

Integration of Climate Change Impacts and Adaptation in British Columbia

Environmental Assessment: Research vs. Reality in the case of mining

Anujin (Anu) Baatarkhuu

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Executive Summary

The primary aim of this paper is to evaluate the state of how climate change impacts and adaptation have been assessed in the British Columbia Environmental Assessment process as compared to what is recommended in the literature.

Climate is an important component of the operating environment for the British Columbia mining sector. However, in recent years, mines across British Columbia have been affected by significant climatic hazards, which are viewed to be indicative of climate change. For the mine sector, climate change is a pressing environmental and business risk. The extent to which the mining sector is able to adapt to climate change will affect its long term success and prosperity, and have profound economic and social consequences for host communities. This paper draws upon approved Environmental Assessment applications reviewed in depth to characterize the vulnerability and adaptability of the British Columbia mining industry to climate change. Key findings discussed here are: how climate change is perceived by the mine sector practitioners and the literature community in terms of risks on mine projects; environmental factors that have been impacting these risks; and proposed adaptation strategies. Findings of this paper argue for greater collaboration among mining practitioners, regulators, scientists and other industry stakeholders to develop practical adaptation strategies that can be integrated into existing and future mine operations; cooperation among provinces' Environmental Assessment offices by publishing a guide on current or expected climate

risks and planned adaptation strategies; include current and future environmental impacts on mine projects as a requirement in British Columbia Environmental Assessment applications; educate mine sector practitioners with appropriate knowledge on how to address and integrate uncertainties associated with climate change.

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A significant current discussion among Canadian mining sector practitioners, scientists and institutions, explores the risks posed by climate change and the importance of developing adaptation response options is increasingly being recognized. Canada's mining industry is already being affected by weather events and it is expected that the impacts will be even larger in the future (Pearce *et al.*, 2009). However, little has been proposed as solutions to help the mine sector to adapt, and far too little attention has been paid to the importance of this issue. The mining researcher, Jason Prno *et al.* reinforces this argument "Because of [mine sector] dependency on the natural environment, it is particularly vulnerable to the consequences of climate change" (2010). Prno highlights this further that through surveys and interviews with practitioners he "found a significant number believe that climate change is already having a negative impact on their operations" (2010). This trend can be seen on a global scale as well; in a survey done by Acclimatise over 80% of global mining companies' claim their physical assets would be affected by extreme weather events, yet only 13% report taking action to protect their assets that are critical to business success (2009). Without building adaptation measures into their business plans, climate risks could impact upon companies' financial and operational performances, increasing operational and capital expenditure. In this sense,

companies should provide evidence throughout the Environmental Assessment processes that they integrate various adaptation methods into their decision making.

The aim of this paper is to evaluate the state of how climate change impacts and adaptation have been assessed in Environmental Assessment in British Columbia compared to what is recommended in the literature.

The paper has been divided into five sections. Section 1 provides background information on the British Columbia Environmental Assessment (BCEA) procedure, the role of the mining sector in British Columbia economy, and the overall trend of climate change in the province. Section 2 outlines the key conceptual steps required to conduct the assessment on how climate change impacts and adaptations could be assessed in BCEA applications. Section 3 focuses on the analysis of the approved EA applications, introducing central climate risks and adaptation methods. Moreover, the section will deal with how climate change risks are perceived by the diverse literature community. Section 4 is dedicated to identifying and filling the gaps in knowledge between the analysis of approved EA applications and the literature reviews. Lastly, the paper will be concluded with section 5, recommendations and future research.

Definitions

The literature on vulnerability and adaptation is both deep and extensive. It is therefore natural that differences exist in how one defines a concept such as vulnerability or adaptation, and how one explores the relationship between them. In this paper, vulnerability is defined as “the likelihood of destruction or degradation arising from a natural or environmental hazard” (Miranda *et al.*, 2003). Natural and environmental

hazards, such as earthquakes or floods, can cause or exacerbate mine related problems. There is no one agreed upon definition of adaptation or what adapting to climate change will entail for the mining sector and its planning. Climate change adaptation is an “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm” (IPCC report, 2001). It includes activities that are taken before impacts are observed – anticipatory or proactive, and after impact has been felt, or reactive.

1. Background information

1.1. British Columbia Environmental Assessment

The British Columbia Environmental Assessment Office (EAO) manages the assessment of proposed major projects in BC as required by the *Environmental Assessment Act*. The assessment process examines major projects for potentially adverse environmental, economic, social, heritage and health effects that may occur during the life cycle of these projects. According to EAO, there are three stages in an environmental assessment – pre-application, application review and the decision phases. The pre-application phase ensures that when an application for an environmental assessment certificate is reviewed, it contains the necessary information to allow the EAO to undertake its assessment and make recommendations to the Minister making the decision. During the Application review phase, applicants must fulfill the ‘Application Information Requirement’ and submit documents accordingly. In the last phase, the decision stage,

assembled materials are submitted to ministers for decision making. In between these three phases public hearings are held and posted online for comments (BC EAO website).

2.2. Role of the mining sector in British Columbia

Over the last years, British Columbia has experienced a strong resurgence of the mineral exploration and mining industry. According to the Mining Association of British Columbia (MABC), almost half of the proposed mining projects in Canada are in British Columbia, making it a world center of mining expertise and investment. Suggested in a Pricewaterhouse LLP (PwC) 2010 report, direct mining expenditures in British Columbia totaled \$5.2 billion in 2010; an additional \$3.7 billion was spent in secondary and support industries and services resulting in a total of \$8.9 billion of economic activity across British Columbia. Furthermore, the mining industry alone was responsible for generating 45,703 jobs in 2010, and generated \$938.6 million in total tax revenue (Pricewaterhouse LLP, 2010).

1.3 Climate change in British Columbia

With the reality of changing climate, some level of adaptation to both expected and unexpected vulnerabilities is crucial. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) states that the warming of the climate system is unequivocal (IPCC, 2007b).

British Columbia will have greater warming and changes in its precipitation regime than the global average, and an increase in winter and summer temperatures is predicted.

Warming will be greater in northern British Columbia than in southern British Columbia

and greater in the winter than in the summer, particularly the minimum winter temperature (Ostry *et al.*, 2008). The frost free period, growing degree days and frequency of occurrence of extremely warm days are also predicted to increase (Ostry *et al.*, 2008).

2. Method

This section outlines the methodology used to evaluate how climate change risks and adaptation have been assessed in BC Environmental Assessment applications. The applications of interest for this study are approved Environmental Assessment applications for mining projects in BC. The applications that were accessible to this study consisted of EA applications completed and certified between 1992 and 2010. The applications were obtained from the Environmental Assessment Office (EAO) on the Project Information Centre (PIC) website. Because there are only twenty- seven approved and certified Environmental Assessment applications obtainable regarding the mining projects, no statistical sampling method was used. This resulted in twenty seven certified Environmental Assessment applications over the eighteen year period. Out of these twenty seven complete Environmental Assessment applications, fifteen were inaccessible. Out of twelve complete applications that were accessible through PIC, six approved applications between 2002 and 2010 carefully examined climate change risks and proposed adaptation methods. All six applications were reviewed one by one to assess the inclusivity of climate change risks on the projects and potential adaptation methods.

These six applicants are:

1. Brule Mine Project (approved in 2006)
2. Ruby Greek Molybdenum (approved in 2007)
3. Hermann Mine Project (approved in 2008)
4. Swamp point Aggregate Mine Project (approved in 2006)
5. Mt.Milligan Gold/Copper Project (approved in 2009)
6. Galore Greek Copper-Gold-Silver Project (approved in 2007)

Subsequently, a literature review was conducted for comparison purposes with the approved EA applications. The availability of academic literature on climate change risks on the mine sector was limited. For this reason, literature that was considered in this research consists of non-governmental organizations and consulting companies' publications and engineering papers.

3. Results

This section describes some of the climatic conditions to which mining operations in Canada have been exposed, how they are changing, how sensitive operations are to these changes, and the adaptive strategies that have been addressed and employed to deal with them.

Based on the reviews conducted on the available literatures and the Environmental Assessment applications attained from EAO, I established a list of five most frequently mentioned climate change risks on the mine sector and their probable adaptation strategies. Climate change is expected to impact mining in terms of:

1. Infrastructure (on site)
2. Transportation (access roads)
3. Tailings ponds (acid rock drainage and metal leaching)
4. Overburden (slope instability)
5. Operational concerns (activity timing/delays, workers health and equipment compatibility)

3.1. Results and Analysis of the Environmental Assessment applications

The following analysis was based on the review conducted on the six mine projects' applications.

Climate Change Risks	Brule Mine	Ruby Greek	Hermann Mine	Swamp point	Mt.Milligan	Galore Greek	Environmental Factors
Infrastructure	NO	NO	NO	YES	YES	YES	Swamp point Aggregate: earthquakes, marine storms & tsunamis; Mt.Milligan and Galore: storm events and fire risk
Transportation	YES	YES	YES	NO	NO	YES	Brule Mine and Hermann Mine: High snow fall and snowpack accumulation & slope movement/failures; Ruby Greek and Hermann Mine: Landslides/Slope movement; Galore Greek: Flooding
Tailings ponds (leaching)	NO	NO	NO	NO	NO	NO	---
Overburden (slope instability)	NO	NO	NO	NO	NO	NO	---
Operational	YES	YES	YES	YES	YES	NO	Brule Mine, Ruby Greek, Hermann Mine: Cold winter climate and freezing conditions, high

snowfall, Flooding; Forest
fires Swamp point:
Landslide; Mt.Milligan:
Forest fires

Table 1. Results of the six Environmental Assessment applications review

It is apparent from this table that the most sought after environmental factor threatening the mine sector is change in the frequency and the intensity of precipitation. This change will lead to extreme flooding events, frequent landslides due to overly saturated soil, acid rock drainage and minerals leaching, and other hazardous events such as avalanche risk (Pearce *et al*, 2009). These environmental factors will yield in interruptions in production, damage to mining infrastructure, and other unexpected associated costs. Another major environmental factor having a huge impact on the mine sector is extreme temperatures both during the summer and the winter. Increase in temperature extremes will degrade working conditions of outside workers (which include majority of the employees in mine industry), especially during winter periods when temperatures fluctuate greatly compared to summer months (where forest and on site mine prone to fire risk). These factors and risks will result in termination of operations making employees dependent on seasonal employment. The third environmental factor affecting the mine sector would be an increase in incidences and intensities of hazardous events such as, landslides, tsunamis, and storms, among many. These events threaten all aspects of the mine industry: infrastructure, transportation, mine drainage, tailing ponds and operational regulations. Mining assets have been designed on the basis of historic climate data and a period of relatively stable weather.

The most striking result to emerge from the data is that none of the applicants were concerned about risks associated with tailings ponds and waste dumps. Tailing ponds

function as a storage facility for leftover toxic mixture of water, sand, clay and residuals. Besides the toxic chemicals that are contained within the tailings, the water in these storage facilities attracts methanogenic bacteria, which produce methane, a greenhouse gas (Greenpeace, 2007). These ponds pose serious risks for many birds and animals that come in to contact with them and risk of leaking into the groundwater in the area affecting near communities' livelihoods. In the case of waste dumps failures, consequences to the public include the loss of life by burying events (Kent, 1993).

3.2 Proposed Adaptation strategies

Changes in climate have already exacerbated some pre-existing climate sensitivities for mining operations, requiring mines to undergo some level of adaptation. As per Smit and Skinner (2002), in most cases adaptations can be described as either reactive and ad hoc in nature, or pro-active. Anticipatory or proactive adaptations will incur lower long term costs and be more effective than reactive adaptations (Burton, 2007). The type and nature of response to deal with climate change exposure-sensitivities differs among mining operations and regions and is influenced by a variety of climatic and non-climatic factors.

Infrastructure.

➤ Current impacts

Mt Milligan Gold/Copper and Galore Greek Copper-Gold-Silver Projects suggested adapting to forest fires by setting a treeless buffer zone on the project periphery. Other suggestions include having vehicles and people on site who can help fight fire, water

reservoir and distribution system located at the mine site, and more attention and caution during lightning storms.

➤ Possible Future impacts

Swamp Point Aggregate Mine Project proposed following methods to deal with marine storms and tsunamis: mine facilities can be designed at 10m above the highest water level (HHWL) except for the barge loading/unloading ramp; refugee surface facilities can be built at higher elevation, weather station at site can be established to provide accurate temperature and precipitation data as a warning. Both projects highlighted there are no standards to deal with climate change uncertainties when it comes to storm events and other natural hazards.

Transportation.

➤ Current impacts

Both Brule Mine and Hermann Mine Projects recommended dealing with high snow fall and snow pack accumulation by frequent snow clearing.

➤ Possible future impacts

To prevent slope movement and failures Brule Mine and Hermann Mine suggested coming with site specific design criteria to ensure stable slopes and rock cuts, and avoid destabilizing naturally active slide areas. Ruby Greek Molybdenum recommended dealing with landslides by conducting terrain hazard mapping along the access road to identify potential hazardous sites. In Galore Greek Copper-Gold-Silver Project case, to prevent closure of access road due to extreme flooding, road maintenance and repair program will be implemented and leak detection system will be installed.

Operational.

➤ Current impacts

Swamp Point Aggregate Project is located in a landslide prone area, which threatens its operational period. They are dealing with this by constructing the mine perimeter road as a 2m elevated embankment along the slope toe which will provide suitable rock fall capture.

➤ Possible future impacts

Brule Mine and Hermann Mine Projects did propose the negative effects of freezing winter temperatures, where working conditions and mine equipment will be undermined. This will affect the operational periods and duration of mines. However, they did not recommend any adaptation strategies. Flooding can be prevented by constructing flood protection berms around the perimeter of the facility, and reflect on water management facilities, which have been designed to withstand (in this case) a 1:200 year flood. Both projects suggested dealing with fire risk by ensuring adequate on site fire protection systems, locating fire caches along the road, developing a Fire Response Plan, and collaborating with other industrial users and the Ministry of Forests during high risk periods. For the fire risk adaptation method of Galore Greek Copper-Gold-Silver project, refer back to the infrastructure section.

3.3. Results of Literature review

Climate Change Risks	Environmental Factors	Adaptation
Infrastructure	Early melting ice and freeze and thaw cycle (Instance <i>et al.</i> , 2005); Increase	“No regrets” measures (enforcing engineering codes and

	and decrease in precipitation could affect the water management structures (Stratos Inc., 2011); Increase in precipitation will lead to infrastructure instability (Climate Institute); Susceptible to structural weakening and failure due to increased frequency and severity of extreme weather events and climate variability – flooding, ice storm and wind events (Auld and MacIver, 2006);	standards while encouraging continued learning about adaptation opportunities and capacity (Auld <i>et al.</i> , 2006); Further research on climate relevant building codes and standards (Fernandez, 2003)
Transportation	Early melting ice (Instane <i>et al.</i> , 2005); Warming winter temperatures (Prowse <i>et al.</i> 2005); Permafrost thawing (Alessa <i>et al.</i> , 2008); Lake-effect from rapid warming and moistening of air masses (IJC, 2003);	Can be flown out – higher cost (Hodgkinson, 2010); Improved ocean access (Prno, 2008); Construction of a seasonal overland route is being explored (Diamond mining); Modified transport schedules to coincide with mid-winter months, enhance thickness through surface flooding or spray ice (Pearce <i>et al.</i> , 2009);
Tailings ponds (Drainage/Leaching)	Increased water scarcity will affect mine drainage composition (Bjelkevick, 2005); Increase in precipitation resulting in failure of impoundment structures (Stratos Inc., 2011); Thawing of tailings piles will lead to contamination exposure (Prowse <i>et al.</i> , 2009); Altered freeze-thaw cycles exposing previously frozen tailings (Neale <i>et al.</i> , Unknown)	Further research and development of new cover materials (Auld <i>et al.</i> , 2006); Return mine waste underground through backfilling (Lemly, 1994)
Overburden	Increase in Frequency and Intensity of seismic events; Increase in precipitation (IFC report, 2007).	Dumps should be planned with appropriate terrace and lift height specifications based on the nature of the material and local geotechnical considerations (IFC, 2007); Potential change due to chemical and biologically catalyzed weathering should be considered (change in grain size and mineralogy) – install proper cover system (IFC, 2007)
Operational	Increased frequency of extreme	In high summer temperatures

climate events (Warren and Lemmen, 2004); Low winter temperatures (Ford <i>et al.</i> , 2010); Warmer winter temperatures (Prowse <i>et al.</i> , 2009); Water scarcity limiting production rates, dust suppression, tailing pond covering options, and jeopardizing drainage effluents etc. (Brown <i>et al.</i> , 2006)	activities can be rescheduled to night time (Hodgkinson, 2010); Reduce water intake and recycle water (Pearce <i>et al.</i> , 2009)
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Table 2. Results of the literature review

4. Conclusion

The manner in which the mining industry responds to the challenges brought on by climate change has important implications for both the provincial and national economy. Climate concerns are a central fact of business life and adapting to the reality of climate change is in the best interests both of mining companies and communities whose wellbeing is intractably tied to the success of the industry.

The purpose of the current research was to determine the state of how climate change impacts and adaptation have been assessed in British Columbia Environmental Assessment applications compared to what is recommended in the literature.

The following conclusion can be drawn from the present research - a strong discrepancy exists between the literature community and Environmental Assessment applicants in recognizing climate change risks and recommending adaptation strategies. The results of this research support the idea that Environmental Assessment applicants perceive climate change to be primarily an economic and regulatory risk, mostly caused or to be caused by increased frequency and intensity of extreme weather events; their preferred approach for addressing climate change is mostly through reactive approaches such as monitoring, among others. Whereas, the literature community view climate change as a physical risk

caused or to be caused by an increase in intensity and frequency of precipitation and other environmental factors associated with it, such as flooding. Their proposed adaptation strategies were mostly engineering and technical methods. This discrepancy is and will affect adaptation methods that are being or will be proposed in the future. Moreover, it is clearly seen from the review of the applications, the mine sector's reluctance to take a proactive stand on adaptation is largely due to the uncertainty about emerging climate and cost related complications.

The findings from this research make several contributions to the current British Columbia Environmental Assessment process and to future mine project applicants. Some degree of future climate change is now inevitable. Collaboration among mining companies, regulators, scientists and other industry stakeholders to develop practical adaptation strategies that can be mainstreamed into existing and future mining operations will greatly enhance chances of success. The British Columbia Environmental Assessment process does require certain applicants, depending on their location and mine type, to submit current and future climate risks on their projects and also their planned adaptation strategies. However, it is not a set requirement for all mine applicants. In this sense, another important practical implication is that current and future environmental impacts on mine projects should be addressed as a requirement in British Columbia Environmental Assessment applications regardless of their mine types and locations. Especially, climate change risks such as infrastructure, transportation, tailings ponds, overburden/waste dumps, and operational and economic risks must be addressed by mine project applicants. For those applicants who are going through both the provincial and federal Environmental Assessment processes, the integration of current and future

climate risks on mine projects can be resolved by an incorporation of British Columbia Environmental Assessment process with the federal Environmental Assessment process. To note here, the integration of these two processes is currently being discussed between the provincial and federal governments.

Moreover, these findings enhance our understanding of the importance of educating mine sector practitioners with appropriate knowledge on how to address and integrate uncertainties associated with climate change. Another reasonable approach to tackle this issue could be to work with other provinces' Environmental Assessment offices by publishing a guide on current or expected climate risks and planned adaptation strategies. There is, therefore, a definite need for more effective scientific knowledge translation to the industry. A fuller understanding and capacity to analyze scientific knowledge in order to develop efficient and effective identification of climate change risks and adaptation strategies and plans are needed.

A number of caveats need to be noted regarding the present study. The current research has only examined the Environmental Assessment process in British Columbia, and specifically looked at mine projects. It is recommended that future research should therefore concentrate on the investigation of determined climate risks and proposed adaptation methods of the mine sector across Canada. Moreover, it would be interesting to compare the experiences of different industry practitioners on addressing climate change risks and adaptation strategies. A further study could assess the quality and robustness of set standards and codes, and its applicability to the mine sector.

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