roughly 300km away), and prompted residents of nearby communities within the Central Highlands Regional Council to raise concerns over the health implications surrounding the release of this mine-affected water (Green 2011). A report released in November 2008 on water quality issues in the Fitzroy catchment revealed that the Ensham mine-affected water discharges had not led to any human health problems (BMA 2009). However, concerns remained around increased levels of saline discharge, metal ion concentrations, and alkalinity levels (Hart et al. 2008; Davies 2011), and potential repercussions this may have on the spawning success of fish species and the sustainability of river water for downstream consumption (Hart et al. 2008; Delzoppo 2011; QFCI 2011b).

By June 2008, Ensham was operating at 50% of its total capacity, moving up to 80% of full production by January 2009 – a year since the floods hit (Price 2009). At this same point in time, the previously submerged dragline was fully recovered and was back in operation following total refurbishment and rebuilding, at a cost of over \$100 million (Porter 2008; Price 2009). Excluding the direct loss of revenue from coal sales, the 2008 floods cost Ensham approximately \$270-300 million, including lost time in production, clean-up costs and loss of infrastructure and equipment (Feary 2008; Lewis 2010). The total duration it took Ensham’s 2008 flood-impacted operation to fully resume production is currently unavailable in the public domain.

4.2.3 *Learning the lessons*

The unprecedented impact of the 2007-08 flooding events, and the mammoth recovery effort that followed, prompted Ensham Resources to initiate a number of processes to learn from the devastating experience. In order to better understand the conditions and events which had caused the flooding, Ensham consulted its immediate neighbours through individual discussions. Nearby landholders who could not be contacted in person were written to, and invited to share their observations and experiences of the flood event. Independent flood studies, conducted by state government departments, the bulk water supplier SunWater, and the Central Highlands Flood Recovery Group were also reviewed to glean any further information about the nature of the floods. Once these studies had been reviewed, Ensham shared the findings with their direct neighbours and sought feedback on how the information could be further refined. In doing so, Ensham sought to create “the most complete and accurate picture of why the floods were so devastating for Ensham and property owners along the Nogoa River floodplain”. This refined information was then incorporated into Ensham’s flood

modelling processes for subsequent planning and decision making around risk and disaster management (DME 2008).

4.2.3.1 Revised mining methodology

In August 2009, Ensham Resources submitted a supplementary report to the Queensland Government which detailed a revised mining methodology for the Ensham Mine (Hansen Bailey 2009). Ensham CEO Peter Westerhuis cited “the impacts of market conditions, lessons we learnt from the flood event in 2008, and feedback from the community” as the reasons for this revised methodology, the key aspect of which was a shift from opencut to primarily underground mining (Martin 2009). In doing so, Ensham hoped to minimise disturbance to the anabranch of the Nogoa River, and also avoid the need to construct an extra 12 kilometres of levee banks (Martin 2009; Stanley 2009). Under these new plans, Ensham suggested the use of bord and pillar and long-wall underground mining methods to reduce the environmental impact of its operations (Martin 2009). The announcement of these changes has been welcomed by groups such as FutureFood Qld (Martin 2009) and AgForce (Stanley 2009).

4.2.3.2 2010-11 Floods

Between late 2010 and early 2011, a positive Southern Oscillation Index, combined with an ongoing monsoon, led to an unprecedented volume of rainfall across Australia (QFCI 2011a). Almost 75% of Queensland was exposed to widespread flooding and cyclone events from November 2010 to January 2011 (Queensland Health 2011). The Ensham mine site was once again inundated, with large volumes of water captured in the pits (Ensham Resources n.d.). Appendix 6 details some of the key impacts of the 2010 floods on Ensham’s operation, among others. However, the measures implemented following the 2007-08 flood event ensured that while Ensham’s operations were impacted during the flooding event of 2010-11, the intensity of the impacts was significantly reduced. To put in perspective, approximately 3000 ML of water at 100 ML per day was released from Ensham’s mine following flooding in 2010-11 (DERM 2010). In comparison, the volume of water released during the 2007-08 event was up to 50 times more with approximately 150,000ML of mine-affected water discharged – at 750ML/day – into the Nogoa-Mackenzie-Fitzroy River system over a period of seven months (Delzoppo 2011).

4.2.4 Important findings from this case study

The case of Ensham underlines arguments presented earlier from the literature that suggest how first-hand experience with extreme events can lead to the adoption of measures that build resilience and enhance the quality of risk management strategies. Ensham’s experiences of dealing with the 2008 flooding event and resulting impacts both on the company’s economic performance and its relationship with communities in the region highlight three important findings: a) the recognition of anticipatory planning, including swift organisation-level capacity building to manage disaster events, and practical and timely support from the regulators is vital in managing extreme events, particularly those which have a much shorter lead time to develop a detailed plan for impact assessment and management. Events resulting from natural climate variability provide a useful case in point, b) it is important to formalise mechanisms that can ensure that organisations capture and establish local and regional knowledge of lessons from past experiences. Systematic learning from past extreme events can play

an important role in avoiding long-term disruption to mining operations and dependent socio-economic life, and finally c) adaptation – although reactionary to the 2008 event – helped avoid large-scale impacts from the 2010-11 flooding. Such reactive learning not only helps in furthering organisational learning referred to above but also aids in reassessing lessons and current risk management practices to improve future adaptation capacity and strategies.

4.3 Barriers to and opportunities for climate adaptation – a mining industry perspective

As discussed earlier in section 4.2, adaptation to climatic changes, although necessary, is often limited by the presence of a variety of factors. This section provides a mining industry perspective on the nature of some of these barriers. It also highlights how a number of these barriers may actually lead to further deliberation on ‘hidden’ opportunities and motivators that can help the resources sector devise a concerted approach to addressing risks from both natural and anthropogenic changes to the climate. As mentioned in section 3, findings discussed below are drawn together from the two workshops conducted with a multitude of industry and other regional stakeholders.

Workshop participants were asked the following overarching question:

- What barriers, challenges, motivators and enablers currently exist that inform and influence your organisation’s response to climatic variability and change? Identify those existing:
 - Within your organisation
 - Within the broader mining industry
 - Outside the mining industry (among other stakeholders – e.g. Local and regional governments, community groups, other industries)

While several important issues were raised during the discussion, the mining industry’s perspective largely centred around six main barriers. It was argued that a number of these barriers often existed in a complex inter-dependent manner, and therefore necessitated a whole-of-systems approach. The latter, it was highlighted, would help bring together the conventionally compartmentalised knowledge existing on risk management and climate adaptation both within and outside the mining industry. Main barriers identified were:

1. The nature of industry’s planning cycles

Typically, the mining industry operates around an annual planning cycle that is driven by production targets and is tied strongly to its annual budget. This shorter-term focus on maintaining production often prevents a systematic assessment and visioning of external factors such as climate risks as influencing the long-term viability of mining operations.

2. Communication

Representatives from the mining industry believed that the nature of communication associated with the sector is extremely difficult to navigate, mainly due to the need to communicate across multiple stakeholders simultaneously (including, but not limited to, various tiers of government, other non-mining industries in the region, communities, other resource players operating within the region, and within the organisation). The presence of divergent priorities, interests and viewpoints across these different stakeholder groups further aggravate the communication challenge.

With regards to engaging with the community, the industry recognises the importance of communicating complex information in a simple language. Yet, lack of appropriate action from the state government and community's own pre-conceived impression about the industry's role in causing ecological disruption leaves little scope for the industry to help members of the community gain a fresh unbiased perspective on the former's efforts in resolving matters of potential conflict, e.g. water sharing, release of mine-affected water and managing consequences from unforeseen climate disasters.

In addition to this, within the same mining organisation, site managers often think and act very differently from technical experts whose immediate objectives are also often in contrast to those of the non-expert staff, including members of the senior management. Individual perspectives and leadership skills therefore, play an important role in how climate-related risks are addressed at various levels within the organisation. Often, budget- and production-driven decisions result in much serious longer-term implications manifested in reduced organisational capacity to deal with extreme events and significant socio-economic and reputational losses.

3. Lack of meaningful climate data and time limitations

Currently available climate forecasts are not useful enough to the industry as they lack localised information and other micro details to enable focused pro-active planning and management of risks. Lack of sufficient time available prior to the onset of extreme events further disables mining operations from rallying internally within their organisations to seek additional financial, technical and human resources to build effective risk management plans.

4. The role of local context

Unfamiliarity with the local context can play an important role in impeding adaptation, particularly in light of Australia's diverse climatic zones and socio-ecological landscapes. Within the one organisation, different sites have demonstrated varying degrees of success in managing risks. While both internal and external communication and individual mine site leadership play an important role, other factors, such as the geographical location of the operation, inter-site climatic variability, socio-ecological regional context within which the mine is located, and unfamiliarity of mining personnel with local climatic conditions can further influence the operation's resilience towards external climatic perturbations.

5. Lack of established memory of events, impacts and responses

The resources sector is characterised by high staff turnover and an organisation-wide short-term memory of extreme events and their impacts on the industry and the broader region. The involvement of contractors on a short-term basis further discourages the establishment of practices, protocols and lessons drawn together from previous experiences of dealing with disasters and extreme events.

6. Community perceptions as both a barrier and motivator

In the past, incomplete, or misplaced knowledge about mining activities in the region has led to a series of negative perceptions among local communities in the region. Although the resource sector finds it difficult to deal with these perceptions over the short-term as they are heavily influenced by the media and other non-mining industry presence, there is an industry-wide acknowledgement that these ill-informed perceptions act as one of the biggest motivators for the industry to bring about significant changes in the way it plans for, and manages climatic risks. The reputational costs associated with underlying community-company mistrust increasingly influence disaster management and enable more informed corporate decision making on climate adaptation.

In the last decade, the crucial role of community beliefs and perceptions has therefore, motivated the industry to invest in systematically improving relations with immediate neighbours by sharing knowledge, facts and data. The latter has, in turn, led to the spread of positive word-of-mouth stories in the region about mining activities.

Figure 7 provides a summary of key barriers, motivators and opportunities identified during the workshops from a mining industry perspective:

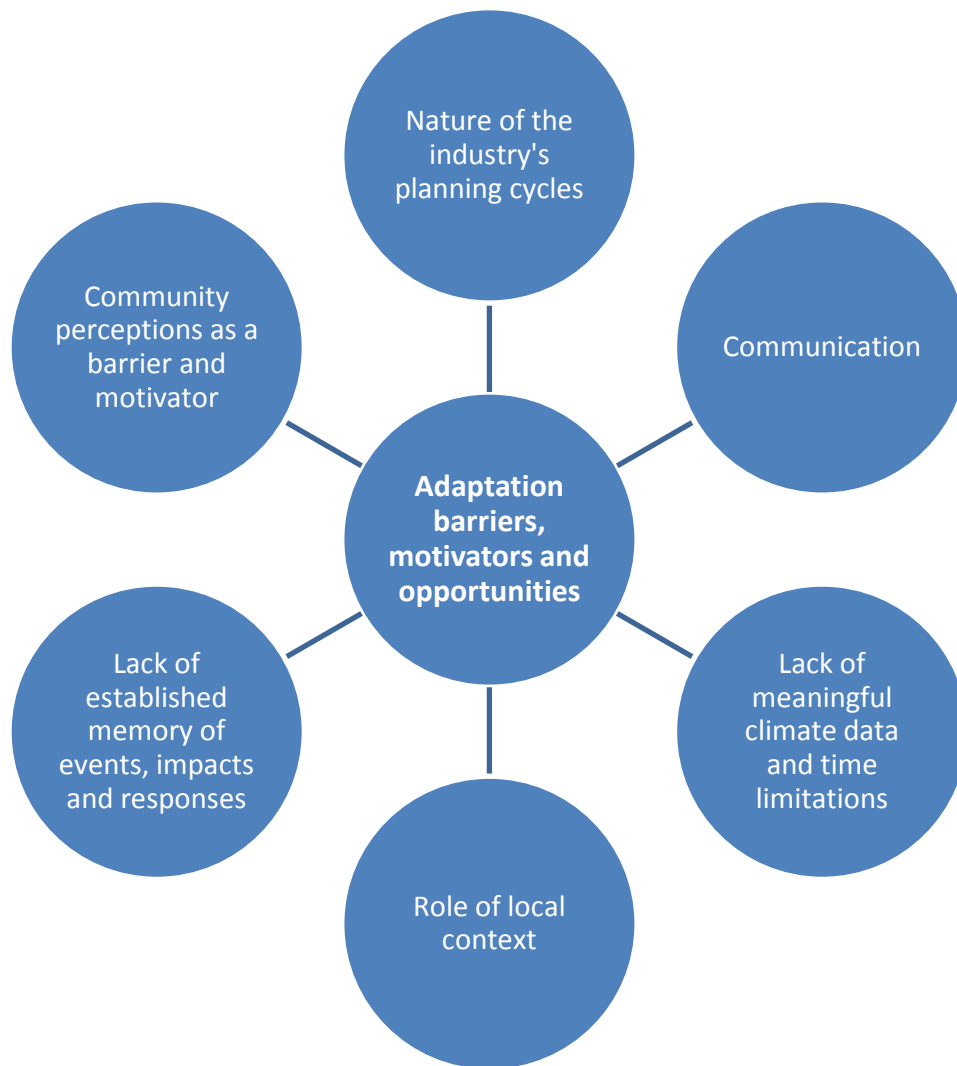


Figure 7: Adaptation barriers, motivators and opportunities – a mining industry perspective

4.4 Barriers to and opportunities for climate adaptation in the broader Central Queensland region – a multi-stakeholder perspective

Apart from gaining a mining industry viewpoint on what may be some of the existing barriers and challenges preventing the industry from developing a coherent climate adaptation program, one of the other key objectives of this research project related to adopting a whole-of-catchment lens to gain a regional perspective on climate adaptation planning and preparedness in Central Queensland. As mentioned earlier, a multistakeholder workshop facilitated the collection of data for this step in the project. Key barriers and opportunities for climate adaptation identified through this workshop included the following:

1. Scope for further collaboration, engagement, and exchange of information

Workshop participants noted that there was much scope for further engaging with small and medium enterprises (SMEs), supply chains and other service providers, including power suppliers, and accommodation providers for mining employees. There is a need for greater resilience planning, particularly around supply chains to maintain their functions during extreme events. Collaborative interaction between and among regional councils to enable sharing of resources, data and lessons learnt is currently need-based and not systematic. As has been demonstrated by the 2010-11 floods, access to monitored environmental data is important with regard to ensuring industry accountability and effective government regulation. Industry measurements have been observed as more timely, accurate and effective in contrast with government monitoring, thereby requiring such information to be available in the public domain.

The importance of clear, honest communication on impacts of extreme events within the mining sector is particularly important to enable local governments to maintain service provision and respond to sudden climatic events in a coherent manner. Lack of basic information from the mining companies on issues such as number of employees living in camps, an estimate of food, energy and other basic service needs can disrupt relations between companies and local governments, and are often detrimental to long-term regional vitality.

2. Lack of political will

Top-down political intervention without much consideration to local needs, issues and priorities was considered an important barrier in planning for climate adaptation. State government agencies have largely been reactive in the past and therefore, significant responsibility for pro-active climate adaptation lies with local governments. Having said that, increasing responsibility has not necessarily led to the allocation of additional human, financial and technical resources to local governments, thereby limiting the degree to which long-term resilience planning has been possible across the region.

There is therefore, a need and a push from the region for the state government to adopt the role of a coordinating authority, which appreciates a regional collective effort to address shared climate-related concerns. Such concerted approach to climate risk management from state government will further provide mentoring opportunities for other mining-intensive parts of Queensland and also other regions across Australia.

For the purposes of this project, the workshop discussion further highlighted that political will is also important to ensure region-wide recognition that the presence of the mining industry significantly influences how the wider region plans for and adapts to climatic changes. While there are several opportunities possible from this linkage, greater institutional intervention is required to mitigate the negatives on an ongoing basis.

3. Short-sightedness

Another major barrier to effective regional climate adaptation highlighted was institutional short-sightedness. Failure to learn from past experiences; inability to undertake long term planning to align with extended temporal dimensions associated with anthropogenic climate change as distinct from planning for natural climatic variability planning which has a much shorter time frame; and the tendency to act – often reactively – when an extreme event is already occurring instead of a consistent approach to planning proactively are elements that characterise the existing institutional nature of climate adaptation. According to a workshop participant, ‘consistency, not complacency is the approach needed to address climate risks and extreme events’.

4. Climate change interacting with existing stresses

Increasingly erratic climate reflected in more intense and frequent extreme events, resulting due to future anthropogenic climate change may begin to interact with existing stresses around water management in Central Queensland, further challenging the region’s overall resilience and risk management processes. Higher evaporation rates due to climate change may, for example, be another ‘potential water user’, thereby creating more conflict around water access between various industries and stakeholders.

Scientific uncertainty around the nature of impacts from climate change therefore provides the motivation to identify areas of research with long-term utility, that are able to capture ‘what we have, what we don’t have, where we want to go, and how are we going to get there’. The latter is possible by recognising that groups with varied interests must come together and pull resources to address shared concerns.

5. Extreme events as an opportunity to drive innovation

Although disruptive in nature, extreme events provide a useful window of opportunity in terms of driving innovation to ensure sustainability of resource regions. They ‘force’ stakeholders in government, industry and the civil society to rethink current processes of risk management and apply new technologies and build collective knowledge that can transform crises into long-term advantages. Although to a certain extent, extreme events trigger innovation organically, they also provide a systematic opportunity to assess the nature of new knowledge needed, and how that can be processed, applied, and methodically updated. Such events are therefore ‘catalysts’ for the region and all public and private stakeholders to be innovative in thinking about risks and resilience. Examples of innovation already in place due to climatic events experienced through the past decade include the industry’s efforts to undertake reverse osmosis treatments and dry beneficiation during floods and droughts respectively to manage water surplus and scarcity.

6. Business opportunities

From a regional sustainability and liveability viewpoint, the presence of the mining industry provides varied skill sets in the form of human resources – albeit short-lived – living in the region. While in some cases, miners can further stretch local government capacity to provide for emergency needs and supplies during disasters, if engaged effectively, it is possible that instead of being considered a ‘socially-detached’ homogenous group, their skills are valued and even utilised during extreme events. In addition, FIFO workers can be champions for the broader region, and can be encouraged to bring their families to live in the region, enhance local businesses and contribute to regional socio-economic sustainability.

Figure 8Figure 7 provides a summary of key barriers, motivators and opportunities identified during the workshops:



Figure 8: Adaptation barriers, motivators and opportunities – a multi-stakeholder perspective

5. DISCUSSION AND POLICY RECOMMENDATIONS

The manner in which changing climatic conditions impacted businesses, governments and other stakeholders in Central Queensland in the past decade highlights two important issues that remain central to the future of climate adaptation strategies in the region: firstly, the multi-layered complex interplay of mining with non-mining entities in the area necessitates a careful re-assessment of what worked in the past and what didn't. The scale of mining operations spread across the region, the associated suite of positive and negative emotions that the communities and governments perceive with the presence of mining, and a wider acknowledgment of the industry's resourcefulness and socio-economic contribution are powerful reminders of how the way in which businesses respond to extreme climates can influence not only their own long-term viability and reputation but also regional – and national – socio-economic and ecological landscapes.

Secondly, and more importantly, in light of growing recognition of Australia as one of the world's most vulnerable regions to anthropogenic climate change (Palutikof 2010) lessons learnt from past experiences in dealing with extreme events combined with observations and recommendations collected through interviews, workshops and QFCI findings provide useful pointers towards how extreme events resulting due to natural climatic variability provide an opportune trigger to plan for and develop strong regional adaptive capacity to address future – natural or anthropogenic – climatic disasters. This is in agreement also with current literature that suggests the role of reactionary learning based on experiences with climatic perturbations of the past as a useful tool to develop pathways to deal with future changes to the intensity and frequency of climatic extremes (Nass et al. 2005; Madsen 2009; Marshall 2010).

A significant message delivered from the past handling of droughts and floods in Central Queensland by mining operations relates to the inherent contradiction in industry mindsets. On the one hand is the push to encourage water conservation during the dry season while on the other hand, and over a period of months, there are calls from within and outside the mining industry necessitating the management of excess water resulting from extreme floods. This contradiction – accompanied with lack of preparedness to deal with sudden and intense changes in the natural climate, and short-sightedness within the industry due to high staff turnover – has exacerbated both the physical as well as socio-ecological vulnerability of the industry to climatic disasters. The past decade and its share of extremes on both sides of the spectrum therefore, offer a particularly timely story to identify lessons that may inform future adaptation strategies for mining-intensive regions both in Central Queensland and other parts of Australia. Although lessons differ by stakeholder groups and the nature of the climatic event, several common learnings emerge that cut across functional and institutional boundaries. These lessons include:

- The critical role of monitoring, ongoing evaluation and feedback to encourage methodical learning, whereby existing adaptation plans and strategies are continually revised and adapted in light of new information;
- The importance of early and timely planning both by governments and industries – for regions such as Central Queensland that rely almost exclusively

on mining and agriculture, both extremely water-intensive industries, long-term water management and resource planning for droughts and preparatory planning for floods is vital;

- Better understanding of the local and regional contexts, including the socio-ecological landscape that hosts mining operations. The reality that several towns in Central Queensland – but also across Australia – are situated on flood plains needs to be appreciated by climate adaptation planners and decision makers.
- Strong political will and commitment from state government agencies to help the industry and local governments plan for a coherent, coordinated approach to climate risk management. Current structures of top-down planning with no provision of additional resources have failed to build effective region-wide resilience to climatic impacts;
- The role of engagement and communication across different stakeholder groups – industry, local governments, civil society, SMEs, service providers and media – can hardly be underestimated. Sharing of data, combining resources to address shared challenges, presenting a collective regional voice to seek help from the state government to address climate risks are important in creating effective systems of risk planning and climate disaster management;
- The importance of collective knowledge management, transfer and training – to develop a common pool of regional and catchment-wide expertise in preparing for and managing both real and or perceived impacts from climatic changes. Establishing this knowledge is also important in light of the high staff turnover prevalent within the mining industry, a steady flow of short-term contractors, and short-lived memory of past disasters more broadly across the region;
- Commitment by all stakeholders to voluntarily collaborate and prioritise resources – human, technological, financial – to address climatic impacts;
- Greater flexibility in resource management plans – to accommodate abrupt changes in climatic conditions;
- Early collaboration with local governments is particularly useful in employing local knowledge and expertise and their established credibility with local communities in addressing social and or environmental concerns; and
- Recognition of extreme events as ‘opportunities’ to drive innovation in the way regions think, plan for and manage disasters. Such events thus provide triggers for innovative entrepreneurship and the pursuit of new technologies and problem-solving techniques to address future climatic events.

In addition to the above, several lessons particular to the mining industry based on its past treatment of climatic extremes highlight the following:

- The need for the industry to adopt a culture of water use efficiency while being aware that the switch from a very dry to a very wet season ‘may be just around the corner’;
- The current climate data available from the Bureau of Meteorology (BOM) is inadequate and impractical in terms of helping the industry develop risk management plans ahead of the small temporal window available for immediate planning, typical of events caused due to natural climatic variability. Current lack of data with finer details about potential localised impacts also makes it

difficult to develop effective contextually relevant adaptation plans for future anthropogenic climate events;

- The importance of reasonable and practical regulatory conditions with regard to authorising mine water releases and monitoring water quality during floods in a consistent manner;
- Collaboration between the mining industry and environmental groups and state agencies to address the inherent tension relating to sustaining the competing objectives of economic development and a high environmental quality;
- The need to work together with regulators to incorporate site-specific requirements concerning water quality and quantity in future adaptation planning;
- In relation to the regulator's approach to inspecting sites and undertaking risk assessments for sites considered most vulnerable to flooding and inundation, it is necessary on part of the State's environmental regulating authority to:
 - maintain consistency in its strategy to identify sites for inspection, and
 - undertake risk assessments in a timely continual manner.

Besides these lessons, the floods of 2010-11 raised several other key considerations emanating largely from concerns raised by the wider community and environmental groups. Further highlighted in stakeholder discussions throughout the project, there is an urgent need to bring together relevant parties to provide definitive responses to region-wide concerns, including: to what extent should mining really be considered to influence both short- and long-term ecological harm observed after the floods? What roles do other industries – mainly, agriculture – play in affecting salinity levels in the regional watercourses observed during and after a high wet season? What are some of the more serious cumulative impacts of flood-led mine discharges on the marine environment? What are some of the more practical measures that can be adopted to address potential points of conflict around risk and disaster management between the mining industry and other industries, media and state government agencies? and, the role of changing regional demographics in influencing social and economic adaptive capacities and how the presence of mining may be further exacerbating this demographic shift in Central Queensland.

Conclusive responses to some of these concerns will have at least a two-fold advantage: firstly, it will enforce adequate monitoring of salts, minerals and other contaminants in flood-affected waterways both at source and end-of-pipe. Doing so will prevent the wider community from making uninformed, perceived assumptions about controlled mine discharges causing significant ecological impacts. An informed understanding of the causal relationships with respect to socio-ecological processes will consequently help stakeholders (miners, agriculturists, community, environmental groups and governments) gain a more cohesive outlook towards each other, better appreciate limitations, and strengthen relationships and communication with other groups.

Secondly, as also stated by the QFCI, better understanding the contributions made by mining operations to the environmental harm observed post-flooding in the region ‘is vital to inform DERM’s response to future flooding at mines in Queensland’ (QFCI 2012, p.357). This will, in turn, help the Department of Environment and Heritage Protection, the Department of Natural Resources and Mines, and individual mining companies and mine sites to work together to address past methodological and technical inconsistencies in mine water release regulations (see Appendix 7) and allow for a more rigorous approach to managing heavy rainfall and floods to limit disruptions to natural environmental processes. The latter will also greatly help in addressing the current tendency among stakeholders in the region to maintain higher expectations about mining industry’s responsibility towards social and ecological sustainability vis-à-vis other industries, such as agriculture.

While not discounting the fact that mining can – and often does – lead to significant socio-environmental disruption, a balanced perspective to assessing impacts from different industrial operations is important for at least two additional reasons: firstly, so actions and resulting impacts can be attributed to responsible industries and a clear program of response planned and executed ahead of time. Secondly, in a situation of extreme event, either due to natural or anthropogenic changes to climatic conditions, clear articulation of roles and responsibilities for climate adaptation across various economic activities can help better streamline organisational capacities and internal resilience to encourage cross-sectoral, regional planning that discourages free riders and resulting mistrust within the community.

5.1 Implications for policy making

This research project has addressed an important – but under-researched – topic of climatic variability impacts on the mining industry and related communities. Given the socio-economic significance of mining for both Queensland and Australia and its immediate dependence on a supportive natural environment, it is important that the industry and other stakeholders are well prepared to address any changes in climatic conditions to maintain long-term business viability and the wider region’s social and environmental sustainability.

The research findings highlight a number of issues that have particular relevance for policymaking across all levels of government. While some of these issues have been considered in different manifestations over time, recognising their role in the particular context of strengthening the resource sector’s resilience and adaptation to climatic changes requires a more coordinated effort from all stakeholders. This project suggests four key implications for policy and decision makers. These implications are vital to both assessing current adaptation efforts in the sector and their effectiveness, as well as identifying opportunities that can help improvise these efforts to deal with future changes more effectively across time and space:

1. **Role of government** – as has been highlighted throughout this report, governments play a particularly important role in coordinating adaptation efforts. Often, there is a lack of clarity with respect to roles and responsibilities at different institutional levels which, in turn, impacts negatively on the nature and

success of adaptation outcomes. In the context of the mining industry, where the state government is both the regulator and the 'beneficiary', clear articulation and differentiation of responsibilities between state and local governments is of vital importance. The latter will also contribute to addressing contradictions between local and state governments due largely to a top-down governance approach without much consideration for local priorities, capacities and aspirations. Not only are the immediate effects of climatic changes most strongly experienced at the local level, local governments are also better aware of existing capacity – or likely barriers to executing this capacity – to adapt to sudden and or gradual climatic changes. These factors necessitate greater involvement of local governments in regional decision-making.

2. **Role of communication, cooperation and collaboration between and among various stakeholders** – one of the key challenges to effective adaptation in a resource sector context is the inherent tendency to consider stakeholders as essentially antagonistic in terms of their values, ideologies, and perceptions of one another. While this may be true on a number of occasions, sudden extreme events or future climate change requires stakeholders to consider climatic challenges as a 'common' concern that may be best addressed by pooling together available resources, exchanging information on climate data, sharing knowledge, skills and expertise in managing risks and disaster events, and rallying together at the local and regional level to demand improved services from state government agencies. While events experienced in the past decade in Central Queensland suggest having led to a number of such collaborative initiatives across hitherto divergent stakeholder groups, there is still a potent demand for improving the scale and consistency of outcomes achieved from such collaborative efforts. For policy makers at the state level, they can play a key role in encouraging – and coordinating – regional and local stakeholders to operationalise effective partnerships for climate adaptation.
3. **Acknowledging extreme events as opportunities to drive innovation** – this research has brought to attention that while the immediate and short-term impacts from extreme events are devastating for the socio-economic and ecological integrity of the region in which they occur, over the longer-term, they provide a unique policy opportunity to trigger innovative thinking, problem-solving and a more resilient set of entrepreneurial skills. Faced with a suite of disaster events in the past decade, various stakeholders in Central Queensland have already drawn on lessons from past experiences to undertake several innovative changes in the design and execution of basic functions and practices including, but not limited to, water saving initiatives at the household and community levels, better coordination among water management activities across stakeholder groups through the establishment of consultative joint committees to develop region-wide consistent water management strategies and actions, and technological innovation within the mining industry to address both scarcity of water during droughts and the management and treatment of excess

water during a wet season. However, these efforts have remained sporadic and largely need-based. As discussed during the workshops, policy makers at the state level can further systematically encourage long-term innovation and creativity in building new relationships, networks, and knowledge for improved local adaptation to changing climatic conditions.

4. **Learning the lessons from past climatic variability to inform future adaptation to climate change** – finally, as highlighted on several occasions in this report, past ability to respond to events and address subsequent impacts is a powerful policy tool to evaluate what worked, what didn't work and what adaptations and or changes to past approaches are necessary to better respond to a future repeat of similar events. In the case of anthropogenic climate change which entails a high degree of uncertainty about the nature and scale of impacts, adapting to changing natural climate variability can provide useful pointers towards policymaking in the area of future climate change adaptation. On the one hand, these pointers will help identify areas for further improvement in adaptation research at a regional level. On the other hand, for industries, such as mining which have thus far tended to consider risks associated with extreme events from an 'event' rather than an 'impact' lens, lessons from past climatic disaster experiences will generate organisation-level appreciation for proactive planning and flexible risk management strategies to deal with the underlying scientific uncertainty about future climate change.

6. CONCLUSION

This report concludes an NCCARF-funded study on 'extreme climatic variability and adaptation responses in resource-rich Central Queensland'. With recent climatic disasters impacting mining-intensive regional parts of Australia, the project provides a timely assessment of the nature of adaptation responses currently in place and barriers and challenges impeding further action in this space.

The project had three main objectives:

1. To establish the nature and scope of climatic events from the past decade impacting coal mining operations in central Queensland and communities within the wider catchment;
2. To draw lessons from the case of a particular mining operation that was impacted by extensive flooding in 2008, and its experiences of impacts from that event; and
3. To identify barriers, motivators and challenges that limit the degree to which mining operations and the regions in which they are located have been able to successfully plan for, and adapt to, changing climatic conditions.

Main research results from this project include: a broad typology of impacts of extreme climatic variability on the mining industry and associated communities; an inventory of extreme events experienced in the study region due to natural climatic variability, including information on the intensity of these extremes, regions affected and associated timelines; major impacts resulting from these events across different stakeholder groups at both regional and local levels – governments, mining industry, community, and peak environmental and other industry bodies; the nature of response strategies and mechanisms implemented by relevant stakeholders in addressing those impacts; key lessons learnt from past experiences that may inform future action on climate adaptation both within the mining industry and communities that are socio-economically and or spatially dependent upon it; and current barriers and challenges that inform and influence region-wide adaptation response to climatic variability and change.

Several important findings emerge from this research, five of which are worth noting here:

1. The importance of effective communication and collaboration among stakeholders to share responsibility towards planning for and managing future climatic impacts;
2. The need to apply sound methodological and technical expertise to better investigate the nature and extent of post-event ecological harm resulting from various industrial operations, including the release of mine-affected water into local waterways;
3. The critical role that lessons from previous experiences with climatic extremes and knowledge about successful and failed actions and strategies may play in building resilience and adapting to future changes in the climate due to anthropogenic climate change;

4. The role of state-level political will and necessary support to local governments and the mining industry in streamlining existing capacities and financial, technical and human resources to develop a coherent region-wide adaptation policy, and finally;
5. The importance of recognising extreme events as 'timely opportunities' to trigger innovation in regional planning, adaptation policymaking, knowledge development and sharing, and monitoring and evaluating current processes of resilience-building to better develop adaptation strategies for future climatic extremes.

Finally, the project has made a number of recommendations that provide pointers towards future policy- and decision-making on climate adaptation in the mining industry but also local communities that are directly or indirectly dependent upon the mining industry for their long-term regional sustainability.

Key recommendations include:

- Better understanding and appreciating the:
 - Role of government
 - Role of communication, cooperation and collaboration between and among various stakeholders.
- Acknowledging extreme events as opportunities to drive innovation.
- Learning the lessons from past climatic variability to inform future adaptation to climate change.

Finally, based on this research,

Table 1 and **Table 2** provide key lessons with regard to climate adaptation within the mining industry.

Table 1: Key lessons for climate-change adaptation from the research

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|--|
| Appreciate the role of monitoring, ongoing evaluation and feedback to encourage methodical learning |
| Value early and timely planning both by governments and industries |
| Better understand local and regional contexts |
| Strong political will and commitment from state government agencies necessary to make effective changes |
| Engagement and communication across different stakeholder groups is vital |
| Collective knowledge management, transfer and training crucial for successful implementation of risk management plans |
| Commitment by all stakeholders to voluntarily collaborate and prioritise resources – human, technological, financial – to address climatic impacts |
| Greater flexibility in resource management plans |
| Early collaboration with local governments |
| Balanced perspective to assessing impacts from different industrial operations is important |
| Recognition of extreme events as ‘opportunities’ to drive innovation |

Table 2: Key lessons for climate-adaptation, specific to the mining-industry

| |
|--|
| Need for the industry to adopt a culture of water use efficiency |
| Industry should acknowledge that the switch from a very dry to a very wet season ‘may be just around the corner’ |
| Importance of reasonable and practical regulatory conditions |
| Current climate data available from the Bureau of Meteorology (BOM) is inadequate and impractical for the industry to use to develop risk management plans |
| Collaboration between the mining industry and environmental groups and state agencies to address inherent tensions |
| Work together with regulators to incorporate site-specific requirements concerning water quality and quantity |
| Important that the State’s environmental regulating authority: <ul style="list-style-type: none"> • maintains consistency in its strategy to identify sites for inspection, and • undertakes risk assessments in a timely continual manner |
| Better understand environmental harm caused by mining operations observed post-flooding in the region |

7. FUTURE RESEARCH DIRECTIONS

Findings from this project suggest a number of thematic and practical areas that will benefit from further research:

1. For time and resource constraints, the present study only focused on coal mining operations within Central Queensland. However, to broaden our understanding of climate adaptation within the Australian mining industry, examining the nature of climatic impacts upon other mining-intensive regions such as the Pilbara in Western Australia with its focus on iron-ore extraction, will be a useful way forward. Western Australia is located in a significantly varied climatic zone – where extreme events are manifested in bush fires and high-intensity cyclones from tropical Queensland. The presence of such localised climatic influences may necessitate a different approach to climate adaptation;
2. A comparative analysis of impacts and responses across different mine sites within the same organisation is another potential research area that will help further identify the role of intra-organisational learning, coordination and site-level leadership in managing climatic risks. As an example, cross-examining climatic vulnerability and the nature of adaptation response across different mining operations owned by the Rio Tinto group can shed further light on flexibility within organisations to address a suite of climatic challenges;
3. Despite several efforts, this project was unable to engage with Ensham Resources to develop a comprehensive understanding of their experiences in dealing with the 2008 flooding event and the nature of organisational learning post these events that influenced their future decision making. While the case study included in this project is largely based on material in the public domain, it will be useful from both a practical and policy standpoint to obtain their feedback on the present case study and collect empirical information from Ensham (through interviews with key personnel involved in managing and addressing the 2008 flood event and subsequent planning for 2010-11 wet season) that can better inform and strengthen current findings presented in this report.

Finally, findings from this project will hopefully help establish a business case for the mining industry to better engage with climate adaptation at all levels – from site operations to organisational planning and decision making. For key mining organisations and service providers operating in Australia, a useful next step will be to engage with their personnel to identify the degree of planning for anthropogenic climate change. A direct conversation of this nature with the mining industry will help on at least two accounts: a) in better capturing what processes and methods are currently being undertaken – at an organisational level – to strengthen both organisational and operational resilience to more intense and frequent extreme events in the future, and b) in identifying opportunities for collaborating with, and collating information across various small, medium and large resource sector stakeholders to develop an industry-wide ‘best practice guide for climate change adaptation’. It is anticipated that the latter

will contain blueprint ideas available for application across the Australian mining industry while also maintaining regional relevance through its consideration of varied local socio-economic and climatic contexts.

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APPENDIX 1: Impact Typology

| Impacted entity | Nature of event | |
|------------------------|--|--|
| | Droughts | Floods and Cyclones |
| <i>Mining industry</i> | | |
| | Substantial increase in community expectation around water conservation | <i>Improved terms of insurance arrangements for resilient industry stakeholders *</i> |
| | Intrinsic uncertainties across the water system – including water supply and management | Reduced asset operating life |
| | Implications for future growth of the mining industry | Increased demand for emergency services from environmental regulators |
| | Reduced reliability of supply sources | Safety risks for mining workforce |
| | Reduced quality of water supply from current sources | Inability to meet performance targets resulting in impacts on share prices |
| | Increased stress levels among employees | Increased demand for changes to infrastructure design standards |
| | Substantial increase in community expectation around water conservation | <i>Increased opportunity for a better review of potential exposure of industry stakeholders to loss and liability*</i> |
| | Increase in costs of water | Disrupted access routes, leading to forced mine closures |
| | <i>Greater need and opportunity for community outreach work by mining companies*</i> | Potential employment loss due to lack of safe access to sites |
| | Significant reductions in the level of industry certainty in water forecasting, thereby impacting long-term operational planning and viability | Slow recovery in a mining-intensive region due to increase in labour costs and availability of equipments |
| | Conflicts with other water users in the region over water availability | Additional costs associated with hiring additional equipment and labour for clean-up |
| | Damage to infrastructure through dust build-up | Impacts on key infrastructure services |
| | Supply chain breakdowns | Force Majeure, sometimes also leading to disputes around delivery |

| | | |
|--|---|--|
| Impacted entity | Nature of event | |
| | Droughts | Floods and Cyclones |
| Mining industry | | |
| | | Obligations |
| | Greater knowledge, awareness and recognition of both physical and economic impacts and resulting socio-ecological severity due to extreme events* | |
| | Increasing expectations from host governments with regards to the industry's involvement in addressing risks from extreme climatic events | |
| | Negative impacts on profitability | |
| | Water is a key production input – imbalance across both appropriate quality and quantity presents an imminent challenge | |
| Socio-economically and spatially dependent communities | | |
| | Reduced reliability of supply sources | Enhanced relationships with relevant stakeholders* |
| | Reduced quality of water supply from current sources | Increased demand for emergency services |
| | Increase in costs of water | Environmental risks (contaminated flows downstream, unauthorised release of flood waters, overflow of tailing dams degrade aquatic ecosystems) |
| | Increased stress levels among community members | Health risks for communities |
| | Substantial increase in community expectation around water conservation | Lack of clarity around floods as a regulatory/ political risk vis-a-vis physical risk |
| | Greater knowledge, awareness and recognition of both physical and economic impacts and resulting socio-ecological severity due to extreme events* | |

| <i>Other stakeholders</i> | | |
|---------------------------|--|--|
| | Tighter water restrictions by the relevant institutional authority | |
| | Economic threats for the local government, due to reduced industrial and agricultural productivity | |
| | Permanent changes to regional economic diversity | |
| | Increasing unpredictability in climatic variability leading to difficulty in quantifying risks for future investment decisions | |
| | <i>Increased opportunity for a better review of potential exposure of other stakeholders to loss and liability*</i> | |
| | Implications for future growth in the region | |
| | <i>New markets for climate resilient infrastructure and related services*</i> | |

Source: LGAQ 2007; Pearce et al. 2009; Locke and Clifton 2011; Nelson and Schuchard 2011

*Note: impacts mentioned in italics are opportunities – rather than threats – that can better strengthen relationships between stakeholders, thereby enhancing mining’s contribution to sustainable development at both regional and local levels.

APPENDIX 2: List of organisations interviewed in Phase 1 of the project

- AgForce
- Anglo American
- Banana Shire Council
- BHP Billiton Mitsubishi Alliance (BMA)
- Central Highlands Regional Council
- Department of Environment and Resource Management (DERM)
- Isaac Regional Council
- Queensland Resources Council (QRC)
- Rio Tinto Coal Australia

APPENDIX 3: List of organisations who participated in Phase 2 of the project

- Anglo American
- Banana Shire Council
- BHP Billiton Mitsubishi Alliance (BMA)
- Central Highlands Regional Council
- Central Queensland Local Government Association
- Central Queensland University
- Department of Natural Resources and Mines
- Department of State Development, Infrastructure and Planning
- Fitzroy Basin Association
- Flinders Group
- Isaac Regional Council
- Justin Power Management Services
- National Climate Change Adaptation Research Facility
- Queensland Police Service
- Queensland Resources Council
- Rio Tinto Coal Australia
- Xstrata Coal

APPENDIX 4: Drought affected regions of the Bowen Basin since 2000

| Event | Month/Year | Regions affected |
|------------------|-----------------------------|--|
| Drought* | June 2002 – December 2002 | <i>Parts of IRC and CHRC:</i> <ul style="list-style-type: none"> • Broadsound • Nebo • Duaringa Peak Downs |
| Drought* | January 2003 – April 2004 | <i>All of IRC and CHRC:</i> <ul style="list-style-type: none"> • Belyando • Broadsound • Nebo • Bauhinia • Duaringa • Emerald Peak Downs |
| Drought* | May 2004 – February 2005 | <i>All of IRC and most of CHRC:</i> <ul style="list-style-type: none"> • Belyando • Broadsound • Nebo • Duaringa • Emerald Peak Downs |
| Partial Drought* | May 2004 – March 2007 | <ul style="list-style-type: none"> • Bauhinia (<i>CHRC</i>) |
| Partial Drought* | March 2005 – February 2008 | <ul style="list-style-type: none"> • Belyando (<i>IRC</i>) |
| Drought* | March 2005 – September 2006 | <i>Most parts of IRC and CHRC:</i> <ul style="list-style-type: none"> • Broadsound • Nebo |

| Event | Month/Year | Regions affected |
|-----------------|----------------------------|---|
| | | <ul style="list-style-type: none"> • Duaringa • Emerald Peak Downs |
| Drought* | October 2006 – March 2007 | <i>Most parts of IRC, CHRC and BSC:</i> <ul style="list-style-type: none"> • Banana • Broadsound • Nebo • Duaringa • Emerald Peak Downs |
| Drought* | April 2007 – February 2008 | <i>Most parts of IRC, CHRC and BSC:</i> <ul style="list-style-type: none"> • Banana • Broadsound • Nebo • Bauhinia • Duaringa Peak Downs |
| Drought | March 2008 – April 2010 | Banana Shire Council |
| Partial Drought | March 2008 – April 2008 | <ul style="list-style-type: none"> • Isaac Regional Council Central Highlands Regional Council |
| Partial Drought | May 2008 – April 2010 | <ul style="list-style-type: none"> • Central Highlands Regional Council |
| Partial Drought | May 2010 – January 2011 | <ul style="list-style-type: none"> • Banana Shire Council |

*For drought-affected regions prior to local government amalgamation in 2008, individual Shires are provided. Source: DERM 2012

APPENDIX 5: Floods and cyclones timeline since 2000

| Type of climatic extreme and intensity | Date | Region | Nature and scale of the event |
|---|---------------|---------------|--|
| <i>Key flood events in Central Queensland</i> | | | |
| Moderate flooding | Feb 2000 | Don River | <p>Intermittently through February.</p> <ul style="list-style-type: none"> Two separate flood peaks experienced at Bowen on the 7th and 8th of February. On 24th February, a flood of similar magnitude to the larger of the two earlier events occurred. |
| Minor flooding | May 2000 | Fitzroy River | During the period from 5 th to 12 th May in the Connors and lower Isaac River but did not extend downstream to the Mackenzie River. |
| Very intense rainfall – moderate flooding | November 2000 | Fitzroy River | Recorded along the coast between Mackay and Rockhampton on 17 November. Moderate flooding experienced in the Connors and lower Isaac Rivers during the following week. Some rises were also recorded along the Mackenzie River but flood levels along the Fitzroy River remained below minor flood levels. |
| Heavy rainfall – moderate flooding | December 2000 | Don River | Recorded on the 28 December and the following day, resulting in moderate flooding in the lower reaches of the Don River at Bowen. Flood warnings issued on the 29 December and finalised on the 31 December. |
| Intense rainfall – moderate flooding | February 2002 | Don River | Rainfall totals between 100 and 175 mm recorded in the Don River on 14 th February, resulting in a moderate flood in the lower reaches |
| Heavy rainfall – moderate flooding | February 2003 | | Recorded in the Capricornia and Southern Highlands early February, resulting in flooding in the Don River of the Fitzroy River system and also the upper reaches of the Burnett River. Rain gradually became more widespread throughout Queensland and flooding occurred in a number of rivers across the region. |

| Type of climatic extreme and intensity | Date | Region | Nature and scale of the event |
|---|---------------|---------------|---|
| Heavy rains – moderate to major flooding | February 2003 | Fitzroy River | 100 to 200 mm rainfall recorded on 6th February in the Rockhampton area. Flooding experienced in the lower Dawson River downstream from Baralaba and the Don River. Local flash flooding reported in a number of small creeks and tributaries. Major flooding continued in the Dawson River for several days with only minor to moderate flooding occurring in the Fitzroy River. The initial flood warning was issued on the 6th February and warnings were finalized on the 13th February when minor flood peak had passed through Rockhampton. |
| Minor to major flooding | January 2004 | Fitzroy River | Recorded in the Nogoa River above Fairbairn Dam with two separate peaks just under the minor flood level, firstly on the 11th and then again on the 16th January. No spillage recorded from Fairbairn Dam. At the same time, major flooding occurred along the Comet River with a peak above the major flood level occurring at Rolleston on the 18th January. Runoff from this system coupled with local inflow resulted in minor flooding along the upper Mackenzie River to its junction with the Connors River during the period The Dawson River at Taroom started rising on the 17th and peaked on the 20th January, resulting in moderate flooding in the area. Rises up to minor flood level occurred along the Dawson River the following week. |
| Heavy rainfall – minor to moderate flooding | January 2005 | Don River | Records of up to 100 mm on 23rd January in the Don River catchment, resulting in sharp river rises and flooding in the upper reaches of the Don River. |
| Heavy rainfall – major flooding | December 2005 | Dawson River | Flooding in the Dawson River at Taroom on 4th December. |
| Moderate flooding. | January 2006 | Dawson River | River rises recorded in the Dawson River at Taroom during mid-January |
| Storms – heavy rainfall – moderate flooding | April 2006 | | Storms experienced in the Don River in early April. Widespread rainfall in the western part of the State resulted in floods that extended down to Cooper Creek well into May. A total of 61 flood warnings issued for seven river basins during the month. |
| Very heavy rainfall – moderate flooding | April 2006 | Don River | Don River recorded up to 150mm in a few hours on the 7th April. As a result, river levels in the lower reaches of the Don River rose sharply causing moderate flooding. The Don River peaked at the Pump Station later in the day. |

| Type of climatic extreme and intensity | Date | Region | Nature and scale of the event |
|---|---------------|--------------------|---|
| Minor flooding | January 2007 | Don River | Rainfall totals of between 90 to 140mm recorded across the catchment on the 24th January. Minor flood warnings issued for the lower reaches of the Don River. |
| Type of climatic extreme and intensity | Date | Region | Nature and scale of the event |
| Very heavy rainfall – major flooding | February 2007 | Don River | Widespread heavy rainfall along the coast at the end of January caused major flooding quickly developing in the Don River, and flood warnings re-commenced on 1st February. Between 120 and 190 mm of rainfall recorded in the 12 hours to 9pm on 1st February. Major flooding in the upper reaches of the Don River subsided to moderate levels within 12 to 24 hours. The Don River at Bowen Pump Station peaked at 5.34 metres with moderate flooding at 11pm on 1st February. Flood warnings were finalised on 4th February. |
| Local to minor flooding | March 2007 | Dawson River | Upper Dawson River flooded between the 15th and 17th March. |
| Minor flooding | December 2007 | Upper Dawson River | The rain band that moved across western Queensland during mid December spread into the headwaters of the Fitzroy River, and produced minor flooding of the Upper Dawson River on 13th of December. |
| Very heavy rainfall – widespread flooding | January 2008 | Nogoa River | <p>Queensland coast between Townsville and Mackay and inland over the Coalfields and Central Interior affected by intense rainfall between the 10th and 20th January. This rainfall produced widespread flooding across several rivers in Central Queensland. However, the most pronounced and intensive rainfall occurred over the Nogoa River and Theresa Creek within the Fitzroy River Basin and the Belyando River within the Burdekin River Basin. Intense rainfall of 143mm fell on Giru over 2 hours, whilst the heaviest daily rainfall totals exceeded 300mm causing flash flooding in several areas. Areas west of the city of Emerald recorded a 4-day rainfall total of nearly 700mm.</p> <p>Many water storage dams filled as a result of this rainfall event including the Ross River Dam near Townsville, the Burdekin Dam near Charters Towers, and the Fairbairn Dam near Emerald. Emergency Services evacuated many houses in and around the city of Emerald around the 20th of January as floodwaters from the Nogoa River surrounded and isolated the city. More evacuations occurred a week later on the Fitzroy River around the city of Rockhampton on the 28th of January.</p> |

| Type of climatic extreme and intensity | Date | Region | Nature and scale of the event |
|--|---------------|----------------------|---|
| Very heavy rainfall – major flooding | February 2008 | Fitzroy River | Widespread 24-hour rainfall totals of between 100mm to 200mm recorded for areas between Townsville and Rockhampton between the 11th and 15th of February, including isolated heavier rainfall in excess of 300mm. The latter caused major flooding across the coastal basins of several river systems in the region. Rainfall then extended further southward to the Fitzroy River where 24-hour rainfalls of between 50mm to 150mm were recorded; major flooding experienced in Rockhampton on the 25th of February. |
| Flood warning | January 2009 | Don River | Flood warnings issued between around mid-January for several river systems in the region, including the Don River. |
| Minor flooding | March 2009 | Connors/Isaac Rivers | River rises extended downstream to the Fitzroy River causing minor flooding. |

| Type of climatic extreme and intensity | Date | Region | Nature and scale of the event |
|---|----------------------|--------------------------------|--|
| Moderate to heavy rainfall – minor to moderate flooding | January – March 2010 | Various parts of the Catchment | <p>Don River – following the path of Cyclone Olga, the monsoon trough produced moderate to heavy falls in the Don River catchment. A minor flood peak recorded at Bowen on the 31st January.</p> <p>Connors/Isaac Rivers – moderate flooding along the Connors and lower Isaac Rivers. Flood warnings began on the 26th of January and continued into February.</p> <p>Dawson River – flooding recorded at Taroom</p> |
| Minor to moderate flooding | | | <p>Rainfall associated with the monsoon trough produced moderate flooding in the Connors and Isaac Rivers during the final days of January. Moderate flood levels continued downstream causing minor flooding in areas around the Mackenzie River. Flood levels at Rockhampton remained well below the minor flood level. Flood warnings which began in January continued through February and into March. Further rainfall recorded between the 16th and 19th of February produced flooding in three of the Fitzroy River tributaries.</p> <p>Comet River – Record flood levels along the Comet River isolated the township of Rolleston. Major flood levels at Rolleston were the highest on record dating back to 1958.</p> <p>Nogoa River – Minor flood levels produced a peak spill of 1.1 metres at Fairbairn Dam. Flood levels at Emerald remained well below minor.</p> <p>Dawson River – Rainfall in the upper Dawson River and tributaries produced a major flood at Taroom.</p> |
| Major flooding | | | Heavy rainfall recorded throughout the catchment produced widespread major flooding including some areas of record major flooding. Flood levels were generally the highest recorded in the area since 1983. Flood warnings that began on the 1st of March continued until the 17th of March. |

| Type of climatic extreme and intensity | Date | Region | Nature and scale of the event |
|---|------------------------------|----------------------------------|--|
| Heavy rainfall – varying degrees of flooding experienced across the Catchment | September – October 2010 | All rivers in the Basin affected | <p>Heavy rainfall recorded in the western areas of the Fitzroy River basin during September produced several flood peaks in the Nogoa, Comet, Mackenzie and Dawson Rivers. Basin-wide flood warnings initiated on the 5th of September and continued into October.</p> <p>Nogoa River – Fairbairn Dam began spilling during the third week of September, eventually recording a below minor flood peak to 1.23m on the 29th September.</p> <p>Comet River - minor to moderate flooding produced along the Comet River as a result of heavy rainfall in the Carnarvon and Springsure areas south of Emerald.</p> <p>Mackenzie River – Minor to moderate flooding produced along the Mackenzie River as a result of upstream floodwaters extending downstream from the Nogoa and Comet catchments</p> <p>Dawson River – Heavy rainfall in the upper Dawson and Don Rivers produced minor to moderate flooding along the Dawson River. A localised major flood peak of 6.03m was recorded in the Taroom area.</p> |
| Intense rainfall – major flooding | December 2010 – January 2011 | Various parts of the Catchment | <p>In total, 79 warnings were issued for the Fitzroy River system between December 2010 and January 2011. From December 2010 to January 2011, between 200 and 1000 millimetres of rainfall was recorded over the Fitzroy River catchment.</p> <p>Dawson River (Taroom) – More than 600 mm of rainfall recorded in the upper Dawson and in excess of 400 mm in the middle Dawson during December 2010. Flood peak recorded at 10.43 metres on 29th December - highest since February 1956. Three other major flood peaks recorded throughout December.</p> |

| Type of climatic extreme and intensity | Date | Region | Nature and scale of the event |
|--|---------------|--|---|
| | | | <p>Nogoa River (Emerald) – More than 600mm recorded in parts of the Nogoa River catchment between December 2010 and January 2011. 95% of all properties in the area inundated. New flood peak recorded at 16.05 metres, which exceeded the previous record of 15.7 metres in 1950.</p> <p>Fitzroy River (Rockhampton) – 9.2 m flood level recorded at Rockhampton in 2011 was the fifth highest peak recorded. Moderate flooding in December converted to major flood level in January.</p> <p>Comet River (Rolleston) – Between 600 and 1000 mm of rainfall recorded across Comet River tributaries in the December 2010-January 2011 period. Flood peak recorded at 8.54 m exceeds the previous flood record of 5.87 m observed in February 2010.</p> |
| Cyclone events in Central Queensland | | | |
| Cyclone Beni | February 2003 | Widespread flooding from Rockhampton to the Gold Coast. Waves recorded to 8.5 m caused more than \$10M worth of damage to infrastructure. | |
| Cyclone Ului | March 2010 | The Dalrymple Bay and Abbot Point coal terminals closed. Rail services also shut down. | |
| Cyclone Tasha | December 2010 | Major flooding in Central Queensland. | |
| Cyclone Yasi | February 2011 | <p>Several mining companies suspended operations in the region in preparation for the Cyclone. QR National, Australia's largest coal freight company, also suspended operations running from inland mines to coal ports.</p> <p>Major coal terminals, including Dalrymple Bay, Hay Point and Abbot Point also shut down.</p> | |

Source: BOM 2010

APPENDIX 6: 2010–11 Flood impacts on key mining operations

| Mine Site | Month/year | Total rainfall/ water captured | Key impacts | Steps undertaken to manage water, regulation and compliance |
|-------------------------------------|----------------|--|--|--|
| Hail Creek Mine <i>Rio Tinto</i> | Dec 2010 | Water storage 98% full by end-Dec 2010. Up further to 105% capacity by end-Jan 2011 Approximately 7 gigalitres of water stored on-site in dams and pits | <ul style="list-style-type: none"> • Water continually pumped from high to low priority areas around the site to maintain operations • All sales contracts suspended from 24 Dec 2010. • Supplies of explosives were delayed due to damage to infrastructure • Sales suspension finally lifted on 12 May 2011 • In Sept 2011, mine still unable to operate at full production on a sustained basis. | <ul style="list-style-type: none"> • Seasonal forecast from the Bureau of Meteorology (BOM) not attended to until Dec 2010 • TEP sought • DERM authorisation granted to release water into surrounding watercourses in Jan 2011 |
| Rolleston Mine <i>Xstrata</i> | Sep - Dec 2010 | 250mm (Sept 2010) Additional 366 mm (Dec 2010) | <ul style="list-style-type: none"> • Production affected indirectly by flooding of both road and rail infrastructure • Reduction in company's production forecast for 2011 by approximately 1.1 million tonnes | <ul style="list-style-type: none"> • BOM's forecast obtained and used since March 2010 • Constructed levees and diversion channels <p>Required two regulatory relaxations to prevent uncontrolled discharges from water storages</p> |

| Mine Site | Month/year | Total rainfall/ water captured | Key impacts | Steps undertaken to manage water, regulation and compliance |
|---|------------|---|---|--|
| Ensham | Dec 2010 | 200mm (2 – 5 Dec 2010) | <ul style="list-style-type: none"> • New levees protected flooding of active mine pits from the Nogoa river • Large amount of surface water on the site • Heavy rainfall on site flooded mine pits, halting production • In Nov 2011, the mine still holding water from the 2007/08 and 2010/11 wet seasons | <ul style="list-style-type: none"> • New levees constructed following inundation in 2008 • Installed additional pipe infrastructure • TEP sought <p>DERM authorisation granted to release water into the Nogoa river</p> |
| Mine Site | Month/year | Total rainfall/water captured | Key impacts | Steps undertaken to manage water, regulation and compliance |
| Moranbah North <i>Anglo American</i> | Dec 2010 | 80mm (20 Dec) | <ul style="list-style-type: none"> • Concerns about the safety of a dam on site | <ul style="list-style-type: none"> • Emergency authorisations successfully sought on 19 and 20 Dec to release water to prevent dam collapse. <p>Longer term authorisation granted on 24 Dec, to allow ongoing release of mine water from its storage facilities.</p> |
| Dawson Mine <i>Anglo American</i> | Dec 2010 | 4.5 gigalitres of water in a single pit | <ul style="list-style-type: none"> • The pit earlier scheduled to be mined in May 2011, still had large volume of water. By Nov 2011, mining had not commenced. | <ul style="list-style-type: none"> • On 28 Dec, Anglo American advised DERM about its inability to manage mine-affected water under existing environmental authority (EA). • DERM authorisations to release water granted in Dec 2010, and Jan and Feb 2011. |

| Mine Site | Month/year | Total rainfall/water captured | Key impacts | Steps undertaken to manage water, regulation and compliance |
|---|---------------------------|---|---|---|
| Moranbah coal seam gas project <i>Arrow Energy</i> | Dec 2010 | Water storage facilities reached full capacity | <ul style="list-style-type: none"> Arrow Energy concerned about structural integrity of one of its dams. | <ul style="list-style-type: none"> Plans to build additional dams and water treatment plant 2.6 megalitres of coal seam gas water released on 13-14 Dec to prevent dam failure, breaching its EA Further rainfall led to more water released between 20 Dec 2010 and 6 Jan 2011. <p>In total, 34 megalitres of coal seam gas water released in breach of the EA.</p> |
| Century Mine | 1 Nov 2010 – 1 April 2011 | 1114.8mm of rain fell around the mine site (> twice the average annual rainfall for the area) | <ul style="list-style-type: none"> Storage of the excess water in the open pit led to significant operational and business risks for the operators | <ul style="list-style-type: none"> 1,850 megalitres of mine-affected water transferred to an open pit for interim storage to maintain compliance with the site's EA. One discharge of contaminated water occurred on 15 Mar 2011, breaching its EA. |

Source: QFCI 2012

APPENDIX 7: Inconsistencies in then DERM's management of flooded mines

Inconsistencies in DERM's past approaches to managing flood-affected mines

| Extreme event | Major impacts from the event | Changes to existing environmental authority | Limitations and results from the proposed changes |
|--|--|---|--|
| 2007-08: Ensham mine severely flooded; 150 gegalitres collected in 4 open pits | <ul style="list-style-type: none"> 138 gegalitres of mine-affected water released into local waterways over eight months Salinity levels and ecological quality downstream severely impacted Ongoing community concerns regarding mining impacts on the environment | <ul style="list-style-type: none"> 'A study of cumulative impacts of mining on water quality' undertaken for the Fitzroy Catchment Report's recommendations introduced the Fitzroy model conditions (FMC) in 2009 | <ul style="list-style-type: none"> Miners unhappy with the process followed in introducing the FMCs – it was hasty and lacked proper consultation FMCs allowed very limited site-specific knowledge to inform new EAs FMCs considered a blanket tool and therefore, ineffective in managing flood water on mine sites Changes to new conditions were sudden – no transitional period made available. Overall, FMCs limited water release opportunities for mine operators |
| Extreme event | Major impacts from the event | Changes to existing environmental authority | Limitations and results from the proposed changes |
| <i>The execution of the FMCs and subsequent restrictions on water releases meant that mining operations had their water storages filled at or near capacity before moving forward to another wet season predicted for 2010-11.</i> | | | |
| 2010-11: several mines flooded, production curtailed | <ul style="list-style-type: none"> Operations used active open pits for additional water storageThe inability to release water following the FMCs led | <ul style="list-style-type: none"> Industry suggested DERM undertake a review of the FMCs Minor amendments made in Nov 2010 – too late to | <ul style="list-style-type: none"> New version of FMCs released in August 2011 – contain several improvements in relation to water release and management, including: |

| Extreme event | Major impacts from the event | Changes to existing environmental authority | Limitations and results from the proposed changes |
|---------------|--|---|--|
| | <p>to water being stored in pits over an extended time, further raising its salinity levels</p> <ul style="list-style-type: none"> Over 100 TEP applications received by DERM to allow water releases outside of existing EAs | <p>make any significant contribution to water management at flooded mine sites</p> <ul style="list-style-type: none"> A full review of the FMCs undertaken in May/June 2011 A major concern related to the extended time it took DERM to process TEP requests | <ul style="list-style-type: none"> Site specific amendments to EA Relaxed monitoring requirements Stepped approach to discharging water into local watercourses Issues still to consider: <ul style="list-style-type: none"> catchment-wide assessment of cumulative impacts of multiple mines releasing water Formalising strategies for prioritising TEP applications and expediting authorisations |

Source: QFCI 2012

APPENDIX 8: Invitation to industry workshop

16 May 2012

Invitation to attend workshop on 'Identifying barriers and opportunities in enhancing industry's adaptation to climatic events in Central Queensland, Australia'

Information sheet for workshop participants

This workshop is part of a project titled 'Extractive resource development in a changing climate: learning the lessons from recent weather events in Queensland, Australia' currently being undertaken by the Centre for Social Responsibility in Mining within the Sustainable Minerals Institute (SMI) at the University of Queensland (UQ). The project is funded by the National Climate Change Adaptation Research Facility (NCCARF).

The aim of the project is to apply the lens of Queensland's drought and flood events experienced in the past decade to strengthen the adaptive capacity of the mining industry to climatic variability and change. By doing so, it proposes to identify barriers, challenges and opportunities – both within and outside the mining industry – that may inform how the resources sector plans and develops a coherent adaptation policy for future climatic events.

In order to best understand current region-wide approaches to strengthening resilience and adaptive capacity towards both sudden and long-term climatic events, we are holding consultation workshops with key stakeholder groups representing the industry, consultants, service providers, local and state governments (largely resource-intensive regional councils, DERM and DEEDI), and peak bodies (such as QRC, FBA, and AgForce).

This information sheet relates to the first workshop that will be held with industry representatives and consultants. It is believed that their understanding of both policy and practical issues related to extreme events and adaptive management will provide useful insights to address several of the project's key objectives.

The workshop is scheduled for 19th June 2012. It will run for approximately three hours and will be organised at the office of the Queensland Resources Council in Brisbane.

Key expected outcomes from these workshops include:

- Better knowledge and understanding of the nature of challenges and barriers – theoretical and practical – that currently exist within and outside the mining industry and therefore, hinder a holistic response to climatic impacts
- How may some or all of these challenges and barriers be best addressed across the whole range of stakeholder groups – public, private and non-government sectors?
- Identify potential avenues for collaboration across key stakeholder groups to learn about and share experiences, data and success strategies in order to

better manage, monitor and report climatic impacts on resource development, both regionally and nationally.

- As a final outcome, issues identified above will guide the recommendations that the project team will make to NCCARF to better enable Queensland's resource industry and relevant stakeholders to pro-actively engage with future climatic changes and make suitable adaptations to ensure long-term regional sustainability.

We hope you are able to nominate a suitable representative to attend the workshop and contribute to the discussions from your organisation's perspective.

Please RSVP by 12th June 2012:

Shashi van de Graaff

Email: s.vandegraaff@uq.edu.au

Phone: +61 7 3346 4041

If you need any further details regarding the project or the workshop, please do not hesitate to contact me; my details are provided below.

We look forward to hearing from you,

Best Regards

Vigya

Dr Vigya Sharma | Postdoctoral Fellow
Centre for Social Responsibility in Mining

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APPENDIX 9: Invitation to regional workshop

15 June 2012

Invitation to attend workshop on 'Identifying barriers, challenges and opportunities to help enhance mining-intensive Central Queensland's adaptation to climatic events'

Information sheet for workshop participants

This workshop is part of a project titled 'Extractive resource development in a changing climate: learning the lessons from recent weather events in Queensland, Australia' currently being undertaken by the Centre for Social Responsibility in Mining within the Sustainable Minerals Institute (SMI) at the University of Queensland (UQ). The project is funded by the National Climate Change Adaptation Research Facility (NCCARF).

The aim of the project is to apply the lens of Queensland's drought and flood events experienced in the past decade to strengthen the adaptive capacity of the mining industry and dependent local and regional governments and communities to climatic variability and change. By doing so, it proposes to identify barriers, challenges and opportunities – both within and outside the mining industry – that may inform how the resources sector plans and develops a coherent adaptation policy for future climatic events.

In order to best understand current region-wide approaches to strengthening resilience and adaptive capacity towards both sudden and long-term climatic events, we are holding consultation workshops with key stakeholder groups representing the industry, consultants, service providers, local and state governments (largely resource-intensive regional councils, DERM and DEEDI), and peak bodies (such as QRC, FBA, and AgForce).

This information sheet relates to the second workshop that will be held with stakeholders from the region. It is believed that your understanding of both policy and practical issues related to extreme events and adaptive management will provide useful insights to address several of the project's key objectives.

The workshop is scheduled for Friday, 6th July 2012. It will run for approximately three hours and will be held at the Department of Main Roads Conference Room in Rockhampton. It will begin with a short talk by Dr David Rissik, Deputy Director, NCCARF to introduce you to the organisation's role, objectives, the type of research it funds and their reasons for supporting this particular study. A detailed agenda will be circulated closer to the date.

Key expected outcomes from these workshops include:

- Better knowledge and understanding of the nature of challenges and barriers – theoretical and practical – that currently exist within and outside the mining industry and therefore, hinder a holistic response to climatic impacts

- How may some or all of these challenges and barriers be best addressed across the whole range of stakeholder groups – public, private and non-government sectors?
- Identify potential avenues for collaboration across key stakeholder groups to learn about and share experiences, data and success strategies in order to better manage, monitor and report climatic impacts on resource development, both regionally and nationally.
- As a final outcome, issues identified above will guide the recommendations that the project team will make to NCCARF to better enable Queensland's resource industry and relevant stakeholders to pro-actively engage with future climatic changes and make suitable adaptations to ensure long-term regional sustainability.

We hope you are able to attend the workshop and contribute to the discussions. If you are unavailable, we will greatly appreciate if you could please nominate a suitable representative from your organisation to be a part of the workshop.

Please RSVP by 29th June 2012:

Shashi van de Graaff

Email: s.vandegraaff@uq.edu.au

Phone: +61 7 3346 4041

If you need any further details regarding the project or the workshop, please do not hesitate to contact me; my details are provided below.

We look forward to hearing from you,

Best Regards

Vigya

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APPENDIX 10: Presentation at NCCARF conference in June 2012

NCCARF 2012 Conference Abstract

Extractive resource development in a changing climate: lessons from a decade of extreme weather events in Queensland (2000-2011)

This presentation reports on ongoing research that examines extreme weather events in Queensland and the direct and indirect impacts of these events on the resources industry, governments and dependent communities. The project is funded by NCCARF's Synthesis and Integrative Research Program.

Australia is not only a location of extreme climate variability but is one of the world's most vulnerable regions to anthropogenic climatic changes. The dependence that national and regional economic structures have on mining-led export earnings combined with the resource sector's potential to impact significantly on environments and communities during extreme weather events makes the minerals sector an important area of focus for climate adaptation research. This project investigates coal mining operations in Queensland, and examines both climate-influenced drought (water quantity) and flooding (water quality) challenges relevant to the future viability of the industry and local communities.

This presentation will include:

- a timeline of extreme events that impacted resource regions in Central Queensland between 2000 and 2011;
- the nature and scope of direct and flow-on impacts from a whole-of-catchment perspective;
- pointers towards what barriers and challenges – both within and outside the mining industry – exist that may prevent the resources sector from developing a coherent adaptation policy for future climatic events; and,
- directions for future research on climate adaptation in the resources sector based on lessons learnt from these experiences.

Data for this project is drawn from a variety of sources, including a systematic review of literature (academic sources, newspaper and other media articles, government and industry reports, and ongoing deliberations as part of the Queensland Floods Commission of Inquiry); targeted interviews with representatives of state and local governments, industry, and peak regional bodies; and a series of workshops with a mix of representatives from relevant stakeholder groups.

Extractive resource development in a changing climate: learning the lessons from recent weather events in Queensland, Australia

Vigya Sharma, Shashi van de Graaff,
Barton Loechel (CSIRO), Daniel Franks



Research rationale

- Extreme vulnerability to both natural and anthropogenic climatic changes
- National and state economies heavily reliant on minerals industry for export earnings
- Inertia within the minerals industry around climate change adaptation
- Adaptation to climatic variability can help inform long-term adaptation to anthropogenic climate change
- Potential that dialogue about industry adaptation to climate change and variability can lead to greater industry engagement around contribution to climate change – enhance mitigation efforts

Project objectives

1. Identify the nature and scope of flood- and other climate-related direct and flow-on impacts on mining operations and the wider catchment
 - impacts, responses and lessons learnt
2. Identify factors that enable or impede the development of adaptation options for the resources sector – the mining industry and relevant communities – to address future climatic events.

Methods

- Project steering committee established
- Phase 1
 - Desk-based review of literature available in the public domain
 - Interviews conducted with representatives from key stakeholder groups in March-April 2012
- Phase 2
 - Review of current literature on adaptation barriers and challenges, particularly for natural resources-based industries
 - Industry workshop in Brisbane (19th June)
 - Multi-stakeholder regional workshop in Rockhampton (6th July)

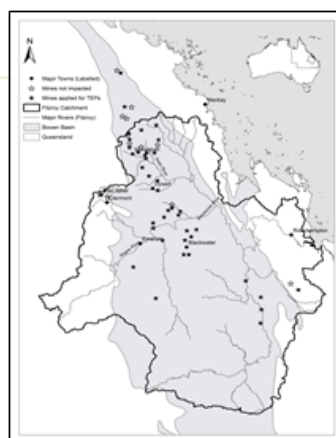


Study region – Bowen Basin, Central Queensland

- largest coal-reserve in Australia
- comprises seven major LGAs – focus on Isaac, Central Highlands and Banana Shire
- total economic output from mining ~ \$8,406 million in 2010
- predominant industry in the region, approx. 37%, 22% and 15% of total employment in the three regional councils respectively
- in 2010-11, the Basin hosted 56 operational open-cut and underground coal mines
- Fitzroy catchment – second largest in Australia; mining and agriculture main industries



Fitzroy catchment



2010-11 flood impacts



Key impacts – snapshot (Phase 1 findings)

- Direct impacts on *production*
- *Damaged relationships* with communities and other water users
 - *competition* for water use
 - concerns over mine water releases
- Impacts on *industry mindsets* to 'switch' to extreme wet conditions
- Unsuccessful *rehabilitation efforts* for lack of water
- Mines provided *alternative source of employment* in drought-stricken farming-based communities
- Impacts on *revenue generation*
- *Economic and psychological impacts* on the community



Lessons learnt (Phase 1 findings)

- Methodical learning – the role of monitoring, evaluation and feedback
- The role of engagement, communication and collective knowledge management
 - Voluntary stakeholder commitment to collaborate and prioritise resources
- Sharing responsibility to influence collaboration and communication
- Early and timely planning both by governments and industries
- Early collaboration with local governments – employing local knowledge and their established credibility with local communities



Phase 2 - Objectives

- Identify factors influencing the development of long-term adaptation options for the resources sector to address future climatic events.
 - Suggest adaptation barriers, challenges, motivators and enablers
- Identify potential avenues for collaboration across key stakeholder groups to learn and share experiences, to better manage future climatic impacts on resource development, both regionally and nationally.



Some preliminary findings on barriers and enablers

Organisational level

- Short-term memory – high staff turnover
- Short-term planning cycles
 - Decisions driven by production imperatives rather than risk management
- Intra-organisation communication channels
 - Lack of understanding of technical issues by senior management
 - Time lost in gaining internal approvals



Some preliminary findings on barriers and enablers

Industry-wide

- Managing community expectations by better communication
- One bad story can generate a lot of misperception
- Company should be the first point of contact, not media
- Difficult dealing with aggressive lobby groups (e.g. AgForce)
- Inter-company collaboration useful – but difficult
 - Fundamentally 'competitors'
 - Sharing commercially sensitive data is risky



Some preliminary findings on barriers and enablers

External challenges

- Greater mistrust from floods than droughts
 - More direct impacts affecting more people, industries
- Greater expectation about mining industry's responsibility vis-a-vis other industries, media
- Mining companies hostage to many groups with vested interests
 - AgForce tactics to improve membership
 - Politicians to build up their 'community profile'
 - Green groups to maintain their ideology regardless of facts
 - Media at sensationalising facts to 'sell' news



Next steps

- Multistakeholder workshop in Rockhampton next week
- Draft final report for circulation amongst steering committee members
- Final report to NCCARE, containing recommendations towards future research directions



Thank you

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APPENDIX 11: Factsheet 1

Extractive resource development in a changing climate: learning the lessons from recent weather events in Queensland, Australia

Rationale

Resource extraction is inherently tied to the natural environment in which it takes place. Mining maintains a direct dependence on suitable natural conditions (habitable climate, access to water resources, and presence of supporting infrastructure, to name a few) to extract resources from the ground and process them for future domestic and international use. Climate change and variability are therefore, emerging concerns for the mining industry. Unlike other economic activities that may be relocated elsewhere should the environment become unsupportive, strategic decisions with regard to operating the mining industry are almost exclusively based on the location of the resource to be mined. It is thus pertinent that stakeholders associated with the mining industry recognise the complex relationship between changes to natural environmental conditions and resulting implications for the long-term viability of the mining industry (Pearce et al. 2009).

Objectives

In light of the above observations, the project had three main objectives:

- Identify the nature and scope of flood and other climate-related direct impacts on mining operations and resulting flow-on effects on the socio-ecological health of the wider region with particular emphasis on areas located further downstream;
- Draw lessons from the case of one mining operation in Central Queensland – that experienced almost-total inundation and devastation in 2008 and subsequently developed successful adaptation measures that, in turn, limited the impacts of the 2010 floods; and
- Identify factors that enable or impede the development of adaptation options for the resources sector – the mining industry and relevant communities – to address future climatic events.

Methods

To start with, the project established an advisory project steering committee to maintain strong end-user engagement and ensure future uptake of the project's findings by government and industry. Committee members included representatives from the Fitzroy Basin Association, Queensland Resources Council, Central Queensland Local Government Association, Isaac Regional Council, and senior researchers with expertise in natural resource management and water management in mine-intensive regions.

Key data collection methods included a systematic review of published literature and relevant information available in the public domain, supplemented by open-ended in-depth interviews with representatives of regional councils, state government departments, mining companies and industry peak bodies. The project also undertook

two workshops – one with industry representatives in Brisbane, and another multi-stakeholder consultation held in Rockhampton.

Key Findings

Besides region-wide competition over water access during droughts and flood-related direct impacts on production and revenue generation for the mining industry, several key issues emerged through this research:

Difficulty switching industry mindsets between extreme 'dry' and 'wet' conditions

There is an inherent contradiction in industry mindsets between encouraging water conservation during the dry season, and managing excess water resulting from extreme floods. This contradiction, accompanied by lack of preparedness to deal with sudden intense changes in the natural climate and short-lived industry memory due to high staff turnover, has exacerbated the physical and psycho-social vulnerability of the industry to climatic disasters.

Economic and psychological impacts on the community

Flood-influenced lost time in production impacted royalty revenues to the State Government, thereby resulting in losses in excess of \$5 billion to Queensland's gross state product (QFCI 2012). Curtailed employment and extended periods of isolation due to inundated properties during floods, combined with increased energy prices due to reduced power production caused by severe water scarcity during droughts impacted socio-psychological wellbeing of communities throughout the region.

Community perceptions of the mining industry

Managing community expectations during periods of extreme climatic events can be a challenge for the mining industry. While community members recognise mining companies as a source of assistance in the immediate aftermath of climatic events, community concerns around mine water discharge during floods, and competition over water scarcity during droughts, can have negative reputational impacts for the mining industry. Although the resource sector finds it difficult to deal with these perceptions over the short-term, there is an industry-wide acknowledgement that these perceptions act as one of the biggest motivators for the industry to bring about significant changes in the way it plans for, and manages climatic risks. The reputational costs associated with underlying community-company mistrust increasingly influence disaster management and enable more informed corporate decision making on climate adaptation.

Lack of available and useable climate data

Mining companies only have a small window of opportunity available (often, around 3 months) to predict a climatic shift from extreme dry to extreme wet conditions. Currently available climate data is not useful enough to the industry as it lacks localised information and other micro details to enable focused pro-active planning and management of risks. Lack of sufficient time available prior to the onset of extreme events further disables mining operations from rallying internally within their respective

organisations to seek additional financial, technical and human resources to build effective risk management plans.

Five policy lessons for improved climate adaptation in the resources sector

1. Coordinated and timely planning

Coordinated and timely planning both by governments and industries is critically important. This includes long-term water resource management strategies and planning for droughts, as well as preparatory planning for floods. Local governments should be included early on in the process due to their local expertise and established credibility with the community.

2. Methodical learning and collective knowledge management

Ongoing and robust monitoring, evaluation, review and feedback procedures are critical to achieving methodical learning from past experiences. Similarly, collective knowledge management, transfer and training can enable the development of a common pool of regional and catchment-wide expertise in preparing for and managing both real and perceived impacts from climatic changes.

3. Engagement, communication and collaboration between stakeholders

Engagement and communication across different stakeholder groups is needed to facilitate timely, multi-directional information exchange and to build cooperative relationships. Collaborations have previously enabled individual stakeholder groups to bring together diverse resources to respond to both water security issues during drought and flood-related disaster and emergency situations.

4. Better understanding of local and regional contexts

Unfamiliarity with the local context can play an important role in impeding adaptation, particularly in light of Australia's diverse climatic zones, and socio-ecological landscapes. Within the one organisation, different sites have demonstrated varying degrees of success in managing risks. While both internal and external communication and individual mine site leadership play an important role, other factors, such as the geographical location of the operation, local floodplain hydrology, inter-site climatic variability, socio-ecological regional context within which the mine is located, and unfamiliarity of mining personnel with local climatic conditions can further influence the operation's resilience towards external climatic perturbations.

5. Sharing responsibility

Co-sharing responsibility with other actors to develop suitable response mechanisms positively influences the degree of collaboration and the quality of communication. Past experience in dealing with climatic extremes demonstrate a high level of collaborative planning and a sense of collective responsibility across stakeholders to condition goals, make decisions and execute plans in order to maintain long-term regional and local social, economic and ecological integrity.

More information

The project was funded by the Synthesis and Integrative Research Program of the National Climate Change Adaptation Research Facility. It was undertaken by researchers at the Centre for Social Responsibility in Mining, The University of Queensland and the CSIRO. For a copy of the full report, visit <http://www.nccarf.edu.au/publications/building-damage-following-2010-11-floods>

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APPENDIX 12: Factsheet 2

Extractive Resource Development in a Changing Climate: Learning the lessons from recent weather events in Queensland, Australia

Barriers, enablers, and opportunities for resource sector adaptation to future climatic change and variability

Background

The mining industry is extremely important to Australia's regional and national prosperity. However, recent droughts and floods in Central Queensland demonstrated the vulnerability of both mining operations and surrounding communities to extreme climatic events. This project engaged with a diverse group of regional stakeholders to identify key lessons from these experiences. Stakeholders consulted included mining industry organisations, local governments, state government agencies, other industry groups and regional planning bodies. These discussions revealed a number of barriers, enablers and opportunities relevant to strengthening mining community's preparation for future extreme weather events – whether due to natural or anthropogenic climatic changes.

Barriers

- Failure to learn lessons from past experiences, and short-sightedness
 - Floods and droughts are not unusual in Central Queensland, but once the crisis has passed, efforts to systematically evaluate responses during past crisis that can better inform future preparation remain inconsistent;
 - The industry's primary focus on planning is production- and output-driven, with negligent efforts undertaken to plan for long-term climatic impacts;
 - Tendency to forget or neglect the lessons from extreme weather events experienced in the historical record;
 - Poor organisational memory, exacerbated by high staff turnover in mining regions, including a significant reliance on short-term contractors prevents the establishment of organisation-wide memory of past experiences.
- Challenges associated with knowledge & resource sharing in a diverse region
 - The wide variety of players active in the region, each with a diverse set of values, priorities and interests makes sharing of information and knowledge particularly challenging;
 - High staff turnover further disrupts continuity of relationships and networks, and consistent knowledge-building;
 - Entrenched vested interests, competition between organisations within the same economic sector or divergent ideological positions lead to misrepresentation of facts and truth, often eroding trust which further inhibits information sharing.

- Inadequate regional level planning
 - Poor integration of broader regional issues and multi-sectoral perspectives, particularly experienced in a resource-rich region, such as Central Queensland;
 - Lack of political will – top-down governance from State government prevents meaningful integrated planning. State interests to foster industry growth and revenue prevent due consideration to local community priorities and ecological impacts;
- Tensions between diverging interests of different industry stakeholder groups
 - Potential for maladaptation - what may be adaptive for one stakeholder may negatively impact others
 - For example, greater ‘flexibility’ in government regulation of stream water quality, allowing de-watering of flooded coal pits into the river system; increased water resource extraction; or water-trading during droughts may lead to conflict situations between mining and agricultural groups.

Enablers

- Ongoing and robust monitoring, evaluation, review and feedback to enable *methodical learning* and timely adjustment to plans and strategies;
- Early and timely *planning* by governments and industries, including long-term commitment to *prioritise resources* – human, technological, financial – to address climatic impacts;
- *Regional leadership*, meaningfully supported by State government and inclusive of local government, to facilitate integrated regional planning and implementation;
- A better understanding of local and regional *contexts*, including floodplain hydrology and the socio-ecological landscape that hosts mining operations;
- *Engagement and communication* across different stakeholder groups, to facilitate timely information exchange and build cooperative relationships that apply a common pool of regional and catchment-wide expertise to prepare for and manage risks; and
- The availability of *traditional organisational risk assessment*, recording and decision-making systems – such as Internal Audit – to integrate climate change data into business planning and to strengthen corporate memory.

Opportunities

- To *build on past experience and learnings* to better inform future climate risk management by developing systems that:
 - build and retain organisational memory; and
 - retain and share collective knowledge and other resources and keep alive relationships around extreme weather events
- To develop *regional leadership* that enables integrated regional planning;
- To capitalise on the presence of the mining industry to *transfer skills to other sectors* through shared workforce (e.g. mining, agriculture, construction);

- To stimulate *regional innovation* in thought, strategy and practice to prepare both individual organisations and collective planning and governance systems to better address future changes in climatic conditions;
- Further research to examine the range of cascading impacts arising from the *interaction between mining industry, changing climate and broader socio-economic-demographic trends* to achieve better regional preparedness for future extreme weather events; and
- To identify the potential of a *regional climate adaptation research and practice network* could help realise many of these opportunities

More Information

The project was funded by the Synthesis and Integrative Research Program of the National Climate Change Adaptation Research Facility. It was undertaken by researchers at the Centre for Social Responsibility in Mining, The University of Queensland and the CSIRO. For a copy of the full report, visit <http://www.nccarf.edu.au/publications/building-damage-following-2010-11-floods>

APPENDIX 13: Factsheet 3

Extractive resource development in a changing climate: learning the lessons from recent weather events in Queensland, Australia

Implications for the mining industry

Project Rationale and Methods

Australia is not only a location of extreme climate variability but is one of the world's most vulnerable regions to anthropogenic climatic changes. The dependence that national and regional economic structures have on mining-led export earnings combined with the resource sector's potential to impact significantly on environments and communities during extreme weather events makes the minerals sector an important area of focus for climate adaptation research. This project investigates coal mining operations in Queensland, and examines both climate-influenced drought (water quantity) and flooding (water quality) challenges relevant to the future viability of the industry and local communities.

The project was based on two key premises:

- Adaptation to climatic variability can help inform the mining industry's long-term adaptation to anthropogenic climate change;
- There is the potential that dialogue about industry adaptation to climate change and variability can lead to greater industry engagement around contribution to climate change – enhance mitigation efforts

Data for this project was drawn from a variety of sources, including a systematic review of literature, targeted interviews and workshops with representatives of relevant stakeholder groups, including mining organisations, local governments, state government agencies, other industry groups and regional planning bodies.

Activities undertaken by the mining industry vulnerable to climate variability

- Dust suppression;
- Maintenance of mined pits, tailings dams;
- Mined land rehabilitation efforts;
- Production and extraction;
- Road and rail accessibility for resource transportation to ports and supply of machinery and other equipment; and
- Water scarcity limits power stations from operating to full capacity – the latter can influence energy prices and thereby impact both residential and commercial users.

Lessons and relevant key findings for the industry

- One of the biggest findings from this project related to the inherent contradiction currently prevailing in industry mindsets. Lack of preparedness to deal with sudden intense changes in the natural climate, short-lived industry memory due to high staff turnover, short-sightedness, and production-driven planning agendas further exacerbate both the physical as well as psycho-social vulnerability of the industry to climatic disasters;
- There is a need for the industry to adopt a culture of water use efficiency while being aware that the switch from a very dry to a very wet season 'may be just around the corner';
- Industry will benefit from obtaining and using both seasonal and short-term climate forecast knowledge provided by the Bureau of Meteorology (BOM) in planning ahead of the wet season;
- It is important that the regulatory conditions authorising mine water releases and monitoring water quality during floods are 'reasonable, effective and consistent';
- Early and timely collaboration between the mining industry, environmental groups and state agencies can help address the inherent tension relating to sustaining the competing objectives of economic development and a region-wide high environmental quality;
- Industry needs to work together with regulators to incorporate site-specific requirements concerning water quality and quantity in future adaptation planning;
- It has been common in the past for relationships between the industry and dependent communities to be negatively impacted due to:
 - competition over access to and use of water during droughts, and
 - concerns over mine water releases and potential implications for the health of the water system supplying water for domestic and agricultural uses.

Having said that, mines have also provided an alternative source of employment in drought-stricken farming-based communities, which has addressed some of the negativity highlighted above.

Industry-wide barriers to climate adaptation

In light of these observations, the mining industry currently faces a number of barriers that prevent the sector from developing a long-term coherent adaptation policy. While some of these barriers are organisational-level, others exist industry-wide. The list below, while not exhaustive, provides key examples of barriers identified through this research.

- Short-term memory
 - the mining industry is characterised by high staff turnover and heavy reliance on contractors;
- Short-term planning cycles
 - decisions are largely driven by production imperatives rather than long-term risk management;
- Intra-organisation communication channels are ineffective and therefore, require further improvement to address
 - Lack of understanding of technical issues by senior management, and
 - Time lost in gaining internal approvals;
- Lack of a consistent approach to timely, factual communication in lay language that addresses ongoing community-wide misperceptions. Currently, communication and information sharing is largely sporadic and need-based;
- Greater – often mis-informed – expectations about mining industry’s responsibility towards ecological sustainability vis-à-vis other industries, such as agriculture and media; and
- Inter-company collaboration is useful but difficult, as various organisations are fundamentally ‘competitors’, and therefore consider sharing commercially sensitive data both risky and pragmatically inappropriate.

More Information

The project was funded by the Synthesis and Integrative Research Program of the National Climate Change Adaptation Research Facility. It was undertaken by researchers at the Centre for Social Responsibility in Mining, The University of Queensland and the CSIRO. For a copy of the full report, please visit <http://www.nccarf.edu.au/publications/building-damage-following-2010-11-floods>

APPENDIX 14: About CSR



Centre for Social
Responsibility in Mining

The Centre for Social Responsibility in Mining (CSR) is a leading research centre, committed to improving the social performance of the resources industry globally.

We are part of the Sustainable Minerals Institute (SMI) at the University of Queensland, one of Australia's premier universities. SMI has a long track record of working to understand and apply the principles of sustainable development within the global resources industry.

At CSR, our focus is on the social, economic and political challenges that occur when change is brought about by resource extraction and development. We work with companies, communities and governments in mining regions all over the world to improve social performance and deliver better outcomes for companies and communities.

Since 2001, we've contributed significantly to industry change through our research, teaching and consulting. The bottom line: we help build capacity to manage change in more effective ways. This is our aim.

The Centre is led by Professor Saleem H. Ali.

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APPENDIX 15: CSIRO's contribution to the project



The present NCCARF study provides an opportunity for CSIRO to both contribute expertise to, and learn from, this investigation of the Bowen Basin coal mining industry and related stakeholders' experience of dealing with extreme climatic events. The CSIRO is committed to assisting Australian industries, communities and government organisations adapt to the challenges of climate change. As part of this commitment the CSIRO is currently undertaking a project on 'Adaptive Mining Communities' that examines the adaptive capacity of the Australian mining industry and its associated communities to climate change in a number of climatic regions around Australia.

APPENDIX 16: Proposed paper abstract

‘Institutional arrangements for strengthening climate change adaptation’

Abstract

Climate change is manifested in different types of weather-related events that occur over a range of timeframes with varying intensity. Some may be rapid and extremely damaging or even life-threatening emergencies such as cyclones, floods and bushfires, while others may be more gradual or chronic processes such as drought. Varied timing and severity of these events suggests that different types of institutional arrangements are required to address their impacts. Additionally, long periods under one set of conditions (e.g. drought) can reduce preparedness for a new set of conditions (e.g. floods), thus leading to maladaptation. The issue of anthropogenic climate change and the related likelihood of greater future weather extremes must also be considered in the regional context. Central Queensland hosts a range of agricultural industries, including an expanding irrigation area, a growing population, and rivers that empty into the Great Barrier Reef Marine Park. It also maintains a large and rapidly growing mining industry that results in a range of economic, social and environmental challenges for the region. While long-term planning is always beneficial, dealing with climatic events as they occur will also require contextually relevant strategies and arrangements. In addition to various practical actions required to improve regional preparedness, a key question remains with regard to the types and combinations of institutional arrangements – regulation, markets, and community or stakeholder collaborations – that may be required to best manage the above challenges. This paper employs lessons learnt from Central Queensland’s recent experiences of dealing with extreme climatic events to better inform current and future institutional arrangements to address climatic changes in mining regions.

By better understanding institutional factors that may encourage improved local and regional adaptation to changing climatic conditions, the paper seeks to contribute towards Objective 3 of the proposed project: “Identify factors that enable or impede the development of adaptation options for the resources sector – the mining industry and relevant communities – to address future climatic events”.

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Queensland
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