Unlocking Data Innovation

for Social License in Natural Resources

Discussion Paper | January 2020

IN PARTNERSHIP WITH

BHP Foundation

IFC International Finance Corporation
WORLD BANK GROUP

Creating Markets, Creating Opportunities

About IFC

IFC—a sister organization of the World Bank and member of the World Bank Group—is the largest global development institution focused on the private sector in emerging markets. We work with more than 2,000 businesses worldwide, using our capital, expertise, and influence to create markets and opportunities where they are needed most. In the 2019 fiscal year,, we delivered more than $19 billion in long-term financing for developing countries, leveraging the power of the private sector to help end extreme poverty and boost shared prosperity.

For more information, visit www.ifc.org.

2121 Pennsylvania Avenue, N.W.
Washington, D.C. 20433

Internet: www.ifc.org

Unlocking Data Innovation
for Social License in Natural Resources

Creating Markets, Creating Opportunities

Contents

ACKNOWLEDGMENTS

This discussion paper was prepared by Alla Morrison, Sustainable Infrastructure Advisory, IFC, and Prasanna Lal Das, Markets & Technology team, World Bank, with research support from Derek Fromson. It was prepared under the guidance of Veronica Nyhan Jones, Manager, Sustainable Infrastructure Advisory, IFC.

This publication would not have been possible without the generous, candid, and thoughtful sharing of experience of numerous contributors, including industry representatives, academic researchers, and peer reviewers. They include Holly Bridgewater (Unearthed Solutions), Louise Edmunton (Anglo American), Hannah Frankish (Unearthed Solutions), Tamiko Hasegawa (Antamina), Antoine Heuty (Ulula), Kieren Moffat (CSIRO/Voconiq), Ray Offenheiser (University of Notre Dame), Anders Pedersen (World Resources Institute), Renae Rutherford (Rio Tinto), Aaron Steeghs (Yamana Gold), and Julia Torreblanca (Cerro Verde).

Within IFC, the authors thank Sacha Backes, Michelle Jacome, and Namrata Thapar for supporting the effort and providing valuable feedback. They also thank Barbara Karni and Ada Calderon for editing the report and Rikki Campbell Ogden for designing it. The team gratefully acknowledges the generous support of the BHP Foundation.

FIGURES AND TABLES

About the From Disclosure to Development Program

This discussion paper is a product of the From Disclosure to Development (D2D) program, led by the Sustainable Infrastructure Advisory team of the International Finance Corporation (IFC). The program, launched in 2017, is funded by the BHP Foundation and implemented in collaboration with the World Bank. It builds on more than a decade of IFC and World Bank experience in natural resources transparency and open data. For the past 13 years, IFC transparency projects in Latin America have aimed to help local governments and communities become more transparent and effective in the use of mining revenues. The World Bank provided investment and advice to more than 50 countries on the design and implementation of national and subnational open data and data innovation programs.

The program's goal is to enhance benefit sharing with communities from investment in natural resources through effective disclosure and data-use practices. D2D develops and tests new approaches, partnerships, and platforms aimed at improving the ways in which companies and governments disclose data, so that communities and other stakeholders can use it to inform their decisions and actions.

Open data is a critical ingredient of transparency in the 21st century. Without transparency, there cannot be accountability or effective sector governance. Without transparency—both actual and perceived—it is easy for companies to lose the trust of communities, which can lead to a loss of their social license to operate and put investment projects at risk.

To bridge the information asymmetry in the sector and give voice to communities, D2D works to improve the disclosure and use of open data with capacity building, multi-stakeholder dialogues, and data-driven innovation activities with youth, infomediaries, and digital entrepreneurs. In its first phase (2017–19), the program piloted the following activities in Colombia, Ghana, Mongolia, and Peru:

- research on natural resources data challenges and opportunities;
- engagement of stakeholders around innovative uses of open data;
- capacity building on data literacy; and
- multi-stakeholder dialogues for improving access to and the use of natural resource data.

The D2D program uses lessons learned from these in-country activities to contribute to global efforts to improve transparency in the natural resources sector through more effective disclosure and use of data. It works with partners such as the Transparency and Accountability Initiative (TAI), the Extractive Industries Transparency Initiative (EITI), Global Integrity, and others.

In the coming years, D2D plans to expand to other countries and infrastructure sectors and to add a gender data component. For more information about the D2D program, please contact Alla Morrison, Program Manager, at amorrison@ifc.org.

Foreword

BERTRAND HEYSCH DE LA BORDE
Director, Energy & Mining,
Global Infrastructure Department, IFC

Technology is set to become a game changer for mining and other natural resource industries—and data innovation will be at the heart of this change.

The mine of the future will be data-centric: massive volumes of raw data will be collected from equipment, wearable sensors, drones, and other sources and transformed in real-time into useful information for optimal decision making. The Fourth Industrial Revolution—with its big data, artificial intelligence, and Internet of Things (IoT) technologies—will fuel increasing automation of labor, expand the use of predictive equipment maintenance, and increase precision in exploration activities. Digital transformation will bring new opportunities but also a new set of challenges, and ensuring sustainability of mining operations will be as important as ever.

The impact of automation on job creation will put a further strain on current approaches to community and government relations. Traditional approaches will need to change. Mining companies will have to work to create a stronger sense of shared value with local governments and communities. They will need to embrace more collaborative modes of engagement that get local communities more invested in mine operations. This discussion paper explores how companies can leverage disruptive technologies to improve their community engagement practices through better collection and disclosure of information. It draws the attention of industry managers and CSR specialists to the need to rethink how they can collect, manage, and disclose data to communities and other stakeholders in new, more effective ways.

It is part of a series of knowledge products by IFC's From Disclosure to Development program, along with two other publications: Transparency for Impact: Lessons from IFC Projects in Peru's Natural Resources Sector and Data in Action: Natural Resources Disclosure for People and Progress. The other two papers distill learnings from IFC's extensive work in the natural resource sector transparency over the last decade. This paper is a forward-looking effort to help the industry prepare to leverage new technologies to better disclose data and engage communities to build trust.

This paper helps advance companies' understanding of the potential of digital data as a new type of a business asset. It provides examples of industry players that have started using data to strengthen their social license. It offers practical tools for managers to start assessing their company's data capabilities. We hope the paper will help spark discussion and lead to deeper and more critical thinking about the role of data for social license in the natural resource and other sectors.

This new research is aligned with IFC's mission to leverage private sector–driven development to create markets and opportunities. Investment in natural resources is fundamental for economic growth, infrastructure, and social progress in developing countries that are rich in resources. Together with agriculture, the metals and minerals sectors provide the raw materials needed to sustain life—if it can't be grown, it must be mined. When developed responsibly and sustainably, in partnership with governments and local communities, metals and minerals can fundamentally improve people's lives—as it has in Botswana, Brazil, Chile, and South Africa, for example. IFC is committed to bringing innovative approaches to companies, communities, and governments to help ensure that benefits from investments in natural resources reach all stakeholders and create long-term value for everyone.

Executive Summary

The social license to operate (SLO) refers to the ongoing acceptance of a company or industry's standard business practices and operating procedures by stakeholders, local communities, and the general public. It is critical for the natural resources sector. Informed acceptance and support from local communities is a way to de-risk large investments and establish the groundwork for sustainability, mutual social and economic benefit, and growth. Transparency and community engagement can also create the foundations for developing proactive systems for companies to recognize and address community concerns and create tangible programs to improve planning with host communities, governments, and civil society. The goal is to establish social value that is measurable and verifiable and emphasizes the issues that matter to different groups of stakeholders.

SLO is particularly important at a time when the natural resources sector is undergoing a major digital transformation. Data is at the heart of this transformation. New data sources such as drones, sensors, unmanned vehicles, and satellite images are increasingly prevalent in "smart mines," in which the use of robots, image analytics, machine learning, artificial intelligence, and sophisticated augmented and virtual reality tools are becoming the norm. Companies use these data-driven tools across the value chain, from exploration and ore extraction to human resources and logistics.

Some estimates suggest that digitalization could bring $425 billion of value to the mining industry, customers, society, and environment by 2025 (WEF 2016). Among mining executives recently surveyed, 46 percent identified digitalization as the biggest contributor to innovation in their organizations (Accenture 2017). This digital transformation is uneven in its pace and geographical spread, but its impact is inevitable. Companies that reinvent themselves digitally will gain the most through this transformation.

The data-led transformation of the natural resources sector creates new challenges for companies and their stakeholders. Digitalization will automate operations, which means fewer physical labor jobs in the future—a traditional value proposition of the sector to communities. New, safer jobs will be created, but they will require digital skills. Lack of data literacy and general digital infrastructure constraints, especially in a sector that employs many relatively unskilled workers living in marginalized communities beset with poor infrastructure and connectivity, are other areas of concern. The challenge is compounded by the fact that the use of data as a social and economic asset is a relatively new phenomenon, and the implications and consequences of many data-driven trends are not yet fully understood.

This report describes how companies can use new data tools, approaches, and techniques to generate and sustain social license in communities. It presents the concept of a data value chain and provides case study examples of how companies have started using data to engage with communities, develop trust, create new social and economic opportunities, establish new forms of partnerships, and give voice to a wide variety of stakeholders in a smarter way. It offers tools that companies can incorporate into their operations and processes that contribute to the development of social capital. It also examines the policy issues most relevant to the topic of social capital.

The report makes several strategic recommendations:

- Become data aware. Understand how data is transforming every aspect of the natural resources sector, including community engagement, trust, and other key elements in the natural resources value chain.
- Invest in data skills and literacy within the company and in the community. Very few community engagement teams include or use data scientists, company management does not understand SLO in the absence of useful metrics, and communities typically do not possess the skills required to interact with data or data-based services.
- Understand the company's data and its value cycle. Companies in the natural resources sector still do not view data as either a mission-critical or strategic asset; they do not manage or govern their data assets properly.
- Use data from across the entire operation and business cycle. Many companies perceive community relations data as independent of and different from core business processes and functions. Data generated during typical company operations—such as environmental information or flow measurements—can be an important component in deepening community engagement and ensuring sustainability.
- Develop a data strategy (and accompanying culture). Very few natural resources companies—and even fewer sustainability and community relations teams within them—have developed a data-first culture and strategy, leaving them poorly placed to take advantage of opportunities created by new data and/or transform related business processes.
- Develop new data-driven products and services. Most teams are still content to use data for classical reporting and monitoring purposes. New visualization, engagement, and analytical tools provide new opportunities to work with communities and stakeholders in new ways.
- Be purposeful about data. Companies sometimes view data as an end and let quantity crowd out quality. Respondents increasingly report survey fatigue. Companies need to think carefully about the incentives for communities to provide data and the importance of showing them why data is being collected.
- Develop new data partnerships and collaborations. Very few companies have the data, skills, or infrastructure/tools to use and manage data effectively across the lifecycle. Companies must learn to develop new data partnerships and collaborations to access and use new data and skills.

Tactical steps companies should take include the following:

- Improve disclosure practices. Focus on data that users value, not just compliance or reporting requirements.
- Collect data more systematically and comprehensively. Learn about new data collection tools and techniques that companies in the natural resources sector already use.
- Develop a modern data infrastructure. Invest in both soft (skills and policies) and hard (connectivity, data centers) infrastructure, to be able to use data effectively.
- Standardize data practices and disclosure formats. Make data interoperable with data from other sources, and adopt sectorwide standards.
- Use data for community engagement. Develop trust through transparency and the creative use of data tools to make messages relevant and usable for communities.
- Co-create data with communities. Engage communities in the design and deployment of data collection tools and processes; position data as a joint asset whenever possible.
- Work with data intermediaries. Identify and use intermediaries that can bring skills, tools, and services to the organization instead of trying to reinvent everything.
- Make data an essential part of real-time decision making as well as measurement and management reporting. Improve management reporting with data that provides actionable and anticipatory insights.
- Understand data regulations in the jurisdiction. Understand the regulatory implications of the use of data and associated tools.

Companies must not treat data as a magic bullet that can resolve all challenges associated with trust building and engagement. The Cerro Verde case study in the report demonstrates the importance of complementing data initiatives with traditional techniques such as face-to-face meetings and regular interaction. Open data can help improve transparency and deepen trust among stakeholders, but it alone cannot fix a broken relationship. The use of new types of data to achieve social license is still very new, and evidence on its effectiveness is still developing. Stakeholder demands and expectations are diverse across geographies; the collection and use of data has socio-political dimensions that companies must be sensitive to.

A company's work on social capital encompasses a wide range of external stakeholders and environments. A company's data-led transformation relies on the digital maturity of its customers, suppliers, business partners, and associated communities; success depends as much on the transformation of the entire sector and stakeholders as it does on innovations within a company. The role of the entire community is crucial in thinking about data and social capital. The toolkit presented in the report examines opportunities and challenges both within and outside the company's boundaries.

This is an exciting, and risky, time for companies in the natural resources sector. This report is among the first to offer a set of practical tools addressing data for practitioners within companies in this sector. IFC invites companies to help grow this knowledge base by contributing new case studies and toolkits on the topic.

The Explosion in Data

Every second, about 2.7 million emails are exchanged, about 75,000 YouTube videos are viewed, and about 60,000 gigabytes of Internet traffic is carried (World Bank 2018). By 2020 global Internet traffic will reach about 127 times the volume of 2005, according to Cisco (2017).

The impact of the digitalization of the natural resources sector is significant. The World Economic Forum (WEF 2016) estimates that digitalization could bring $425 billion of value to the mining industry, customers, society, and the environment by 2025. Data will be at the heart of this digital transformation.

"New" data is characterized by the four Vs: volume; variety (sensors, drones, social media, and other sources); velocity (the rapid generation of data, often in near real-time); and value (the emergence of data as a new asset class). The importance of data is reflected in the fact that in 2017, 7 of the world's 10 largest companies by market valuation were data-driven companies (World Bank 2018).

The rise of new data has also had significant social impact. The wider availability of data and improved analytics have helped improve public decision-making tools, increased transparency and accountability in the public sphere, promoted greater inclusion, improved accessibility to services, increased trust, and reduced discrimination (table 1).

TABLE 1 Characteristics, implications, and examples of value of new data

New data characteristics	Implication	Example
Community generated, local, and social	As more communities become connected, and social tools proliferate, communities have begun to generate large amounts of data of potential value to industry. Many Internet of Things data sources require close collaboration with—and frequently use of—community infrastructure (Lal Das and others 2017), making local engagement essential.	Companies such as TripAdvisor rely heavily on user- or community-generated content to amplify their value proposition. A recent World Bank report (Lal Das and others 2017) describes how companies experimenting with smart transport or smart energy are partnering with municipalities to test technologies in "living" conditions, where they can test the operation of new technologies with communities in public settings.

continued on next page

continued from previous page

New data characteristics	Implication	Example	
Real-time and comprehensive	Most big data sources collect information continuously and in close to real-time. The coverage of many big data sources is nearly comprehensive; there is less reliance on samples (which can be exclusionary, depending on the local distribution of power).	New technologies allow farmers to take snapshots of highly local soil conditions in near real-time and use the data to take action to increase or maintain soil fertility (AgFax 2018). Publicly available data sources such as the Africa Regional Data Cube (a repository of earth observation data and satellite imagery) can help track illegal mining and monitor deforestation (Goldberg 2019).	 
Value through reuse and aggregation	No organization can gather or acquire all the data it needs. Aggregation of data, collaborative development, and reuse of assets are integral parts of the new data-driven business model.	Data pools allow companies access to aggregated data from across sectors. For instance, Predix from General Electric pools data from the devices it is remotely connected to and combines them with other data to improve the operations of power plants or jet engines (Economist 2017).	
Cheaper, faster, easier	Cloud computing and software-as-a-service have made it easier, cheaper, and faster to access and deploy data and related services and applications.	Services such as data storage and document collaboration have increasingly become cloud based within companies of all size (Andrews, Nicoletti, and Timiliotis 2018). Thanks to advancements in cloud technology, the cost of storing 1 megabyte of data dropped from $1 million in 1967 to $0.02 in 2017 (ComputerWorld 2017).	

The Data Value Chain

There is more to data than individual units of information. The data value chain describes the stages of value creation through data. It includes four steps (figure 1):

1. **Collection**
2. **Storage/Aggregation**
3. **Analytics/Application**
4. **Exchange/Dissemination**

The value chain relies on **strong data infrastructure—hard and soft**—to deliver value (including trust). Companies should balance the management of their existing data infrastructure with the requirements of new data technologies (IDC 2017). The value-chain steps may also apply differently to large mines and companies, which typically own very large assets, and smaller companies and mines, which may develop business models that serve niches in the industry for their data-driven operations based on their level of digital capability and adoption.

Collection

Traditionally, companies have thought of data as information about an asset. Modern companies, including some in the natural resources sector, now realize that data themselves are a strategic asset.

The development of data as a strategic asset begins with the identification, generation, and collection of data. At this stage, companies must decide which data to capture, how to source or collect it, what consent or other requirements may need to be met to gather the data, how inclusive their data collection practices are, and what devices or technologies may be most suitable within a particular environment. Companies must be purposeful about their data collection; they must clearly understand and explain why the data is collected and close feedback loops.

In the natural resources sector, data collection has increasingly shifted toward cyber-physical systems (devices such as sensors that are connected to a network). There has been a rapid proliferation of drones, sensors, robots, satellites, wearables, and 3D imaging tools. BHP, for example, uses sensors to maximize the amount of iron ore it can transport from pit to port in Western Australia (IoTHub 2018). In a recent survey, 100 percent of respondents identified sensors and condition-monitoring devices as key technologies of the future (Roberts 2018). Digital twins (digital replicas of physical assets that are connected by the real-time flow of data so that the virtual entity updates and changes simultaneously with its physical counterpart) of individual pieces of machinery or entire facilities have also become prominent in the sector.

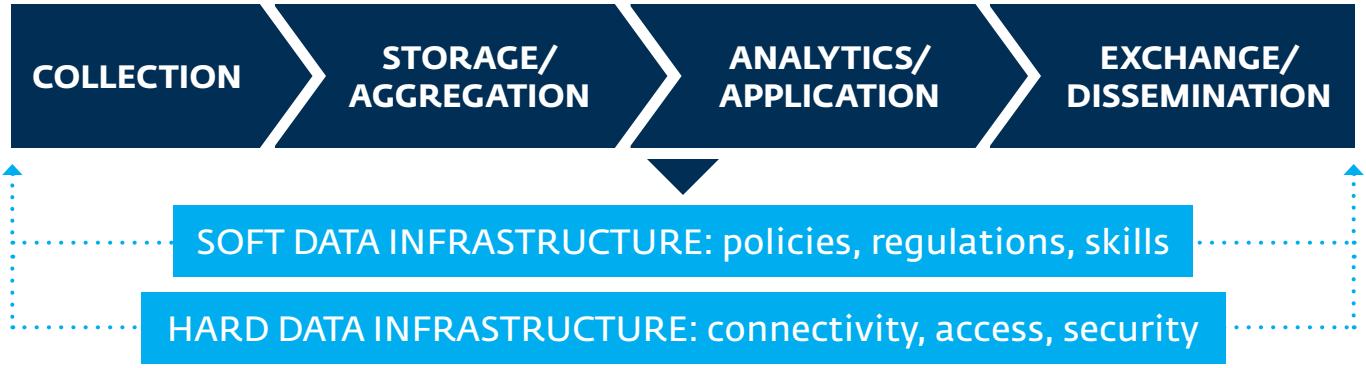

FIGURE 1 The four steps in the data value chain

The question of the ownership of the data collected has become increasingly important. It is not uncommon for service companies that generate data, rather than the operator of the asset, to keep the data.

Storage/Aggregation

Until recently, large amounts of data collected by oil and gas companies were thrown away because of the prohibitive costs of storage. Cloud computing has made it easier and cheaper to store vast amounts of data, changing the equation and making natural resources data truly "big." A typical modern oil and gas seismic data centers contains 20 petabytes of information—about 926 times as much information as the US Library of Congress contains (Beckwith 2011).

Companies must realize that their data collection activities, however large they may be, are insufficient to deliver value at scale. They must be able to access and use data from partners, stakeholders, and public and private sources, as much of the value at this stage stems from aggregating data from these sources for analysis later (for historical trend analysis, for example). Mining companies have begun to "strategically attempt to augment in-house data assets with digital information procured from outside sources, thereby giving them the kinds of massive data sets in which the value of Big Data is often lurking" (Perrons and Jensen 2015). BP, for example, aggregates data on global energy trends (BP n.d.).

Analytics/Application

In the analytics/application stage, companies generate value through the smart use of data to create new insights, automate processes, forecast performance (business and infrastructure), and manage operations. The analytics may be delivered to intelligent operation centers, sent directly to autonomous machines and equipment, or distributed to internal and external stakeholders through apps or online services. Tools and techniques such as artificial intelligence, machine learning, data visualization, and dashboards are gradually becoming more prominent in the natural resources sector. Goldcorp, for example, has teamed up with IBM Watson to better target areas for further exploration using artificial intelligence. The aim is to tap vast amounts of geological data to create more accurate models (Topf 2017).

Exchange/Dissemination

Companies and entire sectors gain in an environment in which there is broad access to data from multiple sources. Protocols ranging from open data (machine-readable data that are free to reuse) to commercial exchange (data that can be bought and sold under different commercial arrangements) are becoming common across the natural resources sector. Although some types of data, such as data on production or grades, can be rivalrous and therefore commercially sensitive, experience from other sectors demonstrates that the benefits of sharing data that were once guarded as commercially sensitive can outweigh the risks.

One example is a data consortium initiated by the Association of German Banks and Standard & Poors that enabled banks to share default data on their project finance activities (interview with Alexei Novikov, Managing Director, Standard & Poor's, 2005–12). Project finance was being impeded by prohibitively high provisioning rates by the regulator, required largely because of the dearth of information on project finance risks and defaults. As a result of the data sharing, project finance became more transparent in Germany, more banks entered this market segment, and the regulator reduced the provisioning rate, further catalyzing project finance activities.

Another example is a data consortium of banks in Saudi Arabia that wanted to diversify their exposure to various sectors but were missing some of the information they needed to do so (interview with Alexei Novikov, Managing Director, Standard & Poor's, 2005–12). The consortium enabled banks to understand the statistical probability of defaults by giving them access to real-time data feed. As a result, banks were able to enter new sectors and provide credit to new customers.

The Extractive Industries Transparency Initiative (EITI) data platform provides access to reusable data from the natural resources sector. Glencore, a commodity trading and mining company, created a smartphone app to keep the community informed about sulphur dioxide management and air quality in Mount Isa (Mount Isa Mines n.d.). The app provides access to real-time data from monitoring stations and a 24-hour forecast of westerly wind conditions (Osei and Young 2018).

Soft Data Infrastructure

Soft data infrastructure creates the enabling environment to develop trust and deliver value to all stakeholders. Key elements of this infrastructure include the following:

- Policies and regulations at the sector and national/international level that make it safe and easy to collect and use data while respecting and safeguarding the rights of consumers, businesses, and governments. Examples include policies and regulations on privacy, data protection, data ethics, data flow across borders, and intellectual property.
- Data management guidelines at the company level that ensure that a company's data practices are both compliant (adhere to local regulations on data privacy, consent, and more) and smart (designed to unlock the value of data by sharing and using data better).
- Data standards, ideally at the industry or sector level, that make it easier to interpret data consistently, promote interoperability, and reuse data.
- Data skills and literacy, both within the company and among stakeholders, to ensure that value can be extracted from data without compromising stakeholders' interests.

- An ecosystem of data innovation and entrepreneurship, which is essential to transform business processes and imagine, develop, and deliver new services and products based on data.

Hard Data Infrastructure

Hard data infrastructure provides the connectivity and data management tools to both capture/store data and deliver services to end users. Key elements of this infrastructure include the following:

- Data collection tools, ranging from traditional enterprise resource planning systems to emerging devices such as sensors, drones, and wearables.
- Data networks that connect mining equipment, the work force, and business process management software. Networks can be difficult to operate in mining environments, which are not conductive to transmission of signals and frequently suffer from clogged frequencies.
- Databases, including cloud-based services, designed to continuously store data and provide interfaces between people and machines.

The Role of Data in the Natural Resources Sector

Market volatility, increasing resource scarcity and remoteness, changing consumer expectations (especially greater demands for corporate accountability related to traceability, ethical sourcing, and circular economy), market competition, increased regulation, and stakeholder and media attention are the new normal for the natural resources industry. At the same time, the sector is in the midst of a digital transformation.

Data-driven technologies—particularly artificial intelligence and machine learning, automation and robotics, mobile-based apps, the industrial Internet of Things, and modern data architecture (including the cloud)—can offer solutions to many of these challenges. A study by the World Economic Forum (WEF 2016) quantifies the potential value of digital transformation in the sector as follows:

- an increase in value for the industry, customers, society, and the environment of $425 billion between 2015 and 2025—the equivalent of 3–4 percent of industry revenue
- a reduction of 610 million tons of CO2 emissions, with an estimated value to society and environment of $30 billion
- improved safety, with about 1,000 lives saved (a 10 percent reduction in fatalities) and 44,000 injuries avoided (a 20 percent decrease in injuries).

Table 2 describes the role of new types of data at different stages of the natural resources value chain.

Data from across the mining value chain can provide new opportunities for strengthening social license and de-risking operations and investments if companies are willing to become more open and collaborative as part of their digital transformation.

It makes financial and operational sense for companies to invest in better data and to open the right data to stakeholders, because doing so helps strengthen social license, thereby adding to long-term shareholder value.

Wearables, for instance, can provide miners (and local communities) with important health and environmental safety information and boost faith in working conditions. Companies can also use data to make supply chains more inclusive and reduce concerns about sourcing and labor. DeBeers, for instance, is experimenting with blockchain-based technologies to make diamonds more traceable. Similar efforts are underway in the cobalt supply chain (IBM 2019).

TABLE 2 Uses of new types of data at different stages of the natural resources value chain

Stage	Potential uses of data	Examples
 Locate, recover, increase throughput	▸ Artificial intelligence to improve exploration ▸ Increased throughput using analytics	• Machine learning techniques combined with new sources of data, such as sensors or satellite images, make exploration more efficient. • Use of artificial intelligence on historical exploration datasets can detect traces of metals and minerals.
 Value	▸ Simulation of price trends ▸ More accurate modeling of expenditures	• Much more data can be processed in near real-time to model/predict finances.
 Construct/ maintain	▸ Predictive maintenance of equipment ▸ Smarter 4D based design (which adds the dimension of transformation over time to standard 3D printing)	• Constant flow of data from equipment keeps equipment managers located on different continents in constant contact with machinery, which they can troubleshoot. • High-resolution data from equipment makes it easier for engineers to schedule and oversee complex operations. • Companies use predictive analytics to manage inventory for replacement of equipment.
 Mine	▸ Intelligent operation centers ▸ Augmented Reality (AR) and Virtual Reality (VR) tools ▸ Digital twins ▸ Autonomous vehicles ▸ Location tracking	• Autonomous haul trucks reduce cost and time. • AR/VR tools improve training. • Wearables provide constant data about mine conditions. • Digital twins make it easier to manage operations (such as ore mixing).
 Process	▸ Process automation and control ▸ Predictive modeling ▸ Waste management ▸ Ore sorting	• Use of sensors for ore sorting reduces mine waste. • Digital mining assets are easier to share among companies and allow otherwise idle equipment to be used. • Mining operations are becoming networks of specialized data-driven service providers with deep capabilities in particular aspects of the business. • As sensing equipment becomes more prevalent in mines, original equipment manufacturers are increasingly required to become service oriented and handle data on behalf of mining operations.
 Sell and maintain customer relations	▸ Identification of market trends ▸ Management of demand ▸ Identification of customer preferences	• New data, including satellite imagery, provides insight into market trends (allowing the volume of oil in storage to be tracked, for example).

Social License in the Natural Resources Sector

The concept of social license emerged in the mining industry in the mid-1990s, as a response to social risk. Its definition has evolved over the years. Different definitions stress different dimensions, ranging from simple descriptions of risk (the ability of communities to stop projects and/or raise costs) to compliance (permits and government approvals) and general business management principles (corporate responsibilities balanced with the socio-political rights of stakeholders). Many definitions are transaction or supply oriented and focus primarily on what a company needs to accomplish to remain profitable. More recent definitions see communities as equal stakeholders and position social license as a way to establish mutually beneficial partnerships.

This report defines social license as "informed agreement and partnership with the local community that allows a natural resources project to exist and grow." This definition draws on recent literature on the role of trust, information sharing, and transparency in community engagement. It emphasizes the importance of informed consent, partnership, and mutual growth (Figure 2).

Major companies in the natural resources sector have been at the forefront of social license–related initiatives. They have invested billions of dollars building local schools, hospitals, and infrastructure and supporting communities through local procurement and employment. According to one estimate (Franks 2015), the 15 largest mining companies spent a combined $1.7 billion on community investment in 2012 alone. Investments have continued to grow since then.

The results of such investments have frequently been sobering, however. Communities in many parts of the world remain vehemently opposed to mining activities and continue to demonstrate their opposition through refusals to negotiate, lockouts, protests, and violence.

FIGURE 2 Overlapping elements of social license

Context matters; there are no universal reasons for the failure of social capital–related engagements. But lack of trust, credibility, and legitimacy have all been observed as factors. Trust has emerged as perhaps the most central issue in discussions of social license to operate (SLO), defined as the ongoing acceptance of a company or industry's standard business practices and operating procedures by its stakeholders, local communities, and the general public. Communities want reassurance that companies will not exploit their vulnerability and develop cooperative relationships that do not place the profit of the companies ahead of other considerations.

Stakeholders often view such investment initiatives as compliance activities with limited community outreach. A study by Watkins and others (2017) shows that a lack of project transparency is associated with 68 percent of documented conflicts. Research by IFC (CAO 2018) suggests that poor

information sharing is often the basis for community dissatisfaction. Figure 3 shows the prevalence of disclosure-related challenges in the mining, oil, gas, and chemicals sectors.

The 2017 annual review of the European Bank for Reconstruction and Development (EBRD) Project Complaint Mechanism lists "information disclosure and community engagement" as the second-largest category of complaints about its projects; the report also identifies the natural resources sector as one of the main sources of complaints (EBRD n.d.). The 2017 EBRD strategy paper on mining cites the "clear lack of transparency over extractive revenues management" as a significant challenge in the sector. The Asian Development Bank (ADB 2019) Accountability Mechanism Annual Report lists several complaints regarding information disclosure, including in the natural resources sector. A paper that examines two mining projects in Finland cites the "importance of transparency in mining operations and the continuity of communications with local stakeholders in building and maintaining the SL to mine" (Heikkinen and others 2016).

Companies increasingly recognize the diversity of stakeholders and their expectations—and the fact that companies are a part of, not independent of, a larger community ecosystem. Focusing only on company–community relationship risks focusing the SLO discussion too narrowly on economic or material aspects while overlooking other important factors that influence SLOs, such as citizens' rights to participation and decision making.

To deliver on the full breadth of SLO programs, natural resources companies cannot work in isolation. Strengthened relationships with local governments and regulatory bodies are essential, as is a deep and nuanced understanding of the power dynamics of all stakeholders, without which the benefits of SLO activities are likely to accrue disproportionately to a small group of stakeholders.

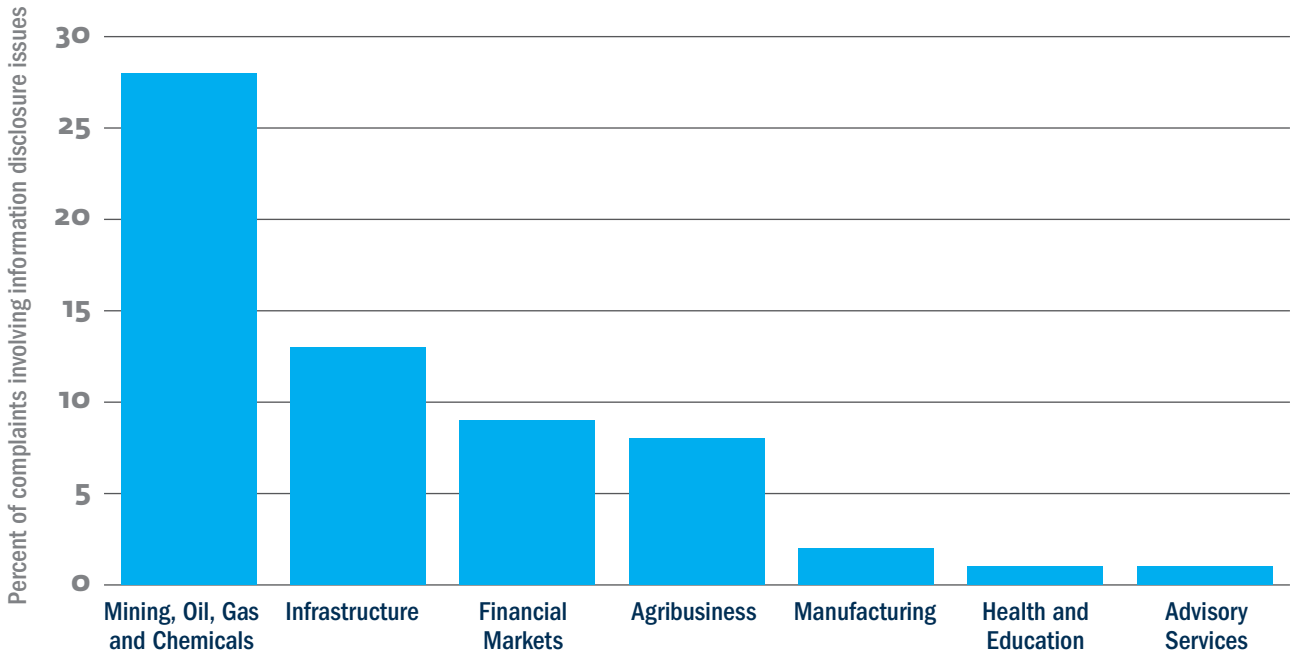

FIGURE 3 Complaints involving information disclosure issues, by sector, FY 2001–18

Source: IFC.

The State of Data for Social License in the Natural Resources Sector

The natural resources sector has a record of extensive investment in social license, but the results have often been underwhelming. Some industry figures have cast doubt on the basic premise of social license, calling it intangible, impermanent, unworkable, and immeasurable. Some people outside the industry have questioned the narrow economic and material focus of social license–related activities in many organizations, which ignore the participatory role of communities in decision making (Muneva 2016).

The critical role of information in fostering social license has long been recognized. Most natural resources companies already use a variety of offline, and increasingly, online techniques, especially mobile technologies (Heuty and Pappagallo 2014), to connect with stakeholders and share information. Establishment of the Extractives Industry Transparency Initiative (EITI), the Natural Resources Governance Institute (NRGI), and the Publish What You Pay (PWYP) global coalition, among other organizations, reveals "substantial international advocacy efforts toward greater transparency for the extractives sector" (Pedersen 2019).

Over the past 15 years, new legal disclosure requirements, national-level multistakeholder partnerships, and voluntary disclosure schemes have yielded new flows of documents—and in some cases, open data. Platforms such as OpenOil (https://openoil.net/about-us/) look beyond companies as they envision an "open data framework for managing natural resources at a supranational level." They offer data tools such as Aleph, which claims to provide access to 2 million searchable "public domain documents filed by oil, gas and mining companies to financial regulators around the world." Resource Watch (https://resourcewatch.org/data/explore), a sustainability data platform operated by the World Resources Institute, publishes several datasets on mineral deposits and mining concessions. By leveraging data sources outside the extractives ecosystem, it allows users to combine datasets on mining assets with satellite imagery data and relevant geocoded datasets—on, for example, water stress and social conflict—breaking data silos and unlocking new insights.

For the social license practitioner in a company, data offers new opportunities for engagement within the company and beyond. Data offers new avenues to develop skills within communities and make community members effective participants not just in their own communities but in the larger global data economy. As data collection and analytical tools become more sophisticated, companies are able to develop and deliver data-driven services that meet the different hierarchies of demand by stakeholders (emphasizing livelihood security and well-being to local stakeholders, for instance, while focusing on issues such as income flow, tax and royalty payments, and environmental stewardship during interactions with government stakeholders).

Social License within the Company

Social license as a concept has gained widespread acceptance within companies, as measured by references to it in corporate documents and websites (Oxfam America 2009). The term, however, remains amorphous within company management, with many in the industry contesting its measurability (and therefore value) (Moffat and others 2016).

To address this ambiguity, there has recently been a trend to "datafy" SLO-related activities and create measurable benchmarks and baselines. The SLO Index, developed by the Commonwealth Scientific and Industrial Research Organisation (an independent Australian federal government agency responsible for scientific research) is one attempt to quantify a company's SLO activities and compare them across the sector and locations (CSIRO 2019). The Yamana and Rio Tinto case studies, discussed below, describe examples of the use of the index.

The primary value of such initiatives has been to strengthen internal reporting and analysis and gain management buy-in. Much of this data is still not shared with communities directly affected by a company's operations.

Social License in the Community and Beyond

In the long term, the greatest impact of data on stakeholders and communities will be outside a company's boundaries (table 3).

TABLE 3 Potential areas of impact of social license

Area of impact	Information and Data Tool	Examples
Transparency and accountability	Open data	https://eiti.org/homepage is the website of Extractive Industries Transparency Initiative (EITI)), which seeks to "promote the open and accountable management of oil, gas, and mineral resources." http://openjadedata.org/datasets.html provides the latest data on Myanmar's jade industry released by EITI. https://data.cdp.net/ provides open data on emissions, climate actions, and climate risks. https://www.shell.com/sustainability/transparency/payments-to-governments.html lists payments that Shell makes to governments through taxes and royalties. https://www.resourcecontracts.org/ provides "plain language summaries of publicly available investment contracts for oil, gas, and mining projects."
Trust	Data stories	https://www.patagonia.com/footprint.html is designed to foster trust in a company's supply chain by providing details about the sustainability activities of its suppliers. https://threadinternational.com/our-process/ uses data to tell the story of steps companies have taken to ensure that their products are responsibly manufactured and managed.
Inclusion and participation	Social platforms	SaharaReporters.com provides a platform for citizen journalists to report corruption and government malfeasance in Africa. http://goxi.org/ offers a "space to share, learn and connect for action towards greater accountability and, in turn, better development outcomes of extractive industries." https://ipisresearch.be/home/conflict-mapping/maps/conflict-mapping-drc/asm-incident-tracker/ is an incident tracker that "allows Congolese civil society to report and track incidents in the mining sector in eastern DRC." https://secure.ethicspoint.com/domain/en/default_reporter.asp provides a platform for citizens to report unethical or illegal activities by an organization.
Accessibility to services	Web or mobile applications	https://fixmystreet.org/sites/ is a platform for citizens to report local problems and track the response of the agencies concerned.
Decision making and responsiveness	Data dashboards and visualization	A study on Uganda shows that a treatment group that received a report card on staff and health center performance had better service delivery and outcomes than a control group (Björkman Nyqvist, de Walque, and Svensson 2017). Easier availability of budgetary information led to reduced absenteeism of teachers in India (Jelenic 2019).
Equality and non-discrimination	Data analytics (including AI/ML)	https://www.urban.org/sites/default/files/publication/99844/toward_an_open_data_bias_assessment_tool_3.pdf describes the open data bias assessment tool (Narayanan and MacDonald 2019), a prototype for measuring the level of bias in open geographical data. https://govex.jhu.edu/wiki/towards-eliminating-bias-in-open-311-requests/ (Peker and McKinney 2018), describes an initiative that uses new data, such as "diverse, nonstandard English text to reflect diverse cities and diverse speech," to ensure that all citizen requests are treated fairly.

Use of SLO-Relevant Data in the Natural Resources Sector

Mining companies use only a tiny fraction of the data they collect—less than 1 percent, according to a report by McKinsey (2015). Research by IFC suggests that data initiatives in the sector fall well short of expectations (Data in Action: Natural Resources Disclosure for People and Progress, 2020). A recent analysis of the state of open data (which can have a significant impact on SLO) in Colombia, Ghana, Mongolia, and Peru reveals three major challenges (Data in Action: Natural Resources Disclosure for People and Progress, 2020):

- Data collection and reporting (especially of nonfinancial data) are often not mandatory, allowing industry and government actors to disclose data at their discretion.
- Lack of regulation on the type of data and the frequency of collection and reporting leaves gaps in data comprehensiveness and utility.
- No enforcement mechanisms exist to ensure that entities are implementing open data initiatives, even where they are required by law to do so.

As a result, data often suffer from coverage gaps (covering only portions of the natural resources value chain); quality issues (including lack of timeliness, consistency, and frequency); and a trust deficit (lack of relevance). Figure 4 describes the state of SLO-relevant natural resources data at each stage of the data value chain.

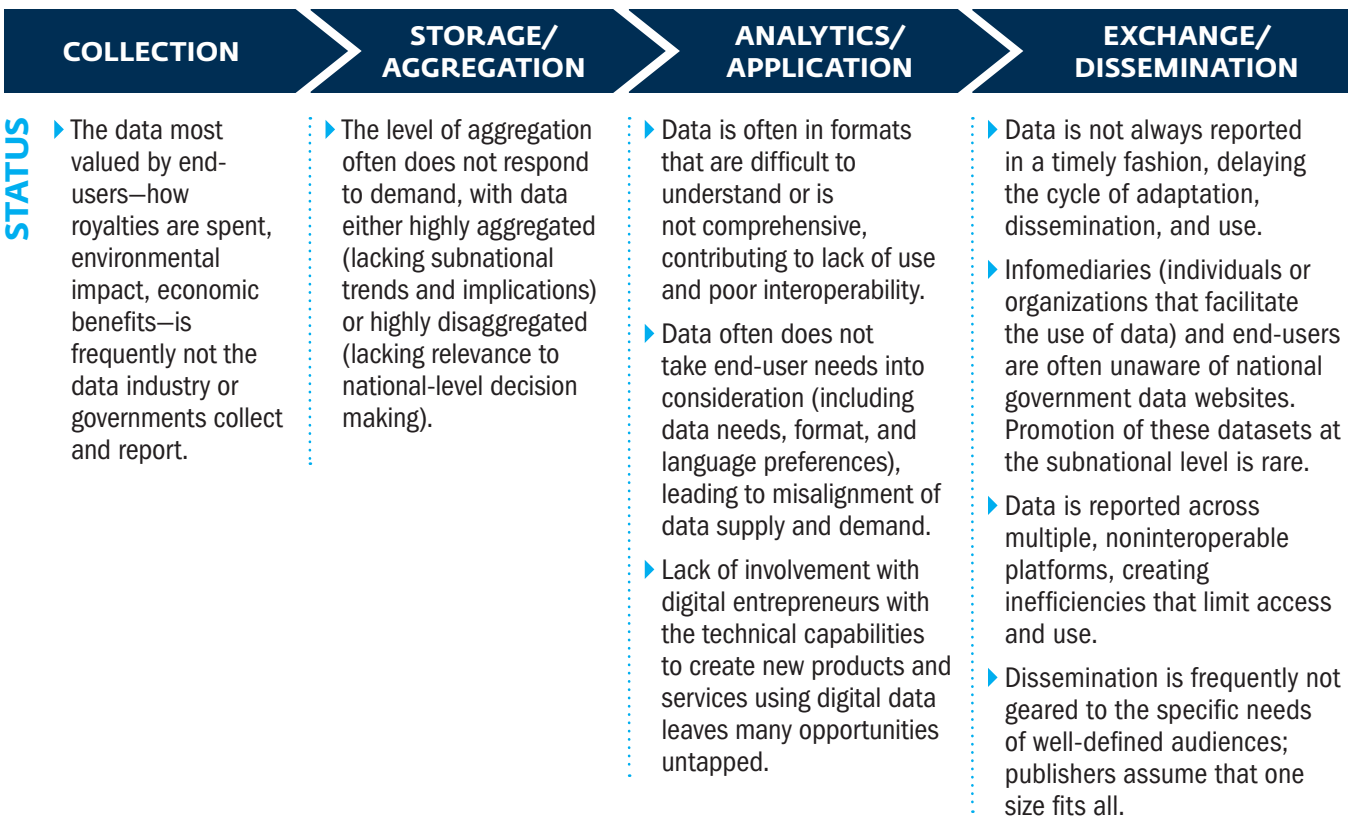

FIGURE 4 Status of natural resources data relevant to social license to operate, by stage of the data value chain

Data Barriers Companies Must Overcome

To maximize the value of data for SLO, companies must address the following constraints:

- **Lack of a well-defined data/digital strategy.** Very few companies have formally established strategies for digital transformation; even fewer have an explicit data strategy.
- **Limited understanding of data opportunities and the data value chain.** Senior management at most companies in the natural resources sector does not recognize the transformative shift digital technologies is triggering.
- **Lack of a data culture.** Most natural resources companies still operate in silos that impede the flow of data and data-driven innovation across the company. Companies need to fundamentally reorient themselves and become more data focused.
- **Limited data skills within companies.** Most natural resources companies still outsource digital projects and tasks; in-house staff have limited information technology (IT) skills.
- **Limited data-related engagement with communities.** Many data initiatives are still driven by reporting requirements rather than thoughtful engagement with communities to understand the demand for and value of data on SLO activities.
- **Limited engagement with entrepreneurs and small companies.** Most large natural resources companies have not yet developed channels to engage productively with small, technologically sophisticated companies with the capability to develop and test innovative solutions that big operations cannot.
- **Poor data infrastructure within companies.** Many companies are saddled with investments in old-fashioned or legacy IT infrastructure, such as siloed databases, which impedes rather than supports digital transformation. Few companies invest in new data sources, such as satellite data.

The Limits of Data

Data can significantly alter the practice of SLO in companies, but it is not a magic bullet that can resolve all challenges associated with managing community relations and gaining trust.

Companies must consider the following limitations:

- Collecting and sharing more data does not automatically generate value.
- Transparency is not an end in itself but a means to ends such as increased engagement, mutual benefit, and trust.
- Data alone is insufficient. The experience of companies so far suggests that data-driven services complement, rather than replace, traditional channels.
- Different data is needed for different stakeholders. Stakeholder expectations vary across geographies and contexts, and different stakeholders understand and use data in different ways.
- Data collection and use have socio-political and cultural implications. Data is not always neutral; there can be significant socio-political bias in the ways data is collected and used. For example, only half the world's countries with indigenous populations include an indigenous identifier in their census forms (Mullane-Ronaki 2017). Companies must be sensitive to social and cultural expectations of local communities.
- Data disruption has negative as well as positive consequences. Although it holds enormous potential, data-driven disruption is likely to lead to a loss of certain types of jobs; the reshaping of the company's role in many communities, as operations become more remote and companies become less directly engaged in many communities in which they operate; and competitive realignment, as more data-savvy companies gain market share and displace incumbents.
- Data can be misused. Data has frequently been used to exclude populations or discriminate against them. Recruitment algorithms, for instance, can discriminate against women (Reuters 2018), and many studies of disease are distorted by their disproportionate use of data on people of European descent (Sirugo, Williams, and Tishkoff 2019). All companies, and their stakeholders, must take this risk into account and seek to mitigate it.
- The evidence base is still developing. Despite some successes, data-driven change and the use of data for SLO are still very new.
- The benefits of data may be unequally distributed. From questions of data ownership to concerns about whom the value goes to, models for the truly beneficial use of data are still developing.

Data and Indigenous Communities

Indigenous communities are critical stakeholders in the natural resources sector. Data initiatives must take special note of their historical circumstances and legal rights. Issues include ownership and the use of data on these communities and their cultural and environmental assets. The Indigenous Data Sovereignty (IDS) provides a framework for maximizing the benefit of open data for indigenous people and other users of indigenous data and ensuring proper stewardship of all data (State of Open Data n.d).

Anglo American

Gauging Community Sentiment in Real-Time

Anglo American is one of the world's largest mining companies, with headquarters in Johannesburg and London and operations in Africa, South America, North America, and Australia. It mines iron and ore, manganese, metallurgical coal, thermal coal, copper, nickel, platinum group metals, and diamonds.

THE BUSINESS CHALLENGE

The impact of a mine on communities within the area of influence is complex and evolves continuously, making it hard to measure and manage. Traditional perception surveys do not provide the continuous monitoring and impact measurement at scale required to proactively engage communities and help prevent company–community conflicts.

DATA IN ACTION

Anglo American uses mobile-based community perception pulse surveys that ask participants to respond to five questions every month. The surveys include questions specific to each location (such as questions about dust levels and noise) plus two questions that are included in all surveys—"Do you trust Anglo American?" and "Do you support it?"—enabling comparisons across locations. Data service provider Ulula collects, analyzes, and manages data for the company.

The response data is available to employees in close to real-time via a user-friendly dashboard that lets them detect changes and react to identified risks in a timely manner (figure 5). Easily comparable data across locations in Brazil, Chile, Peru and South Africa have been integrated in the corporate scorecard, which senior management reviews at quarterly meetings. Anglo also uses the data to communicate directly with communities—through face-to-face engagement and digital channels—to better understand and help resolve issues that surface in the surveys. Surveys were to be added to three more sites by the end of 2019.

LESSONS/NEXT STEPS

Anglo's system helps the company become proactive in dealing with community issues rather than reacting based on complaints that come through traditional grievance reporting mechanisms. Integration of SLO-relevant data in the corporate scorecard put sustainability performance on senior management's radar, along with financial and operational indicators.

Among the challenges Anglo has faced has been finding the right incentives to ensure communities' ongoing participation in the surveys. In some countries, compensation in the form of air-time credits to a respondent's mobile phone account has been effective. Anglo plans to expand to more project sites, where it will engage community members with the goal of closing the feedback loop with them more systematically.

FIGURE 5 Real time dashboard providing interactive site-level analytics

Source: Ulula

Barrick Gold Corporation

Tapping the Digital Talent of Local Communities

Based in Toronto, Barrick is the second-largest gold mining company in the world, with operations and projects in 15 countries. More than 75 percent of Barrick's gold production comes from the Americas.

THE BUSINESS CHALLENGE

Barrick recognized that it was not fully leveraging its own data and that there were business and community engagement opportunities in crowdsourcing digital solutions from local entrepreneurs for potential application to its operations worldwide.

DATA IN ACTION

Barrick collaborated with Unearthed, a large global community of entrepreneurs, software developers, and data scientists that aims to make the natural resources and energy industries more efficient and sustainable. The partnership culminated in a hackathon in Buenos Aires in September 2017 that presented four challenges to innovators regarding the company's Veladero gold, located in Argentina's San Juan Province:

- Forecast maintenance on Veladero's large haulage fleet.
- Create a virtual participation platform for mining communities.
- Forecast the elevation level of Veladero's pregnant solution storage area.
- Visualize gold in three dimensions, and forecast future output of the leach pad.

More than 100 people participated in the event, developing 17 solutions. All participants retained ownership of the intellectual property they created over the 54-hour weekend event. The winning team which included three San Juaninos, designed a solution that used 3D visualization technology and drones to improve gold recovery rates in the mine processing area at Veladero.

The Buenos Aires hackathon was one of a series of data dives organized by Barrick in partnership with Unearthed in 2017. The other four hackathons took place in Toronto, Beijing, Denver, and London. In 2018 Barrick sponsored a hackathon in Las Vegas, in partnership with Cisco, Unearthed, and Switch.

LESSONS/NEXT STEPS

Barrick was able to crowdsource a large array of novel, out-of-the-box approaches from participants with diverse backgrounds and skills. After the hackathon, it formed a partnership with the tech incubator and investor NXTP Labs to help build an innovation ecosystem in San Juan that nurtures and expands technology and entrepreneurial knowhow in the province. NXTP also hosted a week-long accelerator program in Buenos Aires for the top four teams, at which teams competed to attend NXTP's four-month accelerator program.

Cerro Verde

Mixing Technology with Traditional Face-to-Face Interaction to Achieve Transparency

Cerro Verde is a large copper mine located about 20 miles from Arequipa, in southwestern Peru. It is one of the world's largest reserves of low-grade copper. Since 2007 it has been managed by Freeport-McMoRan Inc., based in Phoenix, Arizona.

THE BUSINESS CHALLENGE

Expansions of the Cerro Verde mine required additional water for operations. Meetings with stakeholders revealed concern that Cerro Verde was using more water than the licenses and agreements it had been granted allowed. The company realized that its communication about the expansion process needed to incorporate data in ways that all stakeholders could understand.

DATA IN ACTION

Cerro Verde decided to provide real-time information on the consumption of fresh and treated water (figure 6). It installed new flowmeters at the Chili River intake (the equipment and infrastructure were reviewed by public national authorities to ensure data reliability) and implemented a platform to share the fresh (or river) water data with the National Water Authority. It installed flowmeters to measure the consumption of treated water from the wastewater treatment plant (financed, constructed, and operated by Cerro Verde). Cerro Verde shares this data with the local water authority on a daily and monthly basis and sends quarterly reports to the authority. Cerro Verde also installed cameras and monitors in community areas to simplify access to information from the flowmeters.

LESSONS/NEXT STEPS

The company measures its success by the acceptance of Cerro Verde in the community. One key success metric is the availability of the platform, but the company realizes that transparency requires more than technical infrastructure and that its stakeholders include more than just government and technical institutions. It thus emphasizes face-to-face meetings with community stakeholders to explain and validate the information it provides. It views such consultations as a continuous process, as stakeholders constantly change. Cerro Verde will continue making efforts to use diverse communication channels for different audiences.

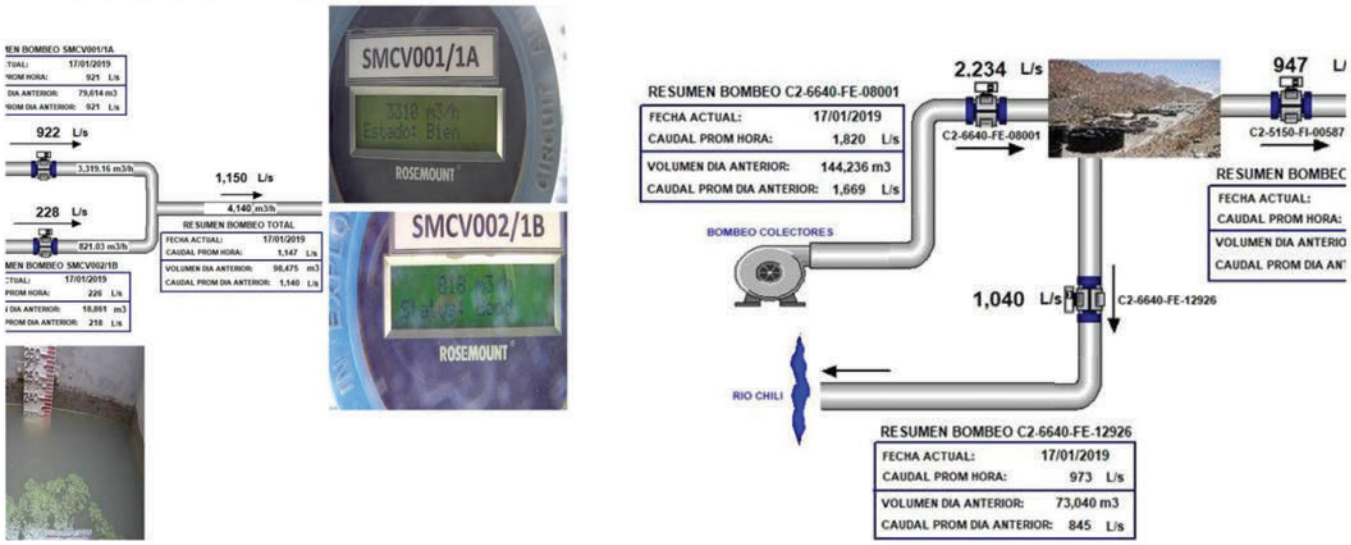

FIGURE 6 System to monitor water flow

Source: Cerro Verde

Rio Tinto

The Intended (and Unintended) Benefits of Data

Rio Tinto is the world's second-largest producer of iron ore and one of the world's leading producers of diamonds. Most of its production is in Australia; its headquarters are in London and Melbourne. The company's operations in Western Australia's Pilbara region represent one of the largest integrated mining projects in Australia.

THE BUSINESS CHALLENGE

In the absence of data and analytics to measure the impact of its work, Rio Tinto regarded community engagement as a soft function. The team wanted to develop a data-driven approach, in line with the analytical work of the rest of the company.

DATA IN ACTION

Rio Tinto partnered with CSIRO to conduct surveys that track community attitudes toward the company's investment programs. Participants share their views about the company's activities through a series of monthly pulse survey that take five minutes to complete online. They receive tokens that they can allocate to eligible not-for-profit community groups, which convert them into cash. CSIRO collects and analyzes the data and shares them with communities and Rio Tinto.

Rio Tinto has registered 800 participants (of a targeted 1,500) since the program's inception in 2017. Although the share of the target is low, the sample is statistically valid.

LESSONS/NEXT STEPS

Insights from the surveys reaffirm and validate what Rio Tinto already knows in most cases. The data is, however, helpful in tracking and reporting trends and telling more effective data stories to both internal management and communities. Transparency has been one of the most critical success factors of the initiative: Rio Tinto publishes all data through an open data website (https://research.csiro.au/localvoices/), a powerful demonstration to communities that it listens and shares.

The open data website has proved useful not only to the communities that Rio Tinto works directly with but also to other communities, educational institutions, and local governments, which find the information valuable and use it to develop their own strategic plans and infrastructure decisions. Schools in Western Australia, for example, use the data to inform their strategic plans. Another unintended benefit of the data has been its use for local procurement.

Rio Tinto believes it needs to make the data more understandable and usable. The lack of data skills is a challenge. Questions also remain about long-term ownership of the data.

FIGURE 7 How Local Voices works

Source: Rio Tinto

Yamana Gold

Data-Driven Reporting to Management on Social License to Operate Activities

Founded in 2003, Yamana Gold is a precious metals producer with a portfolio of producing mines, development projects, and exploration properties in the Americas. The company is headquartered in Toronto and operates in Canada, Brazil, Chile, and Argentina.

THE BUSINESS CHALLENGE

Yamana management wanted to better understand the value of the company's SLO activities. The traditional reporting model—based on the number of stakeholder meetings, open houses, town halls, and focus-group meeting—did not address the primary social performance risks and challenges the company faced.

DATA IN ACTION

In 2018 Yamana adopted the SLO Index and launched related perception surveys in communities surrounding its operations in Jacobina, Brazil; Chapada, Brazil; Florida, Chile; and Cerro Moro, Argentina. An annual anchor survey sought to identify and "datafy" issues critical to community members, including employment, local contracts, and environmental issues, such as water, dust, vibration, and impacts on housing and the housing market. This survey was supplemented by quarterly mobile surveys pushed out via SMS and telephone interviews that zeroed in on a few key indicators of interest in the local context. Yamana outsources data collection (to CSIRO), an important factor contributing to community trust.

The result of the surveys was a rich data set that provided strategic detail on both what and how to improve social license. Yamana also rolled up the data into scores on trust and acceptance (ranging from 1 to 5), which facilitated improved visibility by senior management on a site's social performance.

LESSONS/NEXT STEPS

The Yamana team believes that using data to report on SLO activities and "speaking the language of management" has helped put the social aspects of community relations on a par with health and safety as issues of interest and importance. The team is also exploring the possibility of sharing the findings externally. It believes that the focus on data has helped improved accountability for SLO results within the company and identify social risk as it emerges. It also thinks that having access to industry benchmarks will be a powerful incentive to improve performance.

FIGURE 8 Measuring our social license: the SLO index

Source: Yamana Gold

The Social License Data Toolkit

The following resources can help companies interested in collecting data for SLO. For further information about assessments, contact the From Disclosure to Development (D2D) team.

Self-Assessment of Readiness to Use Data

The rapid self-assessment tool shown in table 4 provides an initial framework to measure a company's readiness to use data successfully.

TABLE 4 Self-assessment tool for determining a company's readiness to use data successfully

INDICATOR		YES	NO	PARTIAL
Leadership	Senior management includes a chief data officer or equivalent			
	There is management commitment to create a digital company			
Strategy/ Policy	The company has a published corporate data/digital strategy			
	The company uses a "whole-of-firm" approach to data[a]; it is committed to creating a unified data framework that cuts across departments within the company			
	The company collects all data digitally			
	All of the company's data is available (to appropriate users) in reusable format			
	The company's strategy provides clear guidance about the access level for each data type			
	The company provides clear guidance about legal/regulatory issues associated with the collection, use, and general management of data			
	The company provides clear guidance about data quality			
	The company uses established and consistent data standards in its operations			
	The company requires the collection and use of appropriate data for SLO			
	The company is committed to sharing appropriate data externally for SLO and other uses			
Skills	The company provides training on data to all its staff			
	The company either employs in-house data scientists or contracts with them			
	The company has access to and uses staff or consultants with expertise in data management, data visualization, analytics, and data governance			
Infrastructure	Staff have access to data analytics tools and services			
	The company's infrastructure is "digital by default" (a set of design and technology principles to make digital services user-friendly and open)			
Engagement	The company uses data-informed approaches in its engagement with civil society actors and other stakeholders			
	The company is committed to sharing appropriate data with stakeholders			
	The company includes data in reusable format as part of its statutory reporting			
	The company co-creates data with communities as part of its engagement strategy			
Funding	Dedicated funding in the company is available for data strategy/infrastructure			

Note: a. The whole-of-firm concept is based on the whole-of-government approach in government (sometimes referred to as joined-up government). The idea in both cases is to establish a framework and provide tools that make it easy for different departments to work together to deliver common solutions to their clients instead of working in the silos that are common in typical government agencies.

Self-Assessment of the Data Value Chain

The self-assessment tool shown in table 5 provides an initial framework for measuring a company's preparedness in different aspects of the data value chain, with an emphasis on SLO.

TABLE 5 Self-assessment tool for measuring a company's maturity along the data value chain

INDICATOR		YES	NO	PARTIAL
Collection	The company has instrumented (through the use of sensors) or otherwise digitalized its operations across the entire value chain			
	The company provides clear guidelines to its field teams about local laws and regulations regarding the collection of data			
	The company has identified and collects SLO-relevant data at all stages of the value chain			
Storage/ Aggregation	The company has a well-defined cloud strategy			
	The company has clear guidelines about data retention and access, including access by local communities			
	The company makes it easy to aggregate and access data from external sources			
Analytics/ application	The company uses data analytics for its operations across the value chain			
	The company has developed tools and applications that make it easy to use its data			
	The company provides data analytics tools and applications to its stakeholders, including local communities			
Exchange/ dissemination	The company has a policy on sharing appropriate data with local communities and other stakeholders			
	The company's data strategy encourages collaborative collection and use of data			
Soft data infrastructure	The company trains its staff on local data regulations and policies			
	There is a strong data culture in the company (evidence may include a published data strategy, emphasis on data/digital in operations, and use of data for decision making)			
	There is an emphasis on increasing data skills and literacy within the company			
Hard data infrastructure	The company has made appropriate investments in its data management infrastructure at every stage of the value chain			

Self-Assessment of the Data Policy Environment

The self-assessment tool shown in table 6 provides an initial framework for evaluating government data policies that may affect the company. The implications for the company in question will differ based on its business model.

TABLE 6 Self-assessment tool for evaluating government data policies that may affect the company

INDICATOR		YES	NO	PARTIAL
Data privacy	There are clear laws regarding the handling of private data in the country			
	The laws clearly describe the accountability/responsibility of private companies in the management of personal data			
Data protection and cyber security	There are clear laws regarding data/cybersecurity and protection in the country			
	The laws clearly describe the conditions under which private companies must share data with the government			
	Laws cover issues such as data breaches, minimization, and liability			
Intellectual property	There are clear laws regarding the intellectual property associated with datasets			
	Existing intellectual property law explicitly promotes access to and reuse of government owned data assets			
Data localization	Existing law requires data localization (companies must store certain types of data within the national boundary)			
	Localization requirements cover only personal data			
	Localization requirements go beyond provisions in international trade agreements			
Data ownership and competition	There are clear laws about the ownership of data collected by companies			
	Regulations are explicit about thresholds for data monopolies			
	Regulations are explicit about the conditions under which data stakeholders can claim ownership over specific data assets			
Freedom of information	There is a formal government policy on freedom of information			
	The policy includes clear guidelines for the commercial reuse of government data			
	There are clear guidelines about access to key data assets for the public			

References

Accenture. 2017. "Digital Technology in Mining: Progress and Opportunity, (SlideShare)." https://www.slideshare.net/accenture/digital-technology-in-mining-progress-and-opportunity.

Access Initiative. 2018. "Mandatory Disclosure Can Make Natural Resources Work for the People." https://accessinitiative.org/blog/mandatory-disclosure-can-make-natural-resources-work-people.

ADB (Asian Development Bank). 2019. *ADB Accountability Mechanism Annual Report 2018*. https://www.adb.org/sites/default/files/institutional-document/514896/adb-accountability-mechanism-ar2018.pdf.

AgFax. 2018. "Soil Probe Offers Wide Data Monitoring, Web Access in Near-Real Time." July 17. https://agfax.com/2018/07/17/soil-probe-offers-wide-data-monitoring-web-access-in-near-real-time/.

Andrews, Dan, Giuseppe Nicoletti, and Christina Timiliotis. 2018. "Going Digital: What Determines Technology Diffusion Among Companies?" Background paper for the Third Annual Conference of the Global Forum on Productivity Companies, Workers and Disruptive Technologies: Ensuring Sustainable and Inclusive Growth, Ottawa, June 28–29.

Beckwith, R., 2011. Managing Big Data: Cloud Computing and Co-Location Centers. J. Pet. Technol. 63 (10).

BP. n.d. "Statistical Review of World Energy." https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

Björkman Nyqvist, Martin, Damien de Walque, and Jakob Svensson. 2017. "Experimental Evidence on the Long-Run Impact of Community-Based Monitoring." *American Economic Journal: Applied Economics* 9 (1): 33–69. https://www.povertyactionlab.org/sites/default/files/publications/97_287_Long-Run%20Impact%20of%20community%20base%20monitiring_jan2017.pdf.

CAO (Compliance Advisor Ombudsman). 2018. *Caseload and Data*. Washington, DC. https://www.cao-ar18.org/caseload-and-data/index.html.

Cisco. 2017. "Cisco Visual Networking Index: Forecast and Methodology, 2016–2021." https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.pdf.

ComputerWorld. 2017. "CW@50: Data Storage Goes from $1M to 2 Cents per Gigabyte (+video)." March 23. https://www.computerworld.com/article/3182207/cw50-data-storage-goes-from-1m-to-2-cents-per-gigabyte.html.

CSIRO (Commonwealth Scientific and Industrial Research Organisation). 2019. "The Social License to Operate." https://www.csiro.au/en/Research/MRF/Areas/Community-and-environment/Social-licence-to-operate.

Deloitte. 2017. *The Digital Revolution: Mining Starts to Reinvent the Future*. https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/deloitte-au-er-digital-revolution.pdf.

Durrant-Whyte, Hugh, Ryan Geraghty, Ferran Pujol, and Richard Sellschop. 2015. *How Digital Innovation Can Improve Mining Productivity.* McKinsey. https://www.mckinsey.com/industries/metals-and-mining/our-insights/how-digital-innovation-can-improve-mining-productivity.

EBRD (European Bank for Reconstruction and Development). n.d. "About the Project Complaint Mechanism." London. https://www.ebrd.com/work-with-us/project-finance/project-complaint-mechanism/about.html.

———. 2017. "Draft Mining Strategy Supporting Responsible Mining." London. https://www.ebrd.com/downloads/policies/sector/draft-mining-strategy.pdf.

Economist. 2017. "Data Is Giving Rise to a New Economy." May 6. https://www.economist.com/briefing/2017/05/06/data-is-giving-rise-to-a-new-economy.

Franks, Daniel M 2015. *Mountain Movers: Mining, Sustainability and the Agents of Change*. London: Routledge. https://doi.org/10.4324/9781315884400.

Goldberg, Mark Leon. 2019. "How Satellite Data Can Fight Illegal Mining in Ghana." UN Dispatch, May 29. https://www.undispatch.com/how-satellite-data-can-fight-illegal-mining-in-ghana/.

Heikkinen, H., E. Lépy, S. Sarkki, and T. Komu. 2016. "Challenges in Acquiring a Social Licence to Mine in the Globalising Arctic." *Polar Record* 52 (4): 399-411. https://www.cambridge.org/core/journals/polar-record/article/challenges-in-acquiring-a-social-licence-to-mine-in-the-globalising-arctic/4393C63BE6E6DFB698833CDE921D4A10.

Heuty, Antoine, and Linda Pappagallo. 2014. "'Let's Talk': Using Mobile Technology to Predict and Prevent Corporate-Community Disputes in the Extractive Industry." Transnational Dispute Management. https://www.transnational-dispute-management.com/article.asp?key=2163.

IBM. 2109. "Ford Motor Company, Huayou Cobalt, IBM, LG Chem and RCS Global Launch Blockchain Pilot to Address Concerns in Strategic Mineral Supply Chains." January 16. https://newsroom.ibm.com/2019-01-16-Ford-Motor-Company-Huayou-Cobalt-IBM-LG-Chem-and-RCS-Global-Launch-Blockchain-Pilot-to-Address-Concerns-in-Strategic-Mineral-Supply-Chains?cm_mmc=OSocial_Blog-_-Blockchain+and+Watson+Financial+Services_Blockchain-_-WW_WW-_-Blockchain+for+the+mining+industry+Ethical+cobalt+production+In+Text+IBM+Newsroom&cm_mmca1=000020YK&cm_mmca2=10005803.

IDC. 2017. "Quantifying Datacenter Inefficiency: Making the Case for Composable Infrastructure." http://www.integra1.net/uploads/files/IDC%20Making%20the%20Case%20for%20Composable%20Infrastructure.pdf

IoTHub. 2018. "BHP Uses Laser Sensors to Put More Ore in Rail Cars." October 22. https://www.iothub.com.au/news/bhp-uses-laser-sensors-to-put-more-ore-in-rail-cars-514317.

Jelenic, Michael Christopher. 2019. "From Theory to Practice Open Government Data, Accountability, and Service Delivery." Policy Research Working Paper 8873, World Bank Group, Governance Global Practice, Washington, DC.

Lal Das, Prasanna, Stefan Claus Beisswenger, Srikanth Mangalam, Mehmet Rasit Yuce, and Martin Lukac. 2017. *Internet of Things: The New Government to Business Platform. A Review of Opportunities, Practices, and Challenges.* Washington, DC: World Bank Group. http://documents.worldbank.org/curated/en/610081509689089303/Internet-of-things-the-new-government-to-business-platform-a-review-of-opportunities-practices-and-challenges.

McKinsey. 2015. "How Digital Innovation Can Improve Mining Productivity." https://www.mckinsey.com/industries/metals-and-mining/our-insights/how-digital-innovation-can-improve-mining-productivity.

Moffat, Kieran, Justine Lacey, Airong Zhang, and Sina Leipold. 2016. "The Social Licence to Operate: A Critical Review." *Forestry: An International Journal of Forest Research* 89 (5): 477–88. https://academic.oup.com/forestry/article/89/5/477/2194485.

Mount Isa Mines. n.d. "Air Quality Management in Mount Isa." http://www.mountisamines.com.au/en/sustainability/air-quality/Pages/Air-quality-in-Mount-Isa.aspx.

Mullane-Ronaki, M.-T.T.K.K. 2017. "Indigenising the National Census? A Global Study of the Enumeration of Indigenous Peoples, 1985–2014." Master's thesis, University of Waikato, New Zealand. https://researchcommons.waikato.ac.nz/handle/10289/11175.

Mundeva, Daniel Asborn. 2016. "Social License to Operate and the Government's Role: A Case Study from Tanzania." Simon Fraser University, Vancouver. https://summit.sfu.ca/item/16385.

Narayanan, Ajjit, and Graham MacDonald. 2019. "Toward an Open Data Bias Assessment Tool Measuring Bias in Open Spatial Data." Urban Institute, Washington, DC. https://www.urban.org/sites/default/files/publication/99844/toward_an_open_data_bias_assessment_tool_1.pdf.

Open Government Partnership. 2019. "Disclosing Environmental Information in the Natural Resource Sector." https://www.opengovpartnership.org/wp-content/uploads/2019/05/FIN20OGP20Issue20Brief20Env20Disc1.pdf.

Osei, Edna, and Charles Young. 2018. "All Hands on the Ghana Extractive Industries Transparency Initiative's New Data-Rich Dashboard." Natural Resource Governance Institute, New York. https://resourcegovernance.org/blog/all-hands-ghana-extractive-industry-transparency-initiative-new-data-rich-dashboard.

Oxfam America. 2009. "Review of Major Mining, Oil, and Gas Company Policies on Free Prior and Informed Consent and Social License." https://www.oxfamamerica.org/static/media/files/ei-company-fpic-and-social-license-policies-with-summary.pdf.

Peker Jessica, and Miriam McKinney. 2018 "Towards Eliminating Bias in Open 311 Requests." Center for Government Excellence. https://govex.jhu.edu/wiki/towards-eliminating-bias-in-open-311-requests/.

Pedersen, Anders. 2019. "Open Data and Extractives." In *The State of Open Data*, ed. T. Davies, S. Walker, M. Rubinstein, and F. Perini. Cape Town and Ottawa: African Minds and International Development Research Centre.

Perrons, Robert K., and Jesse W. Jensen. 2015. "Data as an Asset: What the Oil and Gas Sector Can Learn from Other Industries about 'Big Data.'" *Energy Policy* 81: 117–21.

Reuters. 2018. "Amazon Scraps Secret AI Recruiting Tool That Showed Bias against Women." https://www.reuters.com/article/us-amazon-com-jobs-automation-insight/amazon-scraps-secret-ai-recruiting-tool-that-showed-bias-against-women-idUSKCN1MK08G.

Roberts, Richard. 2018. "Technology Central to Future of Mine Asset Management." *Mining Journal,* March 15. https://www.mining-journal.com/investment/news/1316687/technology-central-to-future-of-mine-asset-management?utm_medium=email&utm.

State of Open Data. n.d. "Indigenous Data Sovereignty." https://www.stateofopendata.od4d.net/chapters/issues/indigenous-data.html.

Sirugo, Giorgio, Scott M. Williams, and Sarah A. Tishkoff. 2019. "The Missing Diversity in Human Genetic Studies." *Cell* 177 (1): 26–31.

Topf, Andrew. 2017. "Goldcorp Partners with IBM to Hunt for Exploration Targets at Red Lake." mining.com. https://www.mining.com/goldcorp-partners-ibm-hunt-exploration-targets-red-lake/.

Watkins, Graham George; Mueller, Sven-Uwe; Meller, Hendrik; Ramirez, Maria Cecilia; Serebrisky, Tomás; Georgoulias, Andreas. 2017. International Development Bank. https://publications.iadb.org/publications/english/document/Lessons-from-Four-Decades-of-Infrastructure-Project-Related-Conflicts-in-Latin-America-and-the-Caribbean.pdf. September.

WEF (World Economic Forum). 2016. *Mining and Metals: Digital Transformation and the Industry's New Normal.* Cologny, Switzerland. http://reports.weforum.org/digital-transformation/mining-and-metals-digital-transformation-and-the-industrys-new-normal/.

World Bank. 2018. *Information and Communications for Development 2018: Data-Driven Development*. Open Knowledge Repository, Washington, DC. https://openknowledge.worldbank.org/handle/10986/30437.

IMAGE CREDITS

Cover | Top and bottom left: ©Anglo American; Bottom right: Simone D. McCourtie/World Bank

Interior | Page 8: ©Rio Tinto; Page 10: ©Anglo American; Page 11 (from top to bottom): Shutterstock, ©IFC;
Page 12 (from top to bottom): Dominic Chavez/IFC, Simone D. McCourtie/World Bank, Arne Hoel/World Bank, Shutterstock;
Page 14: Khasar Sandag/IFC; Page 15: ©Anglo American; Page 16: ©Anglo American; Page 20: Meriem Gray/World Bank;
Page 21: Dominic Chavez/IFC; Page 24: ©Anglo American; Page 25: Dominic Chavez/IFC; Page 26: ©Anglo American;
Page 27 (from top to bottom): Dominic Chavez/IFC, ©Unearthed; Page 29: ©Rio Tinto

IFC
2121 Pennsylvania Avenue, N.W.
Washington, D.C. 20433 U.S.A.

ifc.org

Contact | Alla Morrison, D2D Program Manager, amorrison@ifc.org

Creating Markets, Creating Opportunities