

Water Issues Associated with Mining in Developing Countries

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Research aims:

Water issues and particularly competition for water has meant that effective water management is integral for mines both for operations and sustainability.

The objectives of this work were to:

- Provide a structured analysis of water issues related to mining faced by governments and companies in developing countries
- Understand the factors controlling the issues
- Outline strategies and tools used to address the issues
- Synthesise the operational and institutional barriers to addressing the issues

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Summary of Action Research Activity

Water issues associated with mining in developing countries

This project sought to identify and analyse the main mining-related water issues currently experienced in developing countries, identify priorities for capacity building, and outline solutions and possible barriers to solving the issues.

Eight countries were studied: Mozambique, Zambia, Ghana, Peru, Mongolia, Philippines, Papua New Guinea (PNG) and Indonesia. A range of literature was examined to ensure the perspectives of scientists and academics, mining companies and the community were all included. The report drew on journal abstracts, sustainability reports and websites to obtain a broad overview of the water related issues that have arisen due to mining in developing countries.

It was found that the dominant and highest priority issues identified by all sectors were those involving the community and the environment. Because of past abuses, community concerns were that mining activities would damage the environment, with flow-on effects on livelihoods and health. Communities reported that they were not getting the information they needed to understand the impacts of mine water-related issues. Although there is unbiased information available in the form of the scientific literature, it is not in a format that is accessible to them. Some of the solutions suggested were: that academia and government do more to provide understandable, unbiased information to the community; that mining companies could involve the community in their environmental monitoring; and that governments require greater resources for enforcement and implementation of regulations.

Artisanal scale mining was identified as a medium level issue, due to its impact upon the environment and the miners' own health. The issue was not brought up by the community itself, but by the scientific literature and company reports. Solutions are already in existence: the governments must enforce regulations and close down illegal mines. In at least one example, a mine provided artisanal scale miners with access to its land after the miners underwent training.

Of importance mainly to the companies, was water access for future developments, which was assigned a medium level of priority. It is the respective government's responsibility to ensure that there is sufficient water for all users and it is suggested that governments adopt integrated water resource management principles.

Standardised water reporting was assigned a low priority. It had previously been brought up as an issue in an International Council on Mining and Metals study that looked mainly at developed countries; but for developing countries, there are other more pressing issues.

The findings have been used to drive further research which has already been utilised in the preparation of workshop materials for government advisors.

Water issues associated with mining in developing countries

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1 Executive Summary

The International Mining for Development Centre (IM4DC) provided funding to the Centre for Water in the Minerals Industry (CWiMI) to identify water issues that are currently being experienced in developing countries due to mining, with the aim of creating water management teaching and workshop materials for both government advisors and mine operators. The purpose of this report is to establish the areas of need and the priority for capacity building rather than create workshop material. The objectives of this report are to identify and analyse the mine water related issues of developing countries and outline solutions and possible barriers to solving the issues.

Eight countries were chosen: Mozambique, Zambia, Ghana, Peru, Mongolia, Philippines, Papua New Guinea (PNG) and Indonesia. A range of literature was searched to obtain the perspectives of scientists and academics, mining companies and the community. The report drew on journal abstracts, sustainability reports and websites to obtain a broad overview of the water related issues that arose due to mining in developing countries.

It was found that the dominant and highest priority issues identified by all sectors are the ones involving the community and the environment. Because of past abuses, community concerns were that mining companies would damage the environment which would have flow-on effects to their livelihood and health. Communities are not getting the information they need to understand the impacts of mine water-related issues. Solutions suggested were that academia and government can act to provide unbiased information to the community, the mining companies can utilize the community in their environmental monitoring and the government needs more resources for enforcement and implementation of regulations.

Artisanal scale mining was identified as a medium level concern, due to its impact on the environment and to the miners' own health. The issue was not brought up by the community itself but by the scientific literature and companies' reports. Solutions are in existence: the government must enforce regulations and close down illegal mines. There is at least one example where a mine provided artisanal scale miners with access to its land after the miners underwent training.

Of importance mainly to the companies is water access for future developments which has been assigned a medium level of priority. It is the government's responsibility to ensure that there is sufficient water for all users and it is suggested that governments adopt integrated water resource management principles.

Standardised water reporting was assigned a low priority. It had previously been brought up as an issue in an ICM study that mainly looked at developed countries but for developing countries, there are other more pressing issues.

2 Introduction

The International Mining for Development Centre (IM4DC) was established in October 2011 in collaboration with the Australian Government, the University of Western Australia and the University of Queensland. Its goal is capacity building of key people within government, academia and civil society organisations of developing countries so that they may implement improved policies in the governance of the mining industry and its impact on the environment and its relationship with the civil sector.

Water issues and particularly competition for water has meant that effective water management is integral for mines both for operations and sustainability. IM4DC has provided funding to the Centre for Water in the Minerals Industry (CWIMI) to identify the water issues that are currently being experienced in developing countries due to mining, with the aim of creating water management teaching and workshop materials with both government advisors and mine operators. As this is an initial scoping study, the material generated in this research may not appear directly in training material but it is an important first step in establishing the areas of need and the priority for capacity building.

A similar exercise was undertaken in a previous study commissioned by the International Council for Mining and Metals (ICMM) [1]. The ICMM scoping study was initiated by the ICMM to canvas their member companies on mine water-related issues of international significance so that the ICMM could create a strategy to address them. The issues were ranked according to a hierarchy that was developed in the report. Eight countries were represented; Chile, Peru, Argentina, Australia, South Africa, Guinea, USA and China. With the exception of Peru and Guinea, the study was dominated by developed countries. To meet the aims of the IM4DC, it is pertinent to repeat the study with the focus solely on developing countries and from a broader perspective than ICMM member companies. Whilst many water issues are likely to be common, it is also likely that societal factors in developing countries will create some unique water concerns.

For this study, a range of countries were chosen from three continents; Mozambique, Zambia, Ghana, Peru, Mongolia, Philippines, Papua New Guinea (PNG) and Indonesia. The first five were confirmed by the IM4DC as countries that would be targeted to receive the capacity building programs so it was logical to include them in the study. Philippines, PNG and Indonesia are not listed but they are developing countries and were part of another IM4DC project [2] and we could exploit synergies between the two projects by sharing data. The complementary project looked at broader themes, sustainability reporting in general and water-related sustainability initiatives in the four Asian countries. The focus of this project is to ascertain the mine-water related issues that are being faced in developing countries globally.

The objectives of this work are:

- To provide a structured analysis of water issues related to mining faced by governments and companies in developing countries;
- Understand the factors controlling the issues;

- Outline strategies and tools to address the issues; and
- Outline the barriers to addressing the issues.

3 The ICMM water issues scoping study

It is appropriate that a summary of the ICMM water issues scoping study is presented so that we can compare issues between the two reports. The report authors identified the water issues related to mining through the following sources: sustainability development reports from 18 ICMM member companies and interviews with 13 individuals from mining companies who had corporate responsibility for water, environment and sustainability. The scientific literature was not reviewed thus the water issues that were identified, were from the point of view of the mining companies.

Seven broad water issues were identified from the study. Recommendations were made on how the ICMM can address the water issues along with the priority of the recommendation from one to five (1 having the highest priority). The priority was assessed according to three criteria: leadership potential of the mining industry, the importance of the issue and how well it consolidated an existing position.

3.1 Dynamics of the operating environment

This issue refers to changes in water access and water use due to operational changes over the mine life, community expectations and changing regulations. The recommendation (priority 4) related to stakeholder engagement to manage this issue in an integrated way. An additional recommendation was made for further research on the integration of managing water quantity and water quality issues for a mine site (priority 2).

3.2 Technical Water management

The trend is for mining companies to use as little water as possible. Over extraction of surface and ground water has led to environmental degradation. Population growth and climate change adds pressure to an already stressed watershed. The paper predicted frugal water use even in regions of sufficient water supply. In terms of water quality, the water issues were meeting regulatory limits for discharge and ensuring the water remains fit-for-purpose with increasing reuse of water. The storing of mine waste, tailings and rock dumps, can create water quality problems. The study recommended (priority 4) the creation of tools to manage technical water issues with two areas of concern being water treatment technology and groundwater extraction limits.

3.3 Global changes

Mining companies felt that natural climate variability created more problems than climate change as they were currently able to handle weather extremes across sites in different regions. As land custodians, mining companies were seen to have a role to play with global issues such as the use of water to grow food, biofuel and to support biodiversity values. Of relevance for the IM4DC project was that interviewees were concerned about less mature companies operating in

developing countries with standards that were below good practice. The recommendation (priority 1) was for ICMM to assess how well water-related risks are managed globally. The water-related risks referred to water issues such as the ones under technical water management; limited water supply, an excess of water, water quality and closure problems so that particular recommendation was across a broad set of issues.

3.4 Data and information management

There was no consistent way among companies to report water use. The recommendation (priority 5) was to improve the Global Reporting Initiatives suite of metrics related to water. This has since happened. In 2009, the Minerals Council of Australia unveiled a pilot study of the Water Accounting Framework [3]. In 2012, the ICMM has advocated the use of the framework to its member companies.

3.5 Policy and regulatory environment

Environmental regulations are tightening but companies wanted evidence based policy setting rather than regulators setting too tight a safeguard in the absence of information. Also in this category of water issue, mining companies fear a community backlash if the mining company is seen to drive a price increase in water. However it is something that may happen because water is more valuable than simple cost recovery as access to water becomes harder. The recommendation is that a review of water access arrangements on a global scale be carried out (priority 4).

3.6 Cumulative impacts

Cumulative impacts are difficult to manage because by definition they are not the responsibility of one user. The report gave examples of users cooperating to meet salinity discharge limits into a river and another case study where multiple users timed water withdrawals from a river to mitigate the impact of them. Although not mentioned by name, these case studies would fall under the category of integrated water resource management. It was recommended (priority 3) that a framework be created to address cumulative impacts on regional water systems. In 2010, CSR and CWiMI published a guide for cumulative impacts in the coal industry after receiving ACARP funding [4].

3.7 Mine closure

Whilst interviewees felt that the technical questions surrounding mine closure were known, the gap is in investment in research and knowledge transfer. The recommendation was that it should add water management issues to their current ICMM mine closure toolkit (priority 5).

The last recommendation encompassed all water issues in that it related to a guide for creating a business case for water management (priority 3).

As has been highlighted, some of the recommendations have been carried out, which shows that this type of review process directs and prioritises research activities.

The water issues of other sectors - industries other than mining, government and non-government organisations - were also identified from publically available documents but in this section, the water issues did not have to relate to mining. This purpose was to find out if the water issues experienced by other sectors were the same as the issues experienced by mining and to identify opportunities where other industries have achieved better practice. The results showed that this section did not highlight any new water issues apart from the fact that companies that make consumer products are conscious of brand reputation however even this can be likened to mining's social license to operate.

4 Methodology

The purpose of this IM4DC report is to identify mining related water issues in developing countries, with the eventual aim of creating teaching materials for government advisors and mine operators. Thus it was desired to consider the water issues not just from the perspective of the mining companies, but of other sectors. For this reason the scientific literature was searched to discover the areas of research with respect to mining and water related issues for each of the eight countries. To avoid this generating an unwieldy amount of data the following restrictions were placed on the search: articles are post-1990 and although water-related issues do cover social issues of which health is one, to narrow the scope and the fact that there is another IM4DC research project that covers health-related impacts, the authors have not included papers that research how human health is affected by poor drinking water quality.

Business monitor reports designed for investors provided a summary on the background of the country in relation to mining. From these reports, mining companies that were contributing to economic growth were identified. The sustainability development reports or annual reports of the companies were read to list the water issues from the company viewpoint. Interviews were not part of this study. Websites were searched to obtain the water issues related to mining from the perspective of non-government organisations (NGO) and community groups. A limitation of the study is that there is not the same quality control on web-published content as there is in journal content however it is an important reporting tool for communities and even if the content is not an accurate account of an issue, it still shows their perception of the issue.

There is a gap in the current study in that government websites were not searched although the database did return a few government-sponsored reports and the results appear in Section 5.4.

The purpose of the IM4DC is capacity building so the hierarchy for this paper is to determine training priorities. The criteria for ranking are: the importance of the water issue and the knowledge base of the authorities and mining companies in the target countries.

5 Results

5.1 Scientific articles

One-hundred and forty-five articles were found upon searching the following keywords: mining, water and the name of the country in an environmental science database. The environmental science database was chosen because it was thought that a broad range of issues would be obtained through the other sources when gaining the perspective of the mining companies and the community groups. For each article, the predominant theme was identified from the abstract and the numbers of articles across each country for each theme was counted. Common themes were repeated across countries: integrated water resource management, acid rock drainage (ARD), regulations, groundwater, artisan mining, effect on environment, water treatment, community relations and an 'other' category. For a theme to be considered as its own category it had to have a minimum of five papers, otherwise it was put in the 'other' category. The information has been summarised in Figure 1.

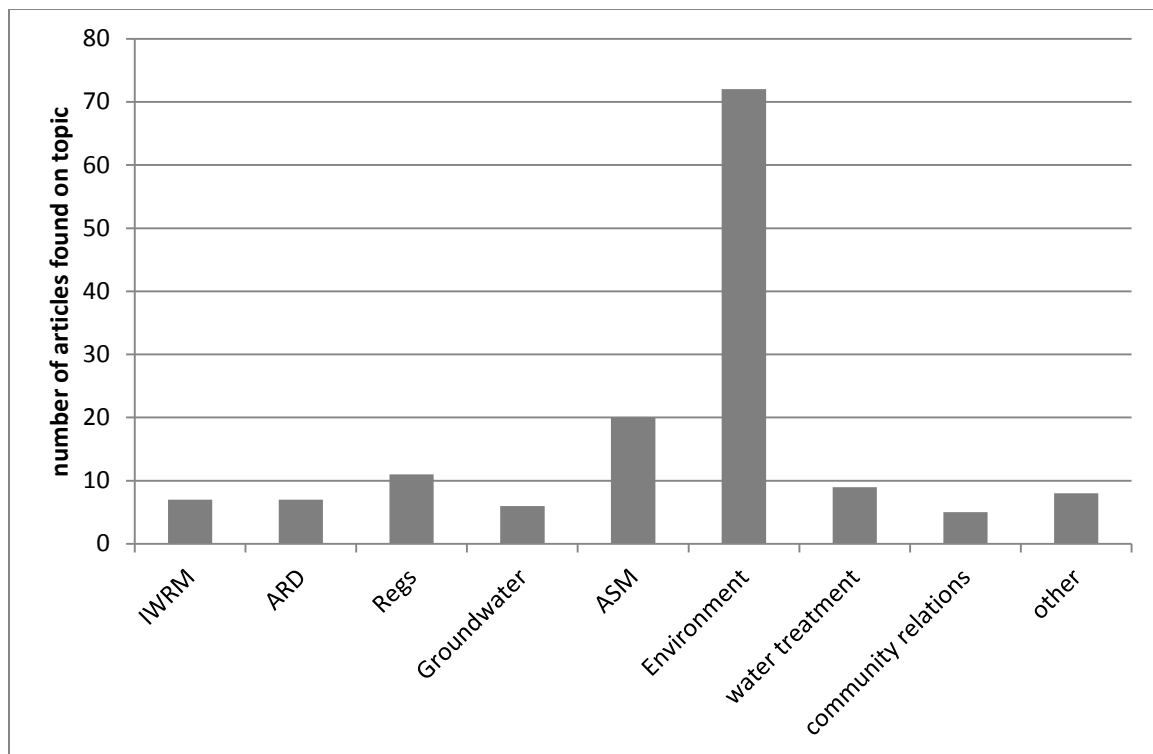


Figure 1: Number of scientific articles found in each listed topic

Out of the 145 articles found, about half are on the effect of mine water on the environment which is not surprising since the database was for environmental science. To break this down further, studies assessed the water quality of groundwater [5-10], surface water [10-16], coastal waters and ocean waters [17-28]. Of interest, was the water quality as assessed against drinking water standards [29-35]. The papers included impacts of mine-water on macroinvertebrates, fish and other animals with the objective of assessing the health of the river or to ensure that commonly eaten fish are safe to be consumed [36-47]. Articles studied the composition of river sediments

for the presence of contaminants [48-54]. In 7 cases out of the 82 journal papers, the effect of the mine on the environment was negligible [11, 24, 46, 55-58], although the proviso is that the conclusions were based on whatever effect the particular study was looking for. For instance, tests on water in two mining communities in the Western Region of Ghana showed that the concentration of radionuclides did not exceed world averages for drinking water [59] however on the basis of this study alone, it cannot be stated that the mine had no impact on the water. Five journal papers studied the impact on the environment of the practice of submarine tailings disposal in Indonesia [60-62], PNG [20], and Ghana [35]. For Papua New Guinea, the main issue was the continued water quality monitoring of the Ok Tedi and Fly River systems due to the fact that the Ok Tedi mine discharged untreated tailings into the rivers [63-76].

The next most common theme identified from the journal articles was artisanal-scale mining (ASM). Mercury is used in the extraction of gold in artisan-scale mining which is detrimental for the environment and for humans [77-89]. Other problems caused by ASM are rivers silting, de-vegetation of the area to provide fuel for the miners, poor sanitation systems contaminating nearby watercourses, noise pollution and air pollution [90, 91]. The mining is unregulated and the legislation is ignored. For instance, artisanal mining is carried out at conservation areas even though it is prohibited [92]. Ghana does allow ASM but the Ghanaian Minerals Commission is understaffed and needs support from local governments to ensure that the environment is protected [93]. The solutions that are promoted are education, technical support and cooperation between large and small scale miners so as to afford environmental protection measures, understanding of the socio-economic factors, enforcement of existing regulations and to close existing illegal mines [88, 94-96].

The theme of regulations covered areas such as the creation of new standards for mining [97, 98], the need for environmental policy [99, 100], the need for enforcement of regulations [101] and the capacity of regulators to enforce these regulations [102-104]. Developing nations have adopted environmental impact assessments but a study was critical of the enforcement of them and suggested that help is needed with post-EIS activities such as monitoring procedures and enforcement options [105]. It was found that environmental governance is lacking and so it has been left to the mining companies themselves to enforce best practice [106]. Some of the barriers that have been identified for the authorities are multiple institutions, economic and human resource constraints, poor data collection and inadequate training [107].

The field of water treatment covered improving the quality of mine effluent in order to reduce negative impacts on the environment [108-113], the need to improve the quality of community borehole water in mining areas [114] and the stability and remediation of tailings dams [115, 116]. One of the findings was that inappropriate water treatment was carried out due to a lack of knowledge [112].

Integrated Water Resource Management (IWRM) involves the co-ordination of stakeholders in the water use of a basin to ensure economic and social development is done whilst maintaining the ecosystem. The term 'stakeholders' includes community members but the studies where

community members were active in river management were put into the community relations theme. The point in this theme was that because river basins span regions and countries, there is a need for co-operation between authorities and nations which should be put into environmental regulations [117-120]. Some of the barriers to IWRM were a lack of hydrological data and models and insufficient institutional capacity to enforce legislation [121]. Mozambique in general had a low amount of literature returned (8 papers), indicating a lack of research effort devoted to this country and most of those papers were in the field of IWRM because Mozambique was part of a larger study involving surrounding countries [117, 119, 121-123].

Acid rock/mine drainage has been given its own category since there were sufficient papers on this topic but it can also be considered a subset of the effect of mine water on the environment. The papers studied water management at the mine site [124], element transport [125], water quality of surrounding waters [126-128] and the effects of multiple mines in an area [129, 130].

Groundwater covers issues such as the study of groundwater recharge [131], supply [132, 133], soil moisture [134] and modelling [135, 136].

The theme of community relations covers papers that studied water competition between human needs, livestock and the mining company [137]; community anger over discharge of untreated tailings into the river [138], a mining company providing infrastructure for the community where the government was lacking [139, 140] and community involvement in river management [141].

The 'other' category is for isolated matters or few papers were returned on a particular subject [142-149].

5.2 Company sustainability reports

The companies that were identified by the business monitor reports for each country (except for PNG which did not have a business monitor report for mining) are listed in table 1 in the Appendix. The sites that are experiencing the most growth have been shown but the company may have more sites than those listed. Also the companies operated in more countries than just the target countries.

Eighteen of these companies had either sustainability reports, sustainability information contained in annual reports or websites. As with the scientific journals, broad themes within the reports emerged. They have been summarised in Figure 2.

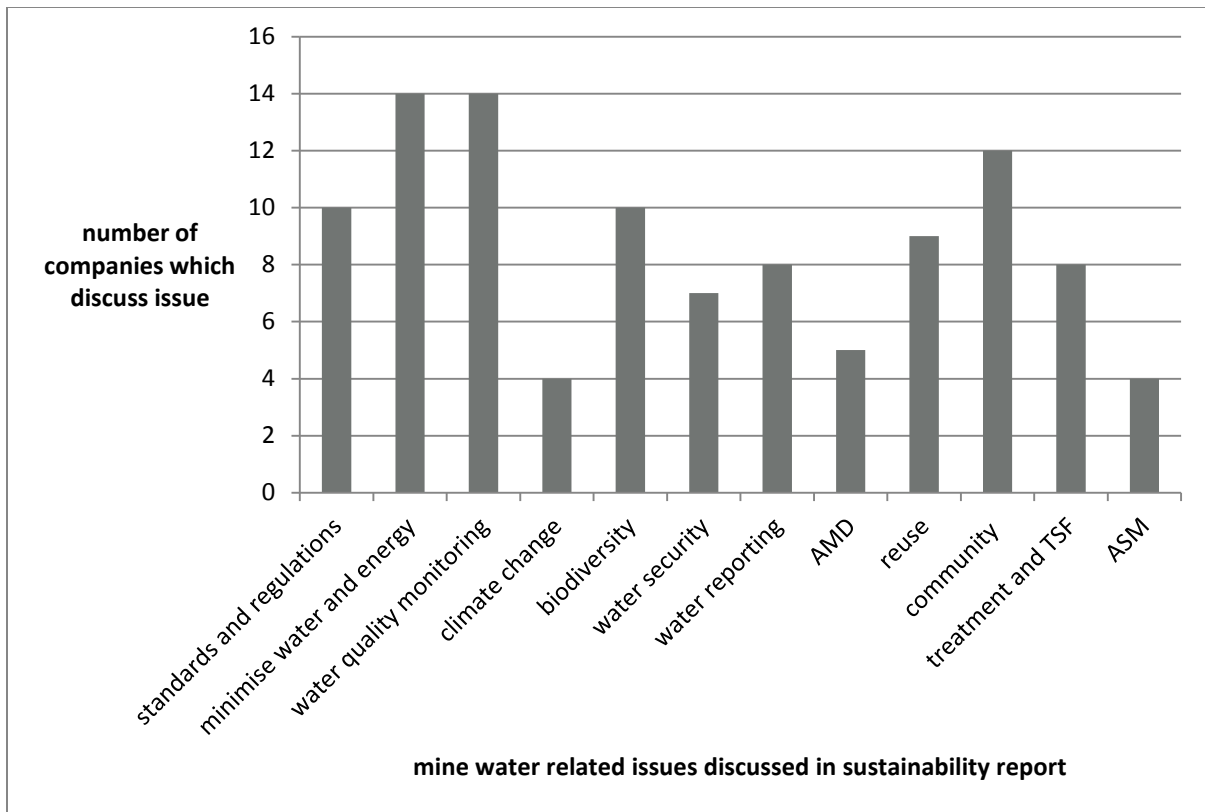


Figure 2: Number of companies which discuss the listed issues in their sustainability reporting

The discussion points or issues that the reports have been divided into are to help categorise them but the reality is that many issues overlap. For instance, minimisation of water, energy and resources in general was a broad objective of the majority of reporting companies (14 companies). Complementary to this was companies increasing their reuse of water in processes which was mentioned often enough to warrant its own category.

Ensuring that the water quality of surrounding water bodies was sustained was a broad goal articulated by most companies (14 companies) and this was done through a variety of means: water quality monitoring, biodiversity monitoring programs and quite closely related were initiatives that discussed improving water treatment and tailings storage facilities. Ok Tedi's sustainability report was dominated by the issue of rectifying the degradation of the Fly and Ok Tedi river systems and surrounding vegetation. Company monitoring showed that copper in the rivers still exceeded ecosystem guideline values. It admitted there was less fish but it was sufficient for community fishing as a source of food. There have been no health issues due to eating fish and food grown in the flood plains of the rivers [150].

The way companies reported community issues covered: how mining companies are creating water related infrastructure such as reservoirs, treatment plants, dams and irrigation canals for neighbouring communities [151, 152], providing clean water to the community [153, 154] and increasing sanitation [155] and involving the community in discussions i.e. stakeholder engagement [156, 157]. Community perception was an issue for a company; downstream

communities felt that water quality had been degraded but monitoring showed water quality exceeded standards so the company wanted authorities to provide independent monitoring [158]

Standards refer to a company's internal standards and regulations are referring to government regulations. Companies referred to the work they were doing in improving their internal environmental management systems and ensuring compliance to them [159, 160]. Some companies mentioned they were meeting regulations [155, 158] and one mentioned that where their internal standards exceeded government regulations of the country, leading practice was the goal [161].

Water reporting refers to companies that reported water related indicators such as water abstracted and water discharged according to the Global Reporting Initiative format. Newmont made the point that there is a lack of context in water reporting and no standardized industry metrics. The MCA water accounting framework is gaining acceptance in the industry and Rio Tinto used the format in their water reporting

Water security also referred to as water availability was seen as an issue that will occur more frequently in the future in light of climate change and competing users. Climate change itself as an issue was briefly mentioned by four companies and often discussed in conjunction with minimising greenhouse gas emissions.

Five companies mentioned acid mine drainage (AMD) or acid rock drainage (ARD) in their corporate reports discussing prevention, water quality monitoring and rehabilitation [150, 153, 156, 162, 163]. Rio Tinto has the ARD Hazard screening tool to identify high risk projects and stated their internal risk reviews were leading practice. Ok Tedi admitted that ARD was in the Middle Fly levees but not in main channel.

Four companies discussed artisanal scale mining representing four of the target countries: Newmont within Ghana, Xstrata referring to the Philippines, PT Timah in Indonesia and Barrick Gold in PNG. Artisanal scale miners (ASM) number in the tens of thousands in Ghana [151]. Whilst Ghana does allow Ghana nationals to carry out artisanal scale mining, the problem is that there are unlicensed miners and the method of using mercury to extract gold, is damaging to the environment and to their health. Solutions suggested in the corporate reports were to recognise that this was a social issue and to provide other livelihoods for the community [157] and the government should improve access to licenses and to remove illegal artisanal scale miners from large-scale mines [151]. A practical measure in Ahafo was that Newmont allowed artisanal scale mining to be carried out in an area of the large scale mine, after the miners received education programs run by the company [151].

5.3 Community perspectives

5.3.1 Environment including Water quality

There have been violent protests regarding Newmont's Conga project in Peru. Recently the protests have resulted in five deaths [164]. The mine location in the Andean highlands means any

impact on water quality affects all downstream users [165]. Whilst Newmont reported that the Conga mine project had been suspended because of protests [151] there is an indication that the government was involved in the cessation of operations. The government commissioned an independent audit of the environmental impact assessment and the recommendation was that improvements were needed with regards to water management before the project could proceed [166].

In Palawan in the Philippines, NGOs and indigenous communities protested against new mining investments because of their potential adverse effects on forest biodiversity, endangered species and watersheds that have been protected by law [167].

The potential impact on water quality is exacerbated in regions which suffer extreme rainfall events. The communities are concerned that companies are discharging tailings during the rainy season [168]. The regulations may have stipulated that it is allowable to discharge during times of high river flow so this issue may be about community perception and education.

The distrust of mining companies is usually due to past abuses. In 2010 both Obuasi and Iduapriem in Ghana had to be shut down due to breaches of environmental standards so in 2011, water treatment was put into place to ensure the water can meet effluent discharge standards and upgrades to the plants were done to increase water reuse [159]. It appears that this development occurred as a result of a report launched by WACAM, an NGO that found most rivers in the mining areas of Obuasi and Tarkwa were polluted with levels of hazardous chemicals above WHO and Ghana EPA levels [169].

Newmont's reputation in Ghana appears to be poor with conflicts occurring at both the Akyem and Ahafo mines. Farmers near the Akyem mine were concerned about the possibilities of damage to the Ajenua Bepo Forest Reserve, water pollution and the destruction of their cultural heritage [170]. Cyanide was found in the raw water dam at the Ahafo mine which killed fish but representatives from the company said that the cyanide was applied by fishermen. At the time, the EPA was still investigating [171].

Inco (now Vale) in Suluwesi, Indonesia had been operating since the 1970's and allegedly contaminated soils and water bodies in the area [172].

5.3.2 Social Impacts

It is very difficult to separate the effect of mine water on the environment without considering the social impact on the surrounding communities. Of immediate relevance to the community is that the livelihood of the people will be destroyed should the water quality degrade or water supply fall. A tribal chief was seeking compensation from Freeport in Indonesia because water pollution caused water shortages for the village communities [173]. Rice farmers in Benguet in the Philippines were concerned about water supply [174].

There are a variety of social impacts when mines claim land and also when they close. Seven hundred families had to be resettled by Vale due to the Moatize site in Mozambique. The claims

were that the families lacked access to water, electricity and agricultural land [175]. However from another source it appears that the anger resulted from the fact that now they had to pay for water where as previously, access to the river was free [176]. An issue raised was that when mining companies provide the community with safe drinking water and sanitation, there are impacts to the community once the mine closes and there is no handover of facilities. The community's standard of living went backwards following the privatization of Zambia Consolidated Copper Mines (ZCCM) [177].

Protestors may come from outside the affected community if they feel the local community is vulnerable. Campaigners against the Mongolian Oyu Tolgoi mine in the Gobi Desert were concerned about the quantity of water that the mine will require, the potential for environmental damage and the social impact on the local community and nomadic herders [178]. Church groups in Mindanao in the Philippines were protesting about the removal of tribal people from their ancestral homes [179].

5.3.3 *Standards and Regulations*

Concerns arise when there appears to be inadequate enforcement of regulations. A website claimed that the environmental impact assessment was lacking for Oyu Tolgoi [180].

Communities look towards the government to protect their interests so when there appears to be inadequate monitoring, the community can turn their anger towards the government. A PNG minister was criticised for not providing independent monitoring of water quality and solely relied on data provided by the Morobe Mining Joint Venture [181].

5.4 **Governance**

Whilst this report did not focus specifically on governance, material was found that covered this aspect. An independent report by a consulting company investigated Ghana's mine water management issues [182]. It found the following issues:

- there were multiple services running in parallel to provide sanitation and drinking water in the Prestea mining compound; the mining company, the water supply company and some NGOs
- the skill set was inadequate in the Prestea Urban Water and Sanitation Board.
- local government had not been involved in studies commissioned by The Minerals Development Fund which has been established to improve the infrastructure of local communities in mining areas, thus the local government had no ownership of the desired outcomes.

6 **Discussion**

In the synthesis of the issues, there has been no attempt to recreate the structure of the ICMM work. This report highlights different issues from the ICMM scoping study because it canvassed other literature sources and some issues are of greater importance in developing countries. The

purpose of this report is to identify the areas required for capacity building of government and mine operators in developing countries.

It is very difficult to separate the issues or themes as many fit into multiple categories. However, we have used the same themes that have been previously identified in the results sections from each perspective and grouped them under broader categories when the issues are linked. We present a summary of the issue, what are the factors controlling the issue, how or if it relates to the ICMM study and we present solutions. The list is not in order of priority ranking.

6.1 Environment

The broad issue 'Environment' includes all measures that are done to ensure the safety of the environment from mining activities; water quality monitoring, biodiversity monitoring, water treatment, waste management and acid mine drainage treatment. Acid mine drainage was given its own category for the scientific perspective and corporate reporting, but it was not identified by the community as a separate issue. Since it is a technical term, it is likely to have been aggregated with water pollution caused by the mines.

Community concerns were that the presence of the mine would adversely affect the environment. They were very concerned about tailings failures and incorrect effluent discharge. In one case there was a perception that the mine was polluting although the company did not believe so [158]. Considering that the majority of papers were studies dedicated to understanding the effect of mine water on the environment, there is unbiased information available. The results of the studies showed the effects on the environment. Corporate reporting is indicating that monitoring is being done. Clearly the gap then is that the information is not in a format that the community can understand. The community responses rarely cited studies and were about perceptions.

The solutions are to ensure that the results of the environmental monitoring are communicated to the community and to involve them in monitoring programs. There is a guide that provides information to a company on if and how a company should conduct participatory water monitoring [183]. It discusses how companies' water monitoring may have technical credibility but does not gain the trust of the community. The type of monitoring may not even address the community's concerns if it is only done to comply with regulations. Where the community is not trusting of companies, it would be best if both mining companies and governments were involved in this type of engagement. There is a role to play within academia too since the results of studies need to be conveyed to the community in the study region.

The technical aspect of the problem is whether the infrastructure to support mining activities is in place? The business monitor reports, where they existed, frequently mentioned that the infrastructure in the target countries was poor and that electricity stoppages were frequent. This might impact on a mine site's ability to treat and move water should blackouts occur, however it seems from the review that the environmental failures are not due to technology failing but design failures. For instance it was known that the Ok Tedi mine would operate without treatment of effluent due to instability of the ground, but the economic benefit to PNG was such that the mine

proceeded. The consequence of this is that one study predicted it will take forty years post-mining for the Fly River system to recover [63]. The solution is to ensure that leading practice is followed in developing countries.

The environment was not its own category in the ICMM study but was part of technical water management of the mine site. This viewpoint ignores the social aspect of this issue. With the broader perspective, the priority should be higher than what was assigned by Moran et al (4) and it has been given a high priority in this study.

6.2 Technical water management due to global changes

‘Technical water management’ covers the minimisation of water and energy, reuse of water, water security and global changes. These concepts are all linked. One of the reasons why companies are minimising their water use and increasing their reuse is because water availability will decrease in light of climate change and increasing demand by users.

The ICMM study had a category called ‘global changes’ and the recommendation was to create a catalogue of water-related risks, assess how well they are handled globally and to be able to relate the catalogue to site-specific case studies. The particular recommendation cuts across a broad set of issues and was given a high priority in the ICMM study but this category was not seen as a high priority for the IM4DC.

Climate change was mentioned by companies only when discussing what they have done to reduce GHG emissions but climate change was not found to be an issue by any of the sectors. Of course, there are papers on climate change in the literature but they are not connected to mine site water issues.

Water security, water availability, water access referring to access to surface water and groundwater (as opposed to the provision of drinking water) were solely mine site issues. The community wasn’t concerned about how they would gain access to water; their concern was that the mine site would pollute the available water (Section 6.1). There are no factors that are unique to developing countries in this section. Regulations will have the biggest influence on a mine site’s ability to access water. The field of integrated water resource management will also be relevant when addressing water access for all users. For water basins that span jurisdictions, there will be a need for harmonization of legislation. The issue of ‘water access’ can be given a medium priority since it is of high importance to the mines but not to the wider community.

6.3 Artisanal Scale Mining

The issue of Artisanal Scale Mining was brought up in the scientific literature and in corporate reporting but not by the community probably because the practitioners of this are members of the community. The results sections listed the damage that the miners caused to the environment and to their own health with the use of mercury. Indirect impacts resulted from the amount of people in one area: de-vegetation of the area to provide fuel for the miners and poor sanitation systems contaminating nearby watercourses. The scientific literature and the corporate reports suggested solutions. In terms of regulations, the suggestions were to close illegal mines, enforce

legislation and improve access to licences. It was important to realise that this was a social problem as well. Solutions for this aspect are to train miners, provide other livelihoods, and to coordinate the co-operation between small and large miners so that small miners can afford environmental protection measures.

This issue was not brought up in the ICMM study as it is unique to developing countries. It is felt that this is a medium level priority because the importance of the issue is high because of the potential for damage, but the capacity to solve this problem is in existence. Both the companies and the scientific literature were able to identify solutions and Newmont for example is carrying out training to allow ASM on their mining lease [151].

6.4 Standards and regulation

The issues identified in the ICMM scoping study under this heading were that companies wanted evidence-based policy setting and that mining companies fear a community backlash if mining is seen to drive a price increase in water. This is similar to the issue of resettled families in Mozambique having to pay for water that previously was free from the river [176]. However, the dominant concern for developing countries for 'standards and regulations' is enforcement of regulations. This was raised by both the community and the scientific literature. Companies focused on meeting regulations and improving their own internal standards.

Possible barriers to enforcement of regulations are understaffing [90] and a lack of knowledge in monitoring and implementation [105]. To improve outcomes, it was suggested that the donors such as the World Bank that assist in the project development phase, should also be involved in post-EIS activities [105]. Another solution is that there needs to be a greater buy-in from local government [93, 182].

Integrated Water Resource Management was not listed in the ICMM study. The issue is that where water basins are shared by countries, regulations across borders must be harmonised. Some of the barriers to IWRM were a lack of hydrological data and models and insufficient institutional capacity to enforce legislation [121].

The priority for this issue is high because the issue is important in that the community is reliant on the government to enforce regulations and the literature has identified that there is a need for capacity building of authorities.

6.5 Water reporting

Most companies reported their water figures using the format recommended by the Global Reporting Initiative. When this issue was discussed in the ICMM it referred to the fact that standardised metrics were needed by the industry for their social corporate reporting. Newmont also mentioned standardisation in their corporate social reporting but in general, the issue of standardised water reporting is a low priority with respect to developing countries. The need for capacity building of the industry in this area is not confined to developing countries; the MCA Water Accounting Framework provides standardization but is a fairly new initiative.

The issue with water reporting in developing countries is that even though companies may believe they are being transparent, the community is not getting the information it wants which is discussed below (Section 6.6).

6.6 Community relations

The community wants to understand the impact of mine water on the environment and to its members. They want to ensure their livelihoods will continue and their health is protected. However the companies' sustainability reports were dominated with initiatives to improve the community's standard of living. There was some mention of canvassing of community issues [156] but no company mentioned community involvement in environmental monitoring.

The solution has been given in Section 6.1 Environment. There is scope in improvement of community relations beyond improvement of living standards. The companies need to embark on extensive community discussions, have them involved in monitoring, and have transparency in reporting in avenues other than the corporate social reports in a format that they can understand. This issue represents an opportunity to companies who can do this well.

The community must be informed during the whole life of the mine including closure plans. There was a disregard for the community in the case study where the mine closed and there was no handover of water and sanitation facilities following privatization [177].

The priority for this issue in the ICMM study was 4 but for mining companies in developing countries to gain access to resources, community engagement will have to be done better than what is currently being done. Because of the fact that community relations span all of the issues identified, the importance of this issue is high and the need for capacity building is high.

7 Conclusion

The objectives of the report were to identify the mine water related issues for developing countries and to prioritise them in order of the need to build capacity within mining companies and governments. Six issues were identified, three with a high priority, two were of medium and one low priority issue.

The high priority issues are community relations, the protection of the environment and enforcement of regulations. All of these issues have the community in common. The review showed that although there is unbiased information available in the form of the scientific literature, it is not in a format that is accessible to the communities. There is scope for government and academia to pass on unbiased results in a way that can be understood by the community. Companies are monitoring their water quality and meeting regulations but communities are suspicious of how well the companies are protecting the environment. There is a need for companies to go beyond providing infrastructure and capacity building to the community, and involve them in the monitoring of water quality. Finally, regulations have to be enforced for communities to trust governments although barriers to this are that governments are understaffed

and require support. There is an opportunity to involve local government in implementation of programs so as they have ownership of outcomes.

Artisanal scale mining and water access for mining companies are medium priority issues.

Artisanal scale mining was identified as having severe impacts to the environment and to the miners themselves but the capacity to solve the problems exists. Both companies and governments have roles to play. The government must enforce regulations and close down illegal mines. Companies can provide training to miners to ensure that it is done safely.

Companies are concerned about continued water access in light of increasing scarcity. Their response is to maximize their efficiencies and limit their inputs. Governments will have to adopt integrated water resource management principles to ensure that water is sufficient for all users.

Standardised water reporting was a low priority issue in developing countries. The issue with water reporting in developing countries is that communities are not getting the information they need to understand the impacts of mine water-related issues.

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10 Appendix

Table 1: Mining companies that are contributing to countries' economic growth

Country	Mining company	Site(s)	Commodity	Expected production	Corporate Social Reporting ?
Peru	Newmont	Conga	Gold	751kozpa 2014	y
	Grupo Mexico	Cananea	Copper	688ktpa	y
	Xstrata	Las Bambas	Copper	400ktpa 2014	y
	Hochschild	Immaculada	Silver	11mozpa 2014	y
Ghana	AngloGold Ashanti	Obuasi, Iduapriem	Gold	571,295oz	y
	Gold Fields	Tarkwa, Damang	Gold	3.6mnoz	y
	Newmont	Akyem, Ahafo , Amoma	Gold	93.5mnoz	y
Mozambique	Vale	Moatize	Coal	12.7mtpa	y
	Pan African Resources	Manica Phoenix	Gold Platinum	30kozpa	y
	African Queen Mines	Fingoe King Solomon	Gold	20kozpa reserves of 450koz	n
Zambia	First Quantum	Kanshanshi Sentinel Trident	Copper/Cobalt Copper	250ktpa/3.5ktpa	y
	Vedanta Resources	Konkola	Copper Cobalt	200ktpa 1.5 ktpa	y

Country	Mining company	Site(s)	Commodity	Expected production	Corporate Social Reporting ?
PNG	Ok Tedi Mining Ltd	Ok Tedi	Copper/gold		y
	Barrick Gold	Porgera	gold		y
	Newcrest	Lihir	gold		y ¹
Mongolia	Ivanhoe/Rio Tinto	Oyu Tolgoi,	Copper, Gold	544ktpa, 330kozpa	y ²
	South Gobi Subsidiary of Ivanhoe	Ovoot Tolgoi	Coal	6.5mntpa by 2014	n
	Erdene Resource Development Ltd	Nomin	Copper	Reserves of 40mnt	n
Indonesia	PT Timah		Tin	50ktpa (tin)	y
	PT Antam	Tayan, Mandiodo, Cibaliung, Kijang	Bauxite, Gold, Silver, Nickel		y
	Bumi Resources	Dairi, Gorontalo, Palu	Coal, Zinc, Lead, Gold, Silver	80ktpa (zinc), 30ktpa (lead)	y
Philippines	CGA mining	Masbate	Gold	5.7tpa	y
	Philex	Bayugo Padcal,	Copper Gold, silver		y

¹ The report has not been included because the acquisition of Lihir happened after the report was written.

² Only Rio Tinto had sustainability reporting