IGF

INTERGOVERNMENTAL FORUM
on Mining, Minerals, Metals and
Sustainable Development

IGF CASE STUDIES

Automation and Water-Saving Technologies

Secretariat hosted by IISD

Secretariat funded by Canada

INTRODUCTION

The rapid advance of new technologies in the mining industry is completely reshaping the way mines operate across the globe. And, while technological progress is a constant feature of human evolution, current industrial innovations, including in the mining sector, are particularly disruptive. Changes are occurring at a speed and scale never before seen. Moreover, the capabilities created by technical innovations are being significantly enhanced by the synergy of many different technological advances working together, including GIS, artificial intelligence, cheap sensors, 5G wireless networks and the ability to process vast amounts of data (i.e., "big data").

As a result of those changes, we expect mining processes to be smarter, leaner, more efficient and more flexible in terms of employment—and arguably more sustainable. This will radically transform the nature of the mining industry and the way people live, work and relate to machines and to their workplace. More fundamentally, it will have far-reaching implications for the relationships between the industry (mining, suppliers) and host countries (governments, local communities, other non-state actors etc.).

Only a handful of business or government leaders are currently focused on anticipating and understanding the extent of opportunities and challenges that such systemic changes are expected to bring. More worryingly, even fewer are thinking about sustainable solutions to leverage opportunities and manage the likely negative impacts to prevent social discontent.

These case studies highlight the key emerging technologies that are being rolled out in the mining sector and their potential impacts on mining-rich countries. Case studies based on innovations in Australia, Mali and South Africa, focusing on two different types of technologies (namely automation and water-saving technologies) illustrate what the possible impacts could be and how governments are responding to those challenges.

KEY EMERGING TECHNOLOGICAL TRENDS

Before looking at the impacts of technological changes, it is important to first understand the different technologies that are likely to have a ground-breaking impact on the mining sector.

We classify disruptive technologies in four categories, illustrated in Figure 1. In essence, these are:

(i) **Enablers of digitalization,** which collect digital data about all aspects of operations—in huge volumes and in real time—and relay them to operating machinery and/or central controllers. Examples include smart sensors, connected wearables, satellites and drones.

(ii) **Integrators or trackers of big data,** aimed at enhancing the performance of mining processes to solve complex problems and allowing the mining environment to be more integrated. Examples include the Internet of Things (IoT) or blockchains.

(iii) **Technologies that optimize productivity and processes,** mainly through the use of big data and robotics. These include machine learning, data analytics, automation, remote operation and digital twins.

(iv) **Technologies that improve mining processes** to enhance sustainability and reduce environmental impacts. Examples include advanced process control, renewable power generation, clean technologies and water management technologies etc.

NO ONE-SIZE-FITS ALL: PACE OF TECHNOLOGICAL ADOPTION AND IMPACTS IS CONTEXT-SPECIFIC

The impacts of technological changes are challenging to predict, and any forecasts will necessarily be somewhat speculative. However, it is safe to say that the scenarios will differ depending on the context in which those technologies are being deployed:

(i) **Developed countries** may be less affected due to their more diversified economic base, higher skill sets, more advanced infrastructure (including connectivity), aging population and lower unemployment rates. In contrast, less-developed countries may face more challenges, given a higher dependency on mining including for jobs and community development; a larger skills gap to transition to more technologically enhanced jobs; or more significant infrastructure deficits.

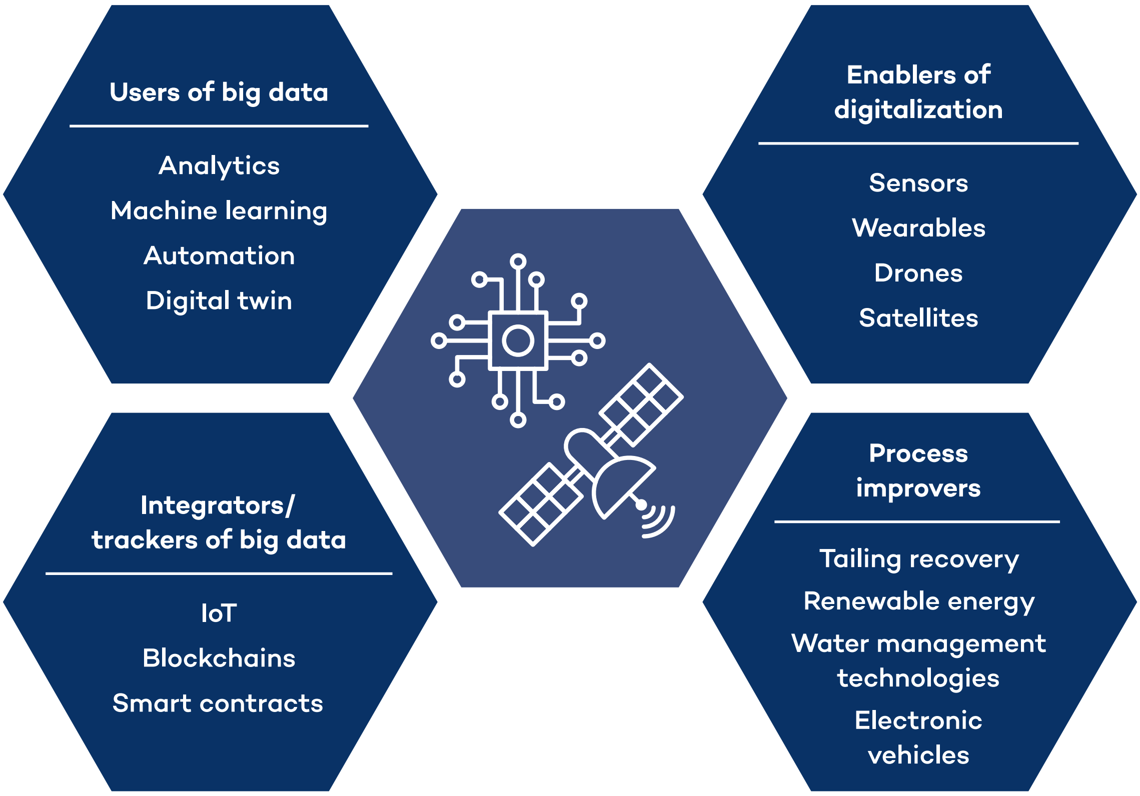

FIGURE 1. DISRUPTIVE TECHNOLOGIES: A VISUAL TAXONOMY

Source: Author diagram.

(ii) **Types (and depth) of mining operations:** underground and open-pit mines may not adopt the same technological innovations (or do so at the same pace) due to the way mines are designed and operated. A further consideration includes whether projects are greenfield or brownfield: it may be economically and politically easier to incorporate new technologies in new mining projects compared to retrofits. In Mali, Resolute Mining currently operates two mines in Syama: An open-pit mine (in operation since 1984) and a full purpose-built automated mine, a greenfield investment that became operational in December 2018. The greenfield investment was part of the licence renewal negotiations. Very few jobs were created at the mine face, but that did not seem to be a problem for the government.

(iii) **Geology, quality of ore grades and lifespan of the resources** will also determine the levels of investments in high-tech processes. These were determining factors in the drive toward automation in Pilbara, Australia.

(iv) **Large mining companies** with deeper pockets are more likely to invest in cutting-edge technologies than more junior mines, as they may have more access to finance.

In addition to the above, the impact of technological innovation will vary according to the type of technology being rolled out, the stakeholders involved and issues at stake. For instance, technologies like automation will improve the productivity and efficiency of mines, but these benefits for the industry will come at a cost to certain types of employees—those whose jobs are likely to be replaced by autonomous machines. From a macroeconomic perspective, it is estimated to have an overall positive effect, but from a community's perspective, the short-term effects on employment and local economic development may be more concerning. In contrast, other innovations such as water- or energy-saving technologies are likely to have positive spillovers on communities. They may also have positive effects on sustainable development, including on indirect job creation resulting from local economic development enabled by improved access to water or power, as illustrated in the case of South Africa in this paper.

CASE STUDIES

The case study on the impact of new technologies in the mining sector takes a closer look at automation and digitization in Australia and Mail. It highlights the impacts that similar technologies adopted in different country settings with different capabilities may have, and what the responses of the mining industry and public policies have been.

The second case study looks at sustainability processes in relation to water and the spillover effects on local communities. It looks at pioneering sustainability processes in water-stressed areas in South Africa.

CONCLUSIONS

The importance of technological innovation in the mining sector should be emphasized, and likely impacts on both businesses and host countries need to be well understood. While there is no doubt about that substantial benefits can be harnessed, distribution will not be an automatic process, nor will it be fair and equal to everyone.

To avoid discontent and conflict, policy-makers and the mining industry—in consultation with local communities—will have to work together to ensure that those stakeholders who stand to lose will find decent and sustainable alternatives. The following key considerations will need to be part of that conversation to manage the transition and turn challenges into opportunities.

(i) **Preparing for the future of work:** The workplace is changing. A number of job categories—essentially low-skilled, repetitive jobs—are being displaced by more sophisticated jobs demanding highly skilled employees. While the number of jobs will undoubtedly decrease, particularly at the mine site, new jobs will require different profiles and capabilities. One critical issue is to find a sufficient pool of labour to meet new opportunities, which are arguably better paid. Another key issue is to prepare the labour force with the required skill sets: this will require a review of the education system with greater focus on science, technology, engineering and mathematics (STEM) and the design of continuous skills-development programs.

(ii) **Finding decent economic alternatives:** The displacement of jobs from the mine will put pressure on the local labour market, and alternative solutions need to be found in other economic sectors. It is therefore necessary to provide incentives to develop non-mining activities and support entrepreneurship and the local private sector so they can create more sustainable formal jobs. Mining companies engaged in traditional corporate social responsibility will have to review their strategies and perhaps move toward corporate investment responsibility or impact investments as ways to support local economic development. This could be done in partnership with governments who would have to provide additional incentives and institutional support so those activities take place within the broader industrial/agricultural development strategy.

(iii) **Sharing the benefits of technologies:** Some of the technologies being adopted by the mining industry can actually be game changers for less-advanced economies. If shared or put to the benefit of local communities, technological infrastructure (such as IT, energy and/or water-saving technologies) can potentially provide gains that dwarf the negative impacts in the medium to long terms, unlocking economic opportunities that would not otherwise have been possible. Examples include access to improved connectivity, cheap(er) energy or more access to potable water, all critical elements of industrial development. Access to energy in particular can provide wider scope for non-mining industrial activities, which can in turn provide significant economic benefits.

CASE STUDY 1: AUTOMATION AND DIGITALIZATION IN AUSTRALIA AND MALI

SPOTLIGHT #1: AUSTRALIA

Type of economy: High-income country

Region: The Pilbara, West Australia

Type of mine: Open-pit

Nature of technological innovation: Autonomous haulage systems (AHS) in existing mines

Australia is the global leader in the adoption of mining automation technology. First trials started in 1994 at Alcoa's Willowdale bauxite mine, in Pinjarra. In the last decade, the region of Pilbara, known for its world-class iron ore reserves (roughly 20 per cent of global stock), has been at the forefront of technological breakthroughs in mining operations, taking the lead in implementing driverless trucks and recently conductor-less trains. Today, Pilbara hosts 75 per cent of the automated vehicle fleets in operation globally (Gleeson, 2019).

DRIVERS OF AUTOMATION AND DIGITALIZATION

The choice to embrace the technological revolution was facilitated by the following factors:

(i) The type of mining operations and topography: The surface mines at Pilbara make it easier for trucks to run smoothly and manage operations using GPS navigation.

(ii) The size, scale and longevity of mining operations: Pilbara mine sites are gigantic, the quality of the ore grade is high and the volume of total annual material movement exceeds the minimum required to make such technology efficient (Gleeson, 2019).

(iii) Their remote locations: operations are situated over a vast region of 502,000 square kilometres, function as fly in/fly out mines, and are 1,280 km from Perth. This entails significant staff transport costs as well as accommodation and associated site services (such as power, water and food). The great distance renders staff recruitment challenging and very costly. For example, annual salaries of truck operators exceed AUD 100,000 (USD 68,880).

(iv) Financial imperatives are also significant, in particular rising pressure to be more productive and more efficient.

IMPACTS FOR THE MINING INDUSTRY

The deployment of AHS in Pilbara generated significant productivity improvement for mining companies. For instance, in 2018, Rio Tinto reported that on average, each autonomous truck operated about 700 hours more than conventional haul trucks during 2017, resulting in roughly 15 per cent lower load and haul unit costs. Fortescue Metals Group recorded 32 per cent productivity gains due to autonomous trucking in the same year. This was in part also due to wage savings on field truck operators.

Other benefits included enhanced mine site safety, less maintenance, a significant increased tire life (40 per cent improvement compared to conventional tires, according to Komatsu), reduced fuel costs for an equivalent tonnage output and better overall truck performance (Gleeson, 2019).

IMPACT ON LABOUR FORCE AND LOCAL COMMUNITIES

The three iron ore mining companies operating in Pilbara together currently employ about 25,000 people (Gray, 2019). As new technologies are introduced, the number of people employed is likely to decrease over time. Truck drivers in particular, but also other workers performing repetitive tasks requiring lower skills will be the most at risk.

However, autonomous mines are not expected to run without a human presence. Despite the drastic reduction in the number of truck operators in the field, the management and oversight of the AHS system currently requires at least two staff in the control room per shift (plus a spare staff member to cross crews). The site still requires two field staff per shift (with an additional role to cross crews). New technologies need people to control and give direction to machines, while managing and overseeing operations. Those technicians are more skilled and therefore get a higher wage. Those tasks cannot be performed by truck drivers, unless the latter have the requisite level of education allowing them to be trained to perform the new tasks.

The macro impact for the region of Western Australia does not seem to be significant. However, a closer look at local communities indicates a notable impact, in particular for the Aboriginal population, which makes up the majority of routine, manual and semi-skilled jobs. Recent census data indicate that 55 per cent of the Aboriginal people are employed as machine operators and drivers, 24 per cent as technicians and trades workers and 6 per cent as labourers. Only 5 per cent are professionals (Holcombe & Kemp, 2018).

The disproportionate impact of automation on the Aboriginal population laid bare the systemic challenges facing these communities. It highlighted the yawning gap in Indigenous levels of education and their skills sets: even if technology will still provide job opportunities, they would appear to exclude Indigenous workers as a result of their low levels of formal education.

The impact also underscored the lack of other economic opportunities, meaning that the Aboriginal population took up mining jobs by necessity, not by choice. The lack of other meaningful economic opportunities has locked them in unsustainable "careers" and poor-quality jobs. Technological change was bound to happen, but Indigenous communities were left out of the transition dynamics that happened organically in other areas in Australia.

IMPLICATIONS FOR PUBLIC POLICY

Australia faces two main challenges. First, as mining becomes increasingly automated and as demographic trends point to an increasingly aging population, the national skills gap is growing, in particular for digital skills. To attract and retain talent, the mining industry has to compete with global leaders in the tech field.

Second, as highlighted above, those likely to be most affected are the Aboriginal communities in remote rural areas. The underlying challenges underscored by job losses imply that public policies would have to support more sustainable economic activities that could provide decent, sustainable and better jobs to those communities. At the same time, the educational system will have to be reinforced to skill them up.

A number of initiatives to address this skills gap are under way. Automation and digitization have created a need for different jobs such as data scientists and engineers in mechatronics, automation and artificial intelligence. The government, in partnership with mining companies, is investing significantly in reskilling and retraining programs for its mining workers. Rio Tinto for example, has invested AUD 2m into a vocational education and training initiative to ensure that the next generation of workers will be equipped to work in the mining sector. In Pilbara, the technical and further education (TAFE) institutions are stepping up efforts to address the country's growing digital skills gap through new training programs focused on areas such as mechatronics, robotics and data analytics. This collaboration led to the first nationally recognized course in automation, launched in June 2019 (Hastie, 2019).

Australia is not investing only in capabilities for the mining sector. The focus is on high-quality and transferable skills relevant for other industries such as the maritime sector, health care, logistics, policing, airlines and defense.

SPOTLIGHT #2: MALI: FULL AUTOMATION AND DIGITALIZATION

Type of economy: Least-developed country

Region: Syama

Type of mine: New underground mine

Type of technology: Fully automated purpose-built mine

The Syama mine is located 300 km southeast of Bamako, the capital of Mali. It is estimated to have total reserves of 3 million ounces of gold. Originally developed by BHP as an open cast gold mine in the 1980s, it was acquired by the Australian company Resolute Mining in 2004. Since then, Resolute Mining has undertaken feasibility studies to design a new underground mine to supplement existing open-pit operations (NS Energy, n.d.). The company decided to go forward with investments in a new underground mine, which became operational in December 2018.

The Syama mine is not considered exceptionally high grade: its ore reserves are estimated to grade at 2.7 grams per ton (NS Energy, n.d.). However, it is very large (200 m thick and over a kilometre long) and has an ore body that lends itself to sub-level cave mining. For this reason, the new underground mine was designed as a fully automated mine.

WHAT TECHNOLOGIES ARE BEING ROLLED OUT?

Sub-level cave mining involves a lot of repetitive activities, and there was therefore a significant potential at Syama to increase productivity and efficiency using more advanced technologies. The mine was designed as a fully end-to-end automated and digitalized mine. To that end, Resolute Mining partnered with the Swedish equipment and tool manufacturer Sandvik Mining. The result was the implementation of a fully automated production system using technologies that Sandvik had tested elsewhere in the world, such as the AutoMine® and OptiMine® systems (Cloete, 2019).

The OptiMine® system provides a full suite of digital solutions, such as advanced analytics, 3D visualization and modelling, location tracking of equipment and mobile fleets, and drill plan visualization. These are aimed at enabling office users to better interpret, predict and manage data for more precise understanding of the mine environment, with a view to improving the efficiency of mining operations and optimizing the production system.

Through AutoMine®, Sandvik delivered a full fleet of mechanized trucks, electrical loaders and autonomous drills to fully automate the mine.

The mine was also equipped with solid digital infrastructure: fibre optic cable was installed to ensure connectivity, essential for data exchange between equipment and control room.

SUBSTANTIAL PRODUCTIVITY GAINS FOR THE MINING COMPANY

Automation has certain obvious benefits. According to Resolute Mining, automation will significantly increase the productivity of mining operations while improving safety. Given the nature of the ore body, in order to be profitable it was necessary to reduce the cost profile of the mine. Automation resulted in an immediate 15 per cent cost reduction, bringing the cost of production down from USD 881 per ounce to USD 746 per ounce, despite substantial upfront investments in autonomous equipment that ranged from USD 10 million to USD 15 million. Over time, Resolute expects mining costs to be reduced by 30 per cent ("Sizing up Syama," 2018).

Equipment efficiency will improve, notably through time saved during shifts or after blasting, when operations have to be suspended to allow for ventilation. As a result, some machines work for 22 hours a day, compared to 15 hours before ("Sizing up Syama," 2018).

It is important to highlight the considerable increases in safety that come with fewer people being exposed to unsafe areas and difficult locations. This significantly lowers the risk to workers. For example, since implementing autonomous technologies in several of its African mines, Randgold Resources has seen a 29 per cent decline in the quarter-on-quarter injury rate ("Kibali Africa's most mechanised," 2017).

In addition to productivity gains, those technologies help improve the sustainability of the mine through the use of cleaner technologies, such as electric vehicles, which limits the release of harmful diesel particulates, as well as reducing greenhouse gas emissions.

LESSER DEMAND FOR LOWER-SKILLED LABOUR BUT MORE DEMAND FOR A TRAINED WORKFORCE

Full automation of underground operators implies that very few employees are needed to operate machines in the field. This is a particularly critical issue for low-income and vulnerable countries, such as Mali, with an unemployment rate of 7.1 per cent and where the mining sector (gold) dominates the economy, accounting for 64 per cent of exports revenues and 21 per cent of government revenue in 2018 (Export.gov, 2019).

Beyond the fact that the government holds a 20 per cent stake in the operations, the Syama mine is an important contributor to the broader economy of Mali. It is currently the largest employer in the region and provides a total of 1,500 jobs at the open-pit and newly constructed underground mine.

The underground mine, in operation since December 2018, provides significantly fewer employment opportunities than a typical underground mine using traditional technologies would have. For instance, the AutoMine® system provided driverless machines, meaning that certain jobs like drillers and truck drivers were simply not created. In fact, very few but a more skilled workforce, is required in the underground operations.

However, a fully automated mine is not people-free. New types of roles have been created in Mali, in particular working with the OptiMine® tools, monitoring machines, and servicing and maintaining the new machines. These positions required new types of skills that were not necessarily immediately available, in particular among the local community. During their permit negotiations with the government to develop the fully automated mine, Resolute committed to training local staff to perform the new roles. Any expatriate staff that were needed to do the jobs pending the training of locals will be requested to transfer skills and know-how to local staff.

The critical shortage of skilled workers pointed to a broader challenge faced by the country, which is the mismatch between human capacity and the demand for new skills sets. This is not specific to Mali, but nonetheless a key issue to address, in order to avoid social tensions between the mining industry and local population, over limited direct opportunities in mining operations.

WHAT ARE THE IMPLICATIONS FOR PUBLIC POLICY?

The Malian government holds a 20 per cent of stake in the Syama mine and is aware of the opportunities and challenges of such technologies. It showed its full support to the company, including by providing generous fiscal incentives so the company can invest in the project. A new Mining Convention was signed in April 2019 between the Republic of Mali and Resolute Mining, providing—among other inducements—a 10-year renewal of the mining permit, new tax incentives, a stabilization clause and duty concessions on inputs for the mine. In addition to development of the mine, the company has committed to providing senior-level job opportunities to the local population, and to source goods and services locally to the extent possible (Resolute, 2019).

While the technology has evolved, the Malian government's approach to the mining operation, as evidenced in the new Mining Convention signed with the company, reflects what some might call the "old deal," wherein the government provides significant upfront benefits to companies. But some of the benefits—such as jobs—that were part of that "old deal" are not likely to unfold in future.

To avoid future tensions, the "deal" must evolve: Unless the scope of the partnership between the industry and the Malian government is enlarged to include other economic actors, patchwork solutions will not work and, what's worse, may aggravate discontent in local communities in the future. The government needs to seize the opportunity to develop strong national policies aimed at addressing the broader challenge of yawning skills gaps in all economic sectors and stimulate cross-industrial partnerships to create new economic opportunities that provide decent, better paid and safer jobs.

Resolute Mining has set the tone in Mali: other mines will follow suit. Mali is a good testing ground for mining companies, as there are more greenfield projects, where it is easier to roll out technologies than in existing mines. Technological innovation is necessary for the viability of the mining industry, which lags behind other sectors. However, for benefits to be shared fairly and equitably, any opportunities that the mine can provide should be accessible to the local population, provided the government is able to make this happen. In many developing countries, this is not always the case.

CASE STUDY 2: WATER-SAVING TECHNOLOGIES IN SOUTH AFRICA

Type of economy: Developing country

Type of mine: All types

Type of technology: Water-saving technologies

BACKGROUND

Water is probably the most important strategic resource on earth, not least because of its sheer volume on the planet but most importantly because of its critical importance for all aspects of human activities. For many countries, it is even an element of national and regional security. While demand for water has never been as high, the World Economic Forum, estimates a global water shortfall of 40 per cent by 2030 (Water Resources Group, 2012), with the shortage of clean fresh water being the greatest global societal and economic risk over the next decade.

The mining industry is a water-intensive activity. Water is used predominantly for mineral processing, dust suppression and slurry transport. In most mining operations, water is obtained from groundwater, rivers and lakes, or, when those are not available, through commercial water service suppliers. Mining can be a source of water pollution too: in a number of countries it is responsible for water contamination resulting from effluent and waste disposal in rivers and lakes: this has caused significant and often irreversible damage to vegetation and fish stocks.

SOUTH AFRICA: A COUNTRY FACING CRITICAL WATER SHORTAGES

The mining industry is a key pillar of South Africa's economy. It contributes about 7 per cent of GDP, directly employs over 400,000 people and indirectly supports over 4.5 million people, notably through indirect and induced employment and business linkages to the mining industry. South Africa is home to various world-class mineral deposits, such as the platinum group of metals (of which it is the largest producer), gold (counts among top 10 world producers) and coal, where it has the 5th largest reserves in the world.

Compared to other economic sectors, the mining industry is not a large consumer of water. Its average consumption is estimated at 3 per cent

(Askham & Van der Poll, 2017) of total water consumption in South Africa, although some mining activities consume considerably more water today than a century ago ("Technology set to unleash," 2017).[1]

The impact of mining on the quality of water is significant: there are 6,000 abandoned mines in South Africa, and they have contributed to uncontrolled acid mine drainage and contaminated surface and ground water resources. Additionally, if not treated, wastewater produced during ore processing and refining may threaten other water resources.

A number of mining activities occur in water-stressed areas, posing sustainability and conflict-related challenges. For instance, Anglo American was prevented from mining in platinum-rich streams in the Limpopo region due to insecure water supplies. Another example would be local communities and authorities, who understandably are increasingly resisting the extraction and use of water from natural sources for mining activities due to fears that pumping would further reduce the level of water available for other uses.

Due to the increasing pressure on water resources and to secure access, a number of mining companies have invested heavily in research and development to improve their water management and efficiency processes. This is not only a business issue, it is inherently a sustainability one as well, given the water crisis in the country. New technologies, alternatives to water use, and ways to recycle and reduce the volume of water used across the value chain have been found.

SOME TECHNOLOGICAL SOLUTIONS BEING DEVELOPED

Innovations such as sensors, connected devices and data analytics have significantly improved the quality and quantity of technical data available regarding water flows, pressure and quality. More precise information and the development of new techniques are making it possible to better forecast and improve the management of water usage.

In this regard, three types of technologies particularly relevant to improving water management, are being deployed in South Africa. Those are:

1. Closed-loop water recycling, a sealed system to deliver greater water efficiencies through direct water recycling and reuse. It aims to minimize water losses by treating and using the same water again and again.
2. Improved techniques for more accurate evaporation control. To secure water supply, mining operations store water in dams. However, it is estimated that between 10 to 25 per cent of total water is lost through evaporation. More accurate measurements help to better understand the water balance. Data thus obtained feed into other technologies aimed at water conservation and process control.
3. Dry tailings disposals: Tailing storage facilities are the largest consumers of water for most mines (Meintjes, 2019). Mining companies are therefore using new technologies to minimize the amount of water sent to tailing ponds.

One company in particular (Anglo American) has developed a pathway to minimize or eliminate when possible, the use of fresh water from its mining processes, especially through the implementation of closed-loop recycling (60 per cent of its current water use comes from this type of recycling) and through the separation and transportation of ore and waste (tailings).

[1] It is interesting to note that—despite constant technological evolution in various mining processes—as it currently stands, the mining industry consumes much larger volumes compared to a century ago. For instance, in 1900, to obtain 40 kg of copper, an average company extracted 2 tons of material and used about 3 m^3 of water and 10 kWh of energy. Today, to obtain the same amount of copper, a company needs to mine 16 times more material, uses 16 times more energy and double the volume of water. A lot of this is due to declining ore grades, but also because old technologies are still being used. Given the rising demand in copper and the increasing need to manage scarcer resources, this has become unsustainable.

As part of its Sustainable Mining Plan, developed to reflect the UN sustainable development goals, the company has committed to reducing the use of fresh water in water-scarce regions by 20 per cent and increasing its water-recycling levels to 75 per cent[2] by 2020 (Leonida, 2019).

In addition, the use of maturing robotics technology along the mining value chain also makes it possible to unearth less materials from the ground. One such technology is "swarm robotics," in which small robots make extraction processes more precise. This in turn limits energy and water demand. Similarly, other technologies, such as coarse-particle flotation, captures coarse particles that are not generally recoverable using conventional flotation methods. The larger particles significantly reduce the amount of fresh water needed and makes recycling easier. Furthermore, it is easier to extract water from coarser particles, meaning tailings can more easily be dry-stacked, ultimately eliminating the need for tailings dams.

IMPACTS FOR THE INDUSTRY

Water scarcity—combined with the risk of being deprived of ground sources and commercial access to water—is a growing concern for the mining industry, which warns that assets can be stranded and investments held up if the issue is not deal with. South Africa is facing one of the most severe drought periods it has known in decades. In 2015, it recorded its lowest rainfall levels since measurements started in 1904 (Askham & Van der Poll, 2017). It is estimated that by 2030, the country will face a shortfall of 17 per cent in water supply, exacerbating the already tense situation, not only on rights of access to water, but equally between economic groups.

Tensions over access to water almost led to riots in 2016 in Limpopo province between agriculture and the mining sector. Previously, there had been an informal agreement between farmers and coal plants to share water for the Waterberg Coalfield. However, extreme droughts put an end to this fragile co-existence, when a mine under construction disclosed that it would be using 1 million gallons a day from the Nzelele river, already under stress due to higher temperatures and lower rainfalls (Schneider, 2016).

Although a much wider approach is warranted, the use of some types of technologies—such as coarse-particle flotation—can be revolutionary in terms of costs for the mining sector, not only as a result of the reduction in water use (estimated at 30 to 40 per cent), but also because it can improve material recovery in the process (Anglo American, 2018).

Some mining companies are expecting to run waterless mines, meaning that they will eliminate the use of fresh water and use only recycled water through their mining operations.

WHAT DOES THAT MEAN FOR THE COMMUNITY?

The city of eMalahleni, in Mpumalanga province, South Africa, is located in a water-stressed area, where a number of mining companies also compete for access to ground and surface water for their operations. The region had also faced water contamination due to acid mine draining, exacerbating water access challenges for the population.

In 2007, the city of eMalahleni entered into an arrangement with neighbouring mines to tackle the two water-related challenges. Developed as a partnership with Anglo American, BHP spin-off South32, the central government and the municipality, a water reclamation project was implemented in 2007. The project involved the construction of pipelines to carry water from participating mines to a water storage facility, as well as a water treatment plant and two reservoirs, all providing potable water for the population.

The plant supplies around 12 per cent of the city's water daily needs. This significantly decreased the percentage of people without access to drinking water from 14 to 2 per cent. The partnership was also beneficial for the

[2] The aim is to reduce its abstraction of fresh water in water-scarce regions by 50 per cent by 2030.

nearby mines, which became self-sufficient in water (World Coal Association, 2013).

Another positive impact of the project was the use of mining wastes as an input for the construction of housing. The waste produces about 200 tons of clay-gypsum a day, which is in turn transformed into bricks to build affordable houses for the local population. More than 60 houses were built for residents.

New advances in new technologies can take such initiatives to a higher level: smart technologies coupled with big data can help better manage water and provide access not only to communities, but also to other economic sectors, like agriculture and industries.

Sharing the benefits of such types of technologies can be a formidable offset strategy for mining companies, and thus compensate for other challenges such as job losses. In fact, new forms of community engagement—such as impact investments using new technologies—could potentially minimize tensions arising from the threats of job losses.

REFERENCES

AngloAmerican. (2018). *Picture this: The waterless mine*. Retrieved from https://www.angloamerican.com/futuresmart/our-industry/technology/picture-this-the-waterless-mine

Askham, T.M., & Van der Poll, H.M. (2017). Water sustainability of selected mining companies in South Africa. *Sustainability*. Retrieved from https://www.mdpi.com/2071-1050/9/6/957

Cloete K., (2019). *Sandvik, Resolute gear up for the fully automated Syama Gold Mine*. Published in Creamer Media's Mining Weekly, 7 February 2019. Retrieved from https://www.miningweekly.com/article/sandvik-resolute-gear-up-for-the-fully-automated-syama-gold-mine-2019-02-07/rep_id:3650

Export.gov. (2019). *Mali - Mining & minerals*. Retrieved from https://www.export.gov/article?id=Mali-Mining

Gleeson, D. (2019). Why the Pilbara leads the way in haul truck automation. *International Mining*. Retrieved from https://im-mining.com/2019/08/06/pilbara-leads-way-haul-truck-automation/

Gray, D. (2019). No one behind the wheel: The new workforce driving Australia's mines. *Sydney Morning Herald*. Retrieved from https://www.smh.com.au/business/companies/no-one-behind-the-wheel-the-new-workforce-driving-australia-s-mines-20190411-p51dd2.html

Hastie, H. (2019). Machine learning: Australia's first automation course launched at WA TAFE. *Sydney Morning Herald*. Retrieved from https://www.smh.com.au/business/workplace/machine-learning-australia-s-first-automation-course-launched-at-wa-tafe-20190612-p51ww4.html

Holcombe, S. & Kemp, D. (2018). *Indigenous employment futures in an automated mining industry. An issue paper and a case for research*. The University of Queensland Australia, sustainable Mining Institute and Centre for Social Responsibility and Mining.

Kibali Africa's most mechanised gold mine – Randgold. (2017). *Mining Weekly*. Retrieved from https://m.miningweekly.com/article/kibali-africas-most-mechanised-mine-randgold-2017-11-02

Leonida, C. (2019). Mining without water. *The Intelligent Miner*. Retrieved from https://theintelligentminer.com/2019/05/09/mining-without-water/

Meintjes, A. (2019). Tailings dam technology: Learning from failure (Part 1). *Mining Mirror*. Retrieved from https://www.na.srk.com/en/publication/za-tailings-dam-technology-learning-failure-part-1

NS Energy. (n.d.). Syama Gold Mine. Retrieved from https://www.nsenergybusiness.com/projects/syama-gold-mine/

Resolute. (2019). *Mali government awards new Syama mining convention and extends mining permit*. Retrieved from https://www.zetaresources.limited/files/9115/5554/3767/2019.04.18_RSG_New_Mining_Convention_and_extended_Mining_Permit_for_Syama.pdf

Schneider, K. (2016). *As drought grips South Africa, a conflict over water and coal*. Yale Environment360. Retrieved from https://e360.yale.edu/features/south_africa_drought_coal_renewables

Sizing up Syama: The world's first fully automated mine. (2018). *Mining Technology*. Retrieved from https://www.mining-technology.com/features/sizing-syama-worlds-first-fully-automated-mine/

Technology set to unleash mining innovation – Anglo's O'Neill. (2017). *Engineering News*. Retrieved from https://www.engineeringnews.co.za/article/technology-set-to-unleash-wave-of-mining-innovation-anglo-americans-oneill-2017-08-16

Water Resources Group. (2012). *The Water Resources Group: Background, impact and the way forward*. Retrieved from http://www3.weforum.org/docs/WEF/WRG_Background_Impact_and_Way_Forward.pdf

World Coal Association. (2013). *Anglo American eMalahleni Water Reclamation Plant – Winner of WCA Award for Excellence in Environmental Practice 2013*. Retrieved from https://www.worldcoal.org/file_validate.php?file=emalahleni_water_reclamation_plant_online(13_05_2014).pdf

Published by the International Institute for Sustainable Development

Written by Isabelle Ramdoo

IISD

The International Institute for Sustainable Development (IISD) is an independent think tank championing sustainable solutions to 21st-century problems. Our mission is to promote human development and environmental sustainability. We do this through research, analysis and knowledge products that support sound policy-making. Our big-picture view allows us to address the root causes of some of the greatest challenges facing our planet today: ecological destruction, social exclusion, unfair laws and economic rules, a changing climate. IISD's staff of over 120 people, plus over 50 associates and 100 consultants, come from across the globe and from many disciplines. Our work affects lives in nearly 100 countries. Part scientist, part strategist—IISD delivers the knowledge to act.

IISD is registered as a charitable organization in Canada and has 501(c)(3) status in the United States. IISD receives core operating support from the Province of Manitoba and project funding from numerous governments inside and outside Canada, United Nations agencies, foundations, the private sector and individuals.

IGF

The Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) supports more than 70 nations committed to leveraging mining for sustainable development to ensure negative impacts are limited and financial benefits are shared. It is devoted to optimizing the benefits of mining to achieve poverty reduction, inclusive growth, social development and environmental stewardship.

The IGF is focused on improving resource governance and decision making by governments working in the sector. It provides a number of services to members including: in-country assessments; capacity-building and individualized technical assistance; guidance documents and conferences which explore best practices and provide an opportunity to engage with industry and civil society.

The International Institute for Sustainable Development has served as Secretariat for the IGF since October 2015. Core funding is provided by the Government of Canada.

IGF INTERGOVERNMENTAL FORUM on Mining, Minerals, Metals and Sustainable Development

Secretariat hosted by IISD

Secretariat funded by Canada