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OPPORTUNITIES FOR TECHNOLOGY USE IN RESPONSIBLE MINERALS PRODUCTION AND SOURCING IN THE DRC

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Opportunities for technology use in responsible minerals production and sourcing in the DRC

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EXECUTIVE SUMMARY

This report examines the opportunities for using technology solutions in responsible minerals production and sourcing in the DRC. It explores the DRC context in terms of technology penetration, maps out existing technology solutions and analyses lessons learnt from their application, including the views of stakeholders. Through this multi-perspective approach, the research provides insights into the opportunities presented by technology as well as the pre-conditions and enabling environment required for technology to contribute effectively to responsible minerals production and sourcing. While technology applications play a central role in terms of increasing efficiency, promoting transparency and scaling impact, the report also addresses some limitations, emphasising the role of pre-existing processes, behaviours and stakeholder engagement in responsible minerals production and sourcing.

MAPPING TECHNOLOGY SOLUTIONS FOR RESPONSIBLE MINERALS PRODUCTION AND SOURCING IN THE DRC

To understand the existing scope of the technology sector to support responsible minerals production and sourcing, the research mapped against set criteria existing technology applications operational in the DRC or with potential to deploy in the region. The mapping identified 19 different solutions from which 7 detailed case studies were drawn.

The solutions covered in this research illustrate the wide scope of the applications that already exist in the responsible minerals production and sourcing field. The existing initiatives present different levels of maturity, where some have been implemented for some time and others are still in development or piloting stage. They can be categorised into:

- Due diligence platforms
- Traceability systems
- Geospatial data
- Data collection and monitoring
- Solutions for education

Through research with stakeholders within and outside of the DRC, every effort was made to include all those that fit within the criteria. However, the sector is rapidly developing, and the list is not guaranteed to be exhaustive. The mapping process also focused on presenting a diversity of types of technology in use, including with regard to those solutions not yet applied within the DRC.

HOW TECHNOLOGY PENETRATION IN THE DRC SHAPES OPPORTUNITIES FOR TECHNOLOGY USE IN RESPONSIBLE MINERAL PROUCTION AND SOURCING

The main indicators used to understand technology penetration and therefore the feasibility of technology solutions in the DRC include access to electricity, mobile phone connection and internet access. These indicators are clearly central to the development of technology solutions in the minerals sector, which need electricity for power, and network access to collect and share information. They present a picture of low but growing penetration.

- Access to electricity is clearly a fundamental enabler of technology applications, yet in 2018 only 19.1% of the total population of the DRC had access to electricity despite the immense potential of energy production in the country.
- Mobile phone penetration is higher, reaching 40% of the population in 2020, with 2G network coverage being more extensive than 3G and 4G.
- Internet access was available to only 13% of the population in 2020 but saw a growth rate of 122% on the previous year.
- Electricity and internet access also remain unequal throughout the country, with urban populations having greater access to these services.
- Overall, almost 80% of internet access is through mobile phones.

Analysing the solutions through the lens of the DRC context reveals that some of the country-specific indicators function as inhibiting factors for technology solutions and suggests others that could encourage success.

- The low and unequal access to, and unreliable availability of, electricity, internet access and mobile phone coverage present significant barriers.
- It is not only access that influences the feasibility of technology uses, but also the quality of the service and the condition and age of the available hardware and systems.
- Even where infrastructure is sufficient to make services available, further barriers come into play in the costs of mobile services and the taxation system faced both by operators and consumers.
- The large and low-density nature of the DRC population and limited access to education can also inhibit the application of technology solutions.
- More positively, the expansion of ICT and mobile technologies in particular are considered by many stakeholders to be an important driver – and outcome – of socio-economic development, positioning technology solutions positively for future expansion.
- In the current context, it was observed that solutions based on mobile phone access can offer greater accessibility and results.

WIDER ENABLING FACTORS, OPPORTUNITIES AND LIMITATIONS

The role of technology in responsible minerals production and sourcing

Moving from the context and enabling environment to the implementation of technology solutions, the research highlights important outcomes in terms of the limitations of technology applications' capacity to solve the challenges of responsible mining and sourcing of minerals, as well as opportunities to overcome these limitations.

- Behaviour and processes should be the primary considerations before turning to technology solutions. While the technology might serve as a tool, ultimately the mindset, skills and processes of responsible minerals production and sourcing need to be established before technology can add value.
- It is also necessary to look at technology beyond the traceability component, distinguishing clearly between solutions which only focus on traceability and those which provide broader scope in terms of due diligence and responsible sourcing.
- Other limitations are linked to security from the perspective of appropriate use and interpretation of information once it is collected, and in terms of guaranteeing the security of users in the mining area.
- The fact that mineral supply chains are often complex and crowded ecosystems also creates limitations for lean technology solutions.
- Specific limitations apply in the 3TG sector in eastern DRC, where the levels of complexity and lack of accountability in the supply chain presents a challenging set of circumstances for any technology-led solution.

Enabling factors for success with technology use

Where technology solutions are in use, the research identified a number of enabling factors and opportunities for supporting successful implementation and achieving impact.

- Local ownership and bottom-up approaches (driven by producing countries and not only by mid-downstream companies and international actors) are paramount. Such approaches should also include engagement of local authorities and regulating bodies.
- Opportunities for country-wide applications and integrating technology solutions into mineral resources governance are also highlighted. Technology solutions bring opportunities in the shape of access to regular data from producing locations, including data on social and environmental impacts, and can help scale the impact of existing initiatives.
- With regard to technical considerations, the interoperability of different solutions represents both opportunity and need, especially when dealing with complimentary applications or solutions applied at different stages of the supply chain.
- In terms of access to devices and feasibility of use, mobile phones and tablets present the greatest potential.
- Consideration might also be given to the potential use of solar panels as an opportunity to improve access to energy around mining sites.

Opportunities for scale

Perspectives on the industry-wide application of technology solutions were sought during the research. While the report does not reach specific recommendations in this regard, it provides some reflections on conditions and opportunities.

- The clearest opportunity resides in the potential for industry-wide applications to streamline requirements and reduce reporting burdens, particularly on producing organisations.
- Conditions for success would include involving supply chain actors that directly collect and provide the data in the design of the solution.
- Industry-wide applications would also need to be scalable, cost-effective and simple to use.
- At the governance level, implementation of any solution at industry scale would require clear leadership from one or a group of actors, who would be able to bring different initiatives together and be capable of implementing a whole supply chain system.

INTRODUCTION

The report presents the results of research conducted by Levin Sources into opportunities for technology use in responsible minerals production and sourcing in the DRC.

This report is organised under the following sections:

- Technology penetration in the DRC
- Inhibiting and enabling factors, opportunities and limitations
- Case studies of 7 technology solutions
- Conclusions
- Annexe: Map of technology solutions

This research is grounded in broader questions concerning the extent that technology can contribute to the responsible production and sourcing of minerals and the wider factors that influence its role. Using the example of the DRC, Levin Sources has mapped and analysed technology solutions that are currently being applied in the DRC or have potential to expand into the country. We also captured stakeholders' perspectives and carried out information analysis to assess wider questions relating to the role of technology in the responsible production and sourcing of minerals.

The research aimed to:

1) **Outline the context of the DRC** in terms of technology penetration and, to a limited extent, specific responsible mining and sourcing technology applications or initiatives.
2) **Map technology solutions** already used or with potential to be used in the DRC.
3) **Analyse the role of technology in supporting responsible production and sourcing of minerals**, drawing from the experience of the solution providers, interviews with local stakeholders, and industry-wide perspectives. This has highlighted opportunities as well as limitations and lessons learnt from implementing technology solutions.

Several technology solutions were identified through the mapping exercise. Their scope of application varies, and the research focused primarily on the following categories: (1) due diligence platforms, (2) traceability systems, (3) geospatial data, (4) data collection and monitoring and (5) solutions for education. While some have already been in use for several years, others remain at the development or piloting phase.

Through research with stakeholders within and outside of the DRC, every effort was made to include all those that fit within the criteria. However, the sector is rapidly developing and the list is not guaranteed to be exhaustive. The mapping process also focused on presenting a diversity of types of solution, particularly with regard to those not yet applied within the DRC.

In terms of methodology, the report is based on both secondary data review and primary data collection through stakeholder interviews. Interviews were conducted with 9 technology solutions providers, 5 minerals sector organisations and initiatives, and 11 minerals sector actors based in the DRC.

This research was supported by a private company that is engaged in responsible minerals sourcing. The report's authors independently designed the research, collected and analysed data, and interpreted their findings. The mapping of technology solutions was carried out in two phases. Levin Sources initially mapped 19 technology solutions, of which 7 were subsequently selected by the client for analysis in more detail against the specific criteria listed in the case studies section of this report. The research was carried out between November 2020 and March 2021.

LIMITATIONS

The nature of the research has presented a number of limitations to this report, which are explored further in the conclusions and recommendations for further research.

The research covered the DRC as a whole rather than focus on specific mining locations or minerals in the DRC. This has enabled information to be collected and assessed from an extensive application into the sector but has inevitably limited the extent to which detailed practical recommendations can be made on specific technological solutions.

The early-stage nature of a number of the technology solutions identified has meant that, in some cases, limited data was available to assess their impacts.

Mobile money solutions were not explored in detail during the scoping stage. There is potential to explore mobile money solutions in greater depth in further research, considering the role played also by Congolese initiatives in this space.

While Levin Sources spoke with a wide range of stakeholders, the depth of the conversation has been partially limited by the broad scope of the research. However, it is an indication of the growing relevance of technology in responsible minerals production and sourcing that most of the stakeholders expressed interest in following up the conversation.

Finally, the final research did not cover two specific areas which would benefit from further study. The first is the practical application of some of the solutions by large-scale mining (LSM) operations, as this would have required more time to interview mining companies as well as solutions providers. The second is the integration of technology into mining operations (e.g., automation, data management, etc.). Although there might be socio-economic consequences from the increased use of technology for mining activities[1], this specific perspective was not considered in the research.

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[1] 2016, Mining a Mirage? Reassessing the shared-value paradigm in light of the technological advances in the mining sector, Aaron Cosbey, Howard Mann, Nicolas Maennling, Perrine Toledano, Jeff Geipel and Martin Dietrich Brauch

TECHNOLOGY PENETRATION IN THE DRC

This section presents background information on the DRC with respect to the main demographic and development indicators, infrastructure, and technology penetration. It sets out the context for the subsequent analysis of responsible sourcing and mining technology solutions.

The DRC has several characteristics that make it a suitable context country for the analysis of technology solutions. First, it is widely recognised as a mineral-rich country where there is already substantial investment in minerals production and sourcing (see figure 6 below). Second, within the DRC there is significant artisanal and small-scale mining (ASM) as well as large-scale mining (LSM) activity, which creates a varied operating environment with a range of challenges for technology solutions relating to responsible sourcing and production of minerals. Third, the national electricity and internet infrastructures remain limited but expanding, which provides both challenge and opportunity for technology solution use cases.

The DRC has a population of almost 88 million people[2], 45% of whom live in urban areas and cities.[3] The population density equals 39.5 people per km[2]. The capital city, Kinshasa, is the country's largest, with more than 12 million inhabitants, followed by four further urban centres having each one million or more inhabitants (Lubumbashi, Mbuji-Mayi, Goma and Kananga) and 116 cities with more than 500,000 inhabitants[4]. While urbanisation can represent an indicator of economic development, adequate infrastructure and access to energy and other essential services are key to realising this potential. In 2018 fewer than 19% of the total population had access to electricity. Electricity access increases to 50% in urban areas, which – while still low – illustrates the disparity in access between those living in urban and rural areas[5]. At the same time, the DRC has great potential to generate its own energy, being rich both in renewable (hydropower, biomass, solar, wind, geothermal) and non-renewable energy sources (oil, natural gas, uranium). Currently the majority of Congolese electricity is produced through hydropower. The Grand Inga project, a series of seven proposed hydroelectric power stations at the site of the Inga Falls, has the potential not only to improve access to electricity in country, but also to make DRC an energy exporter[6]. The map below shows how access to electricity could look by 2030, per type of access solution, according to the Africa Case. This is used in the Africa Energy Outlook 2019 as one of two scenarios assessing how governmental policies might affect investment and access to energy. While one scenario is based on the current government policy and framework, the Africa Case is developed on the premises set by Agenda 2063 agreed by the Africa Union in 2015[7].

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[2] World Bank data: Population, Congo Dem. Rep. https://data.worldbank.org/indicator/SP.POP.TOTL?locations=CD, 2019

[3] Statista, Democratic Republic Of Congo: Urbanization from 2009 to 2019

[4] World Bank. 2018. Democratic Republic of Congo Urbanization Review: Productive and Inclusive Cities for an Emerging Democratic Republic of Congo. Directions in Development. Washington, DC: World Bank. doi:10.1596/978-1-4648-1203-3. License: Creative Commons Attribution CC BY 3.0 IGO

[5] World Bank data: Access to electricity (% of population and %population in urban areas) Congo, Dem. Rep. https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=CD, 2018

[6] 2019, The International Energy Agency, Africa Energy Outlook 2019, Overview; Democratic Republic of Congo

[7] 2019, The International Energy Agency, Africa Energy Outlook 2019, Overview; Democratic Republic of Congo
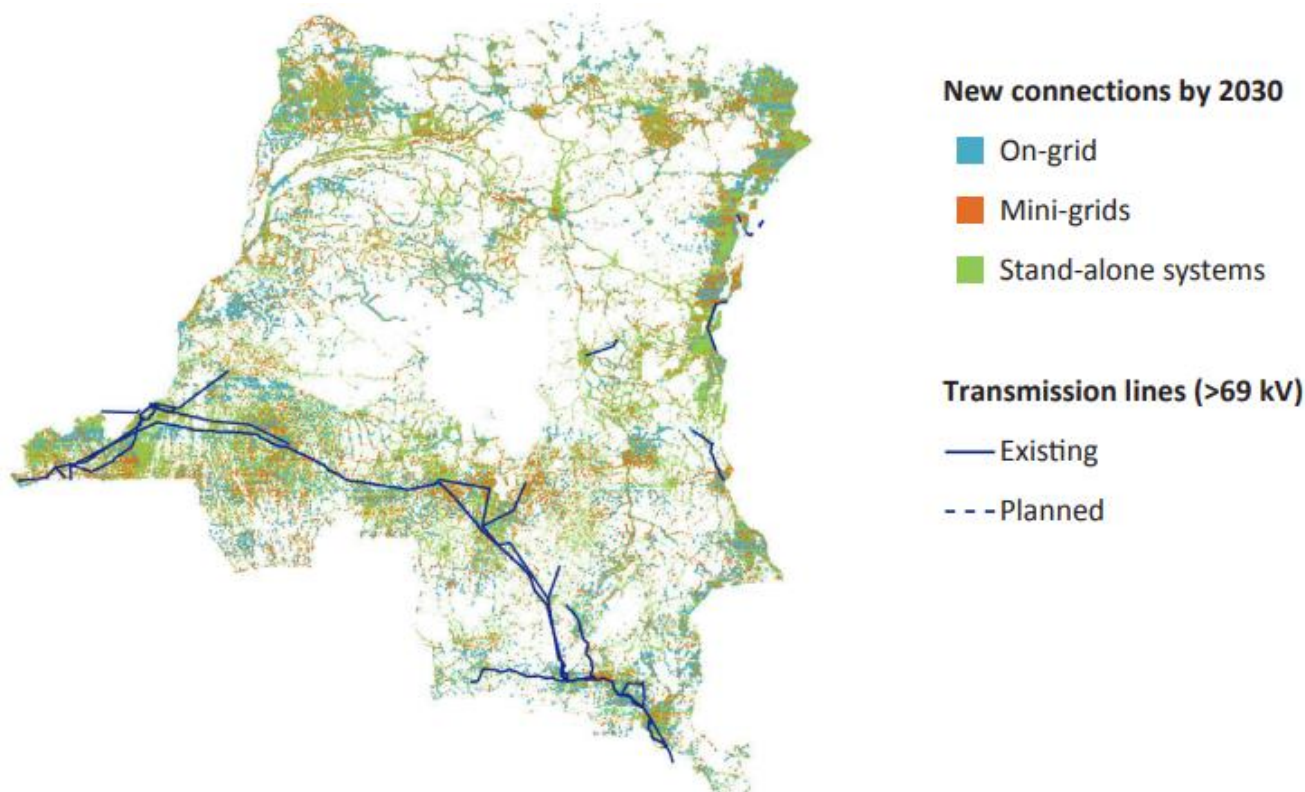
Figure 1. DRC electricity access solution by type in the Africa Case. *– Source: The International Energy Agency, Africa Energy Outlook 2019, Overview; Democratic Republic of Congo*

Technology penetration in the DRC is weak on a global scale. The DRC scored 1.55 in the Information and Communication Technology (ICT) Development index 2017, ranking 171 out of 176 countries included in the index. The ICT Development index is a composite index that combines 11 indicators on access, use and skills for ICT into one benchmark measure[8] on a 0-100 scale. For the DRC, scores in the three specific areas are respectively 1.68, 0.68 and 3.03[9]. Some specific indicators and data on access and use of ICT are displayed in the tables below[10].

Table 1: Mobile usage

NUMBER OF SUBSCRIPTIONS	% OF POPULATION	% ANNUAL DIGITAL GROWTH (2019-2020)
35.13 million	40%	+ 3.1%
Percentage of mobile connections that are pre-paid		Percentage of mobile connections that are post-paid
95%		5 %
Percentage of mobile connections that are broadband (3G-5G)		
41%		

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[8] The ICT Development Index (IDI): conceptual framework and methodology: https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis/methodology.aspx

[9] 2017, ITU ICT Development Index, Democratic Republic of Congo

[10] 2020, The data has been structured based on the Hootsuite – We are social Digital 2020 DRC report, which combines all key indicators of mobile, internet and social media usage

Table 2: Internet usage

NUMBER OF USERS	% PENETRATION	% ANNUAL DIGITAL GROWTH (2019-2020)
16.35 million	13%	+122 %
Average speed of mobile internet connections:		Average speed of fixed internet connections
13.73 MBPS		6.25 MBPS
Share of traffic by device		
Mobile phones 76.9%	Laptops and desktops 22.1%	Tablet computers 1%

Table 3: Social media usage

ACTIVE SOCIAL MEDIA USERS	% PENETRATION	% ANNUAL DIGITAL GROWTH (2019-2020)
3.10 million	3.5 %	+ 28%

The data above show that:

- Less than half of the population of DRC have access to mobile subscriptions or internet.
- Most users access the internet through their mobile phones, which is more affordable than a laptop or other means.
- Internet access is growing rapidly, albeit from a low base.

The four top telecommunication providers are Vodacom, Orange, Africell and Airtel. In terms of smartphone operating systems, more than 70% of smartphone holders use android, about 20% use unknown systems, about 7% iOS, and the rest other systems[11]. The cost of internet data remains significant, ultimately representing one of the main barriers to internet access, which will be explored in the next section. Access to electricity plays a role in the data above, as people living in rural areas will be less likely to have internet access (due to lack of infrastructure or high costs) and would often own cell phones rather than smartphones. Data on digital growth are, however, impressive and provide significant potential opportunities.

To complement the information on mobile subscriptions and internet access, the maps below show mobile connection coverage (2G, 3G and 4G) throughout the country, which show the pronounced inequality of access between urban and rural populations. Viewed alongside the map illustrating key minerals presence, these can provide a basic estimation of mobile connectivity within mining communities and show that the best connectivity rates tend to overlap with areas of mineral endowment.

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[11] Mobile operating systems market share (November 2019-2020). Data Source: Statcounter
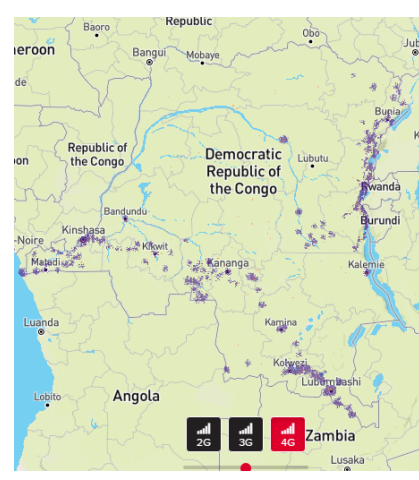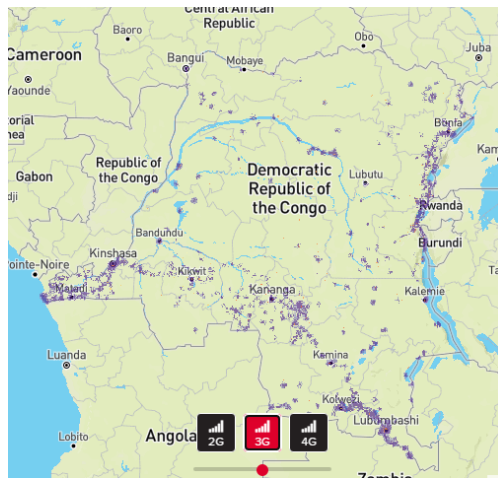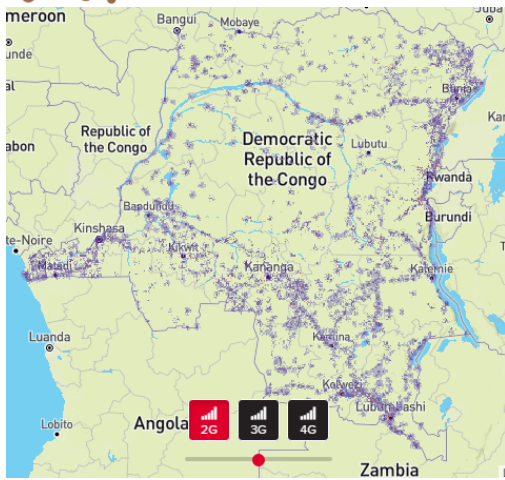
Figure 4. 2G connections – Source: GSMA

Figure 5. 3G connections - Source: GSMA
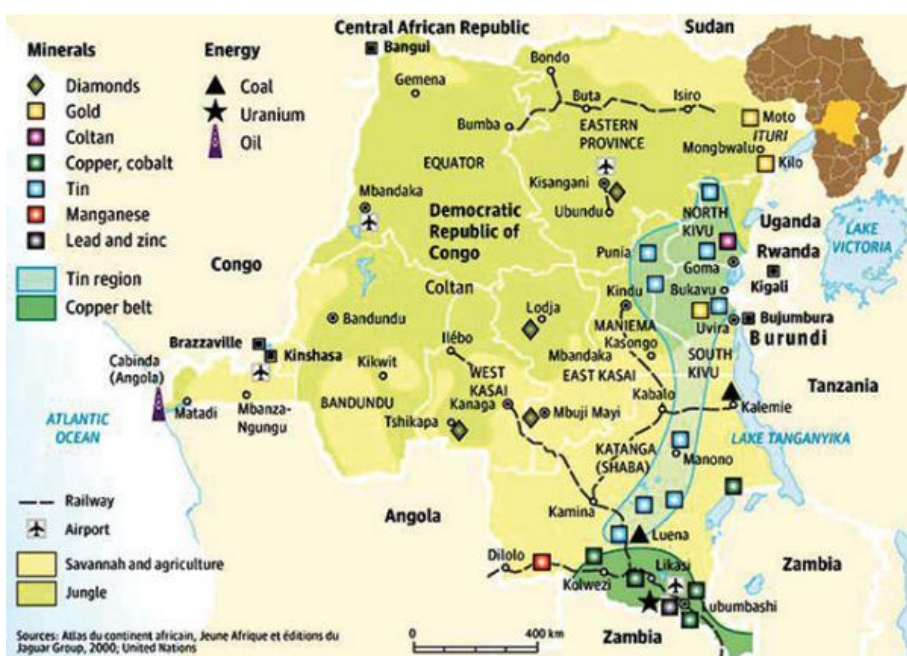
Figure 6. 4G connections – Source: GSMA

Figure 7. Representation of key mineral presence, Source: Atlas du continent africain, Jeune Afrique et editions du Jaguar Group, 2000, United Nations

Alongside this information it is important to understand the key legislative requirements for the ICT sectors in the DRC. This is provided below, together with the most significant institutions and government initiatives [12].

The ICT sector in the DRC is regulated by:

• Law no. 012/2002
• The framework law no. 013/2002 of 16th October 2002 on ICT in the DRC. The framework law identifies two institutions as responsible for managing the ICT sector, specifically:
o The Ministry of Posts and Telecommunications
o The Regulatory Authority for Posts and Telecommunications (ARPTC)
• Law no. 014/2002 of 16 October 2002, creating The Regulatory Authority for Posts and Telecommunications (ARPTC).

The government strategy for the sector is defined in the national ICT policy which describes the strategic priorities with respect to the development of the ICT sector. These include, among others:

• Update and complete the regulatory framework to support its development but at the same time ensure fair competition to protect consumers and optimise access and infrastructure.
• Streamline and clarify the taxation applicable to the sector.
• Develop a plan for universal access.

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[12] Agence National pour la Promotion des Investissements, ANAPI, https://www.investindrc.cd/fr/NOUVELLES-TECHNOLOGIES-DE-L-INFORMATION-ET-DE-LA-COMMUNICATION

- Setting up international broadband access to significantly reduce the cost of access to the internet and ICTs.

With this strategy the government sets out its vision of integrating the DRC into the digital economy. Some practical targets include:

- By 2021, placing into the orbit the first Congolese satellite, the completion of 5,000 km of national fibre-optic backbone and the connection of 30 million lines and mobiles (metropolitan networks).
- By 2030, all public administration and specialised services at border crossings will have to be computerised and the country will need to have sufficient, high-quality human capital in the field of ICTs.

Based on publicly available government information, the following national projects are seeking investment to improve the integration of ICT and supporting infrastructures:

- Construction of a modern national broadband telecommunications infrastructure
- Implementation of multi-purpose telecentres in every part of the country
- Computerisation of the Public Administration, specialised services and border posts
- Implementation of mechanisms for the management of internet exchange points, i.e., network interconnection centres deployed by internet providers
- Hosting of Google cache servers in Kinshasa to contribute to the improvement of access to Google content by end users
- The DRC-Exchange point project, which aims to provide the country with an infrastructure for interconnecting national networks

INHIBITING AND ENABLING FACTORS, OPPORTUNITIES AND LIMITATIONS

The literature review, primary and secondary sources and especially the interviews with stakeholders highlighted a set of inhibiting and enabling factors, opportunities and lessons learnt with respect to technology applications and ICT sector development in the DRC. These findings are presented in the following sections, which consider:

- Overarching and countrywide inhibiting and enabling factors for ICT development.
- Factors which determine the extent to which technology solutions can advance responsible production and sourcing in the minerals sector, including preconditions and additional considerations.
- Opportunity for industry-wide application.

Part 1: DRC-specific inhibiting and enabling factors

INHIBITING FACTORS FOR ICT DEVELOPMENT IN THE DRC

Low access and availability of electricity

When considering technology solutions, one of the essential preconditions for success is access to energy to power ICT development. From charging a simple mobile phone to having access to the internet or being able to upload data about mining and supply chain operations, nothing is possible without a reliable electricity supply. Low access to and availability of electricity is key when it comes to technology solutions advancement, so it is significant that in the DRC only 19% of the population has access to energy. Following this, 2G, 3G and 4G connections still have a restricted or unstable network coverage.

Poor service reliability and outdated and old appliances and systems

Even when infrastructures exist and network coverage is available, service reliability in the DRC remains limited, meaning that a technology application dependent on continuous connection might encounter limitations. Another challenge is that many appliances and systems are old and outdated. However, stakeholders who have been working in the DRC over the past decade have noticed a slight improvement and have started to observe a positive trend in smartphone ownership.

High cost of broadband, data and devices

The GSMA Mobile Connectivity Index 2019 scores the DRC at 17.9/100 on affordability (including mobile tariffs, handset price, taxation and inequality)[13]. This demonstrates that the high costs of mobile connections and ICT still represent a barrier to access for many people, especially when considering the poverty level reported in the country (76.6% of the population is below the income poverty line[14]). In a recent study, one out of three respondents confirmed that the high costs of internet data represent the main barrier for internet use[15].

[13] GSMA Mobile Connectivity Index 2019, https://www.mobileconnectivityindex.com/#year=2019&zoneIsocode=COD&analysisView=COD
[14] 2020, UNDP, Human Development Report, DRC briefing note
[15] 2020, What is the impact of fibre connectivity in the Democratic Republic of Congo, Julia Tobias, Katharina Neureiter

In terms of devices, laptops are considered too expensive for most households. As mobile phones are cheaper and easier to access, more than 95% of the population who have internet access use mobile network operators as providers.[16] In the context of limited access to electricity, a mobile phone is also easier to charge than a laptop. Geographically, internet access remains more common around urban areas than in rural ones.

High taxation on consumers and operators[17]

Taxation is another component which makes the costs of internet and mobile connectivity inaccessible to many and which hinders digital inclusion. These taxes affect both consumers and operators and are the highest rates in sub-Saharan Africa. For example, consumers pay 16% VAT on devices and sim cards and for calls, SMS and mobile handsets. Operators, on the other hand, face corporation taxes on profits equal to 35% (or 1% of turnover in case of loss) or customs duty on imported network equipment up to 39.2%.

Large, dispersed population with low levels of education

A low population density, especially outside urban areas, and significant dispersion may represent another challenge in terms of expanding the network coverage and encouraging the purchase and use of mobile services. Additionally, low levels of education can also present a barrier to increased digital inclusion. Adequate investment in both infrastructure and human capital is, therefore, necessary to advance ICT development across more areas within the DRC[18].

ENABLING FACTORS AND OPPORTUNITIES

ICT contribution to development

While not unique to the DRC, various resources and initiatives confirm the role that the ICT sector can play in terms of socio-economic development of a specific region[19]. Mobile devices themselves can represent a driver of socio-economic development. Among the many advantages mobile connectivity offers are access to information both for business (e.g., accessing market information that can improve the productivity in certain sectors) and social purposes (e.g., improving access to education, healthcare, and other government services). Mobile networks can also provide access to relevant market information, such as updates on commodity prices (highly relevant for the mining sector, specifically for artisanal and small-scale operators) [20]. Some of the initiatives mapped below and detailed in the case studies will provide mining sector-specific examples.

Open model and usage of simple tools like SMS

Using a tool such as SMS, which does not depend on an internet connection or a smartphone, was reported to be a clear advantage for ensuring broader reach and onboarding of stakeholders in DRC mining communities. In addition, solutions such as interactive voice response, described further in the case studies, provide a further opportunity in terms of reaching miners with low levels of literacy.

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[16] 2018, ICT in the DRC: Challenges, Solutions and Opportunity, Engineering for Change, https://www.engineeringforchange.org/news/ict-drc-challenges-solutions-opportunity/

[17] 2015, Digital inclusion and mobile taxation in the DRC – GSMA, Deloitte

[18] 2015, Digital inclusion and mobile taxation in the DRC – GSMA, Deloitte

[19] 2013, A comparison of ICT initiatives in South Africa and Democratic Republic of Congo, Antoine Kasiyu Kazadi, Meera K. Joseph, Pretesh Patel

[20] 2015, Digital inclusion and mobile taxation in the DRC – GSMA, Deloitte

Part 2: Prerequisites for the application of technology to support responsible minerals production and sourcing

In addition to the mapping of 19 technology solutions (found in Annexe 1), this report includes focused case studies illustrating 7 applications in further detail. A number of factors have emerged from the analysis that determine the extent to which technology solutions can advance responsible production and sourcing in the minerals sector. The analysis also considers whether these factors are preconditions for technology use or secondary considerations, albeit still important.

Technology solutions are increasingly making their way into the responsible production and sourcing space, the minerals sector included. Blockchain solutions are gaining momentum, and in 2020 the Responsible Minerals Initiative (RMI) published their [Blockchain Guidelines](#) which aim to reduce the fragmentation of blockchain projects by recommending a set of fundamental attributes for projects to include at each stage of mineral supply chains. Blockchain represents just one of the technologies being applied in the sector, as presented in the case studies and annexe, technology applications are also emerging in areas such as due diligence processes, data collection, digital payments and impact monitoring.

The opportunities brought by technology are clear but, at the same time, the review of secondary data and the interviews with stakeholders confirm **that no technology solution alone can replace the role of people and processes in responsible mining and sourcing practices.**

TECHNOLOGY LIMITATIONS

People and process first, then technology

The research confirmed that all technology systems should be treated as tools and not as overarching solutions to addressing responsible minerals production and sourcing. While technology solutions can represent valuable tools for making processes more efficient, they are not a substitute for due diligence processes and procedures. At an operational level, trying to implement a traceability and due diligence technology solution without first establishing basic processes and understanding of due diligence will mean that the initial investment, onboarding of stakeholders and design of process will take much longer. Beyond the operational challenges, an understanding of due diligence and implementation of processes represent a fundamental precondition for the success of the technology application on its own terms. Technology solutions such as blockchain, for example, can provide an incomplete picture of integrity and responsibility taking place within a specific supply chain without proper due diligence and risk management being put in place as essential complements to the technology[21]. This finding represents one of the most important outcomes of this research into the effectiveness and impact of technology applications. However, if the following conditions are met, technology systems are well positioned to deliver benefits.

- **All relevant stakeholders should be informed, engaged and provided with the resources** to implement responsible production and sourcing practices.
- **Responsible mining and sourcing processes should be established before applying a technology solution.** People should be clear on their role and they should benefit from these processes, rather than perceive them as a burden.
- **These processes should fit well with the context and the needs of the key stakeholders involved in their implementation.** This finding is aligned with the importance of bottom-

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[21] 2019, South Africa Institute of International Affairs, Blockchain in the Mining Industry: Implications for Sustainable Development in Africa, Filipe Calvão, Victoria Gronwald

up approaches, detailed in the next section. For example, combining the needs of miners to improve mining practices with the needs of buyers to gather due diligence information.

Once people are engaged and the processes are clear, technology can play a role in terms of streamlining, scaling, and increasing transparency and efficiency. However, data quality verification, information vetting, capacity building and risk mitigation remain fundamental complementary elements of technology applications.

Misuse of information collected through technology solutions

A number of the technology solutions listed in the following section focus on providing invaluable information to help manage risks and impacts throughout mineral supply chains. However, during stakeholder interviews and analysis it emerged that if the data produced is misused due to biases (e.g., based on preconceptions by any stakeholders, including regulators and companies) technology solutions could also pose a threat to supply chain actors. In the case of a company using the data from a technology solution for risk management, if the context is not properly considered or understood (e.g., large scale mining companies engaging with ASM around concessions or community), it could result in the implementation of inappropriate risk mitigation measures.

Due diligence or broader responsible sourcing reduced to traceability

Tracing of the material along the supply chain is a crucial component of due diligence and responsible sourcing efforts. However, a fully traceable commodity is not necessarily a responsibly sourced one. While an increasing number of traceability solutions are being developed, it was observed that most use 'responsible sourcing' terminology when communicating their role. More clarity should be sought to ensure that technology solution providers differentiate between traceability, due diligence for compliance purposes, and broader responsible sourcing efforts which go beyond OECD Due Diligence Guidance risks to address a wider range of social, environmental and governance impacts.

Challenges related to lack of security

In areas where violence is persistent and security is not guaranteed, implementation of any system becomes more challenging and less effective. Effective implementation requires stakeholders (supply chain actors, civil society organisations, government, etc.) to be able to operate safely and to properly monitor supply chain risks and implement mitigation actions.

Mineral supply chains can be crowded and complex ecosystems

Technologies can face challenges when applied in complex and crowded ecosystems. For instance, in the context of artisanal and small-scale mining, the number of people involved in any mine site or mineral production makes the implementation of any process or system more convoluted. From the point of view of a large-scale operation this complexity might reside in the diversity of the setting around any mine site, where the socio-economic and environmental impacts to be managed can vary.

A limited application of technology solutions in eastern DRC and in the 3TG sector

The lack of accountability in 3TG supply chains is considered to be one of the main limitations for the application of responsible sourcing systems, including those using technology. The main barriers and challenges to increased accountability include the involvement of armed groups, false declaration of minerals, child labour in mining, involvement of state armed groups, extortion of minerals, corruption, non-payment of taxes due to the state, weak capacity of public agents, fraud, limited control of financial and material flows, absence of a gold traceability system, lack of due

diligence by gold comptoirs, and more. To this list can be added the high cost of traceability. Any system to improve the degree of accountability in the supply chain should include due diligence processes, data collection, impact monitoring, traceability and education. In addition, any implementation of technological solutions should be subject to a multi-stakeholder approach involving the state, the private sector (economic operators in the mining sector) and civil society at all levels of the chain.

ENABLING FACTORS AND OPPORTUNITIES

Bottom-up approach

The importance of bottom-up approaches was highlighted by several interviewees and in the data collected on the implementation of the technology solutions. Further insights detailed the stakeholders that should be involved and the factors that make a bottom-up approach successful. Notably, many technology solutions are driven by mid-downstream needs for assurance, traceability and due diligence information. While this might reassure companies in terms of compliance, the actual impact on supply chain risks and their management and mitigation requires further assessment and reflection. This view is supported by a 2019 study of due diligence programs in eastern DRC which showed that these did not achieve positive impacts even on major risks such as child labour, forced labour or miners' income[22][23]. The compliance-driven nature of the minerals sector is therefore reflected in the focus of that many of the technology solutions or due diligence systems being deployed. Opportunity exists for implementing systems through a bottom-up approach, even if not through technology at first, that also promote the inclusion of those in the supply chains such as miners, workers and their communities.

Project ownership by local stakeholders, including CSOs

Ensuring that local stakeholders become the lead promoters of the technology solution and its processes was reported to be another important success factor. Engagement and co-creation with local stakeholders should start early, be addressed properly and be factored into the implementation plan, as they are likely to require sensitisation, onboarding time, and capacity building resources. Local stakeholders also play a crucial role in terms of ground-truthing information being collected through technology applications. In the long-term this approach has the potential to create a sustainable and effective model which is owned and promoted by the community and creates value for the mining communities themselves.

Local government engagement

Many stakeholders interviewed recognised and have experienced the importance of engaging government institutions in addressing mineral supply chain risks. They recognise the role of the government in terms of formalising (especially in the case of ASM) and regulating (both ASM and LSM) mineral production and trade. In addition, the government can also support the implementation of a given system, by endorsing it or even integrating it within their own regulatory and formalisation processes (which include traceability systems in the DRC). Local government authorities should be empowered, supported and involved in the implementation of any system.

Opportunity for country-wide solutions embedded in minerals governance

Some stakeholders interviewed recognised the potential of implementing technology solutions country wide and their promotion by the government as a component of minerals sector

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[22] IPIS/ULULA, Assessing the impact of Due Diligence programmes in eastern DRC: A baseline Study, IPIS report, April 2019

[23] A new report is expected to outline the impact of Due Diligence Programmes in eastern DRC, however given the timing of this report, the most recent publication is not covered by this report.

governance. While this represents a potentially desirable scenario, the data surfaced through this scoping exercise and summarised in the previous section (e.g., vast geography, complex minerals sector, required strengthening of governmental institutions) also pose limitations to the feasibility of a country-wide solution.

Access to ongoing data at mine site to manage social and environmental impacts

Technology solutions, including mobile applications, can represent a tool for social and environmental impact monitoring and management. From the mapping of initiatives and some stakeholder interviews there is evidence that reliable, continuous data access is a significant enabling factor. As well as guaranteeing data users adequate access to information, it can also help to guide targeted mitigation and management measures.

Interoperability of technology solutions

Interoperability is addressed in this research as far as available data permits. However, a couple of factors limited a fuller assessment. First, many of the solutions analysed are still at early stage of development, proof of concept or implementation. As a result, while none have excluded the possibility, not many have already explored interoperability in detail. Second, detailed interoperability features are likely to be developed based on specific needs and clear expected outcomes which allow the move from a conceptual possibility to factual propositions. Despite the limited assessment of this criteria, it is evident that promoting interoperability in, for example, risk monitoring and traceability, among complementary and existing systems would be advantageous for both providers and users of technology solutions.

Scaling impact

Several of the solutions and technology applications described in this document present technology as a driver for scaling impact. The potential of technology to increase scale includes, for example, reaching a broader group of miners for training, being able to trace larger volumes of material, or monitoring of extended locations through satellite images and technologies. The following factors have an influence on the potential for technology solutions to work be effective at scale.

Resources required for scalability

Analysis of different systems has highlighted that sustainability and scalability are rarely a limitation of the technology itself. In most cases, once the technology has been developed, maintenance and scalability costs are limited. Instead, most effort is required for activities related to processes and people. The onboarding of stakeholders, engagement of local authorities, and institution of processes were identified as the factors requiring the greatest resources at any scale.

Use of mobile phones and tablets

The success of some solutions is linked to the use of mobile phones and simple communication systems such as SMS. Simple technologies might be more usable and accessible for a larger number of people and their potential should not be underestimated.

Energy provision through solar panels

There is an opportunity to explore further collaboration with solar energy providers to potentially address the challenges around access to energy, which could contribute to the advancement of technology applications across wider geographies.

Part 3: Stakeholders' perspectives on industry-wide application of technology solutions

Industry-wide application of any system, including systems using technology applications, can generate greater impact. By 'industry-wide' we mean not only companies in the same sector who have minerals in their supply chains, but also all companies in the supply chain of a specific mineral. The opportunity for industry-wide application was explored with interviewed stakeholders conceptually, and there is an opportunity for further research to individually assess each technology solution, and the surrounding ecosystem, for potential industry-wide application.

The interviews highlighted the following insights with respect to industry-wide applications.

- **Industry-wide applications could guarantee a more level playing field and less burden on producers** by aligning requirements and systems used.
- **They would promote collaboration among companies from the same industry, and potentially competitors.** It was acknowledged that this might be challenging in some circumstances and competition would need to be taken into consideration in the design and adoption of any industry-wide application.
- **Systems and processes should be established before deploying technology solutions.** Stakeholders reported that technology solutions are still not able to address and solve many of the risks and challenges within supply chain operations. In some reported examples, technology may contribute 10%, while the remaining 90% comes from people and processes such as good due diligence, people's behaviour, training, awareness raising, and mitigation. Technology solutions should be aimed at supporting existing initiatives that have processes already in place which are scalable and ready to move beyond a single pilot project.
- **With any proposed technology solution, companies should be mindful about pressuring supply chain actors to adopt digital processes**, especially where they continue to prefer physical documents over digital ones.
- **Technology should be used where it adds more value, especially for data collection, recording and processing**. However, respondents highlighted that accurate data collection will still depend on the stakeholders producing the information.
- **The local government should be engaged from the outset** to ensure alignment with any institutional initiatives, local needs and to enhance application of the proposed system.
- **Some industry initiatives may not be willing to endorse any specific technological solution.** For instance, the LBMA has taken the deliberate decision not to promote any system given the commercial interests of most initiatives. This is also motivated by their desire not to be perceived as imposing any solution onto companies in their industry. In all cases when proposing a technology solution the different commercial interests and intellectual property aspects should be considered.
- **Mobile money solutions are considered to have untapped potential** to help formalise the sector, especially ASM, and support its recognition as an economic activity.
- **Requirements for industry-level application include cost-effectiveness, scalability and simple usage.** RMI, for example, has reported that their most used tool today is still their conflict minerals reporting template (CMRT), which is a simple Excel file.
- **End-to-end solutions should be sought, as technology applications should be able to collect information upstream in a manner which is relevant both for upstream and downstream actors**. Stakeholders reported that only very few systems are close to end-to-end scope. ITSCI and the Better Sourcing Program (BSP) were highlighted as being among this group.
- **Ideally, there should be a leading organisation which is able to bring all the existing initiatives together and support implementation of an end-to-end system.** Respondents

have not indicated any specific organisation which could play this role. While the identification of a lead organisation was recognised to be a difficult task, stakeholders were able to outline the characteristics it should have:

- o Be able to gain producer countries' buy-in, and ideally be based in the country of mineral production
- o Be open to utilise existing tools, processes and initiatives
- o Have a clear value proposition on how the system is benefitting local communities
- o Focus on improvements in mining practices and not only assurance for buyers

CASE STUDIES

This section presents 7 case studies representing a deeper dive into a selection of technology solutions from the 19 mapped in Annexe 1. The case studies present a qualitative analysis of each solution based on the criteria listed below. As their focus of application differs, solutions have not been benchmarked against each other quantitatively.

The information included in the overview of each solution is:

- About (a brief description of the technology, its objectives and scope)
- Value proposition
- Key stakeholders
- How it works

The criteria for the analysis are:

- Current application: the extent of application and whether the solution is at development, pilot or implementation stage.
- Feasibility of application in the DRC: perspectives from local stakeholders on the feasibility of the solution.
- Measured impact, success factors: how has the solution been measuring impact and what have been the factors influencing success.
- Limitations, lessons learnt: description of challenges and lessons learnt from the application of the solution.
- Interoperability: to what degree is the solution interoperable with others.
- Adaptability, scalability and sustainability: to what extent the solution is adaptable and scalable to new geographies and minerals and what considerations have been made in terms of its sustainability.

The case studies record the views of stakeholders interviewed, presented alongside publicly available information. They do not represent Levin Sources' direct opinion on the technology solutions and should not be interpreted as endorsement or otherwise of any of the individual commercial offerings. The providers selected for the detailed case studies were guided by specific interests of the private company that commissioned the research from which this report draws. Aside from ensuring a range of technology solutions are represented in this section, the selection or non-selection of a product or offer does not represent a judgement from Levin Sources on any other measure. Each case study presents a summary of findings from interviewees and secondary research according to the criteria listed above.

The case studies are presented in alphabetical order.

ASMSpotter

ABOUT

ASMSpotter is a machine learning application that automatically identifies artisanal and small-scale (gold) mining sites (ASM) on satellite imagery (Sentinel-2 and Planet Scope), based on a large training dataset and computer vision algorithms (CNN / U-Net). The technical feasibility was examined in a project with the European Space Agency in Suriname with a pixel-wise accuracy of more than 80%.

ASMSpotter was developed to help address the following issues associated with ASM and its impacts:

- A lack of recent and continuous data on the scale and impacts of ASM.
- ASM globally is predominantly informal and un(der)regulated (70-80%).
- ASM is primarily located in developing and low-middle income countries where resource constraints hamper monitoring, which is a crucial tool for improving regulatory compliance.
- While providing a livelihood for millions (40 million directly and 100-200 million indirectly), ASM is also commonly associated with negative social and environmental impacts.
- Poor understanding of ASM leads to poor policy making, which leads to a sub-optimal enabling environment to incentivise formalisation of activity, resulting in a vicious cycle of informality and negative impacts.

Potential users of the solution include:

- Governments, to support their understanding of the sector, acquire baseline data and inform policy and formalisation efforts.
- Development partners and international organisations or civil society, to support their programmes on the ASM sector.
- Large-scale mining companies and companies sourcing minerals, although the market viability is still being explored.
- Industry associations or multi-stakeholder platforms interested in joint monitoring of the ASM sector.

VALUE PROPOSITION

While the use of satellite images for monitoring purposes is increasing, the added value of the ASMSpotter resides in the machine learning and AI component, which aims to facilitate and speed up the alert system, supporting human driven processes such as risk monitoring and mitigation. This also contributes to reducing potential negative impacts. Importantly, human interaction remains central to improving the algorithm.

ASMSpotter differentiates itself from solutions focused on tracing a specific mineral by providing information at macro-level, for example by identifying production activity over an extended geographical area. As a result, it can provide information about the broader context and help to identify red flags or risks and impacts which require close (and on the ground) monitoring. The involvement of local stakeholders remains pivotal as they will be able to provide ground-truthing and confirmation of the information being identified by ASMSpotter and further analyse its implications and risks. The main advantages of the solution can be summarised in the following points:

- It supports the automation of ASM impact monitoring in a timely manner.
- It can provide early alert mechanisms for regulatory non-compliance by, for example, overlaying of data with cadastral information.
- It can quantify the scale and expansion of mining activities in given areas.

- It could be used to quantify and classify mining operations, by including proxies for illicit activity, population, production, spatial impact and mining types.
- It helps understanding of the evolution and trends of the sector to better inform appropriate policy and programme design.
- It can contribute to better, more accessible data on ASM value to the global economy to support advocacy.
- It can inform the redirection of programmatic resources into support and improved enforcement measures that contribute to sector formalisation.

HOW IT WORKS

ASMSpotter helps public authorities and industry (large-scale mines, buyers, associations, etc.) as well as civil society or international organisation to identify, monitor and assess the direct, indirect and cumulative impacts of artisanal and small-scale gold mining (ASGM) over large geographic regions. It does this by automating the detection of ASGM sites through the application of machine learning and computer vision algorithms to satellite imagery effectively and continuously.

The solution has the following product options:
- Map and track ASM
- Alert system
- ASM monitoring / baseline data

In addition to continuous monitoring, the solution can also analyse historic data and create a system of early warnings based on these analyses.

The ASMSpotter solution combines the advantages of machine learning technology with human ASM expertise, which is crucial for analysing the data in the context of the sector and its characteristics.

CURRENT APPLICATION

Following the pilot stage, several countries and partners are currently being explored for implementation. These are in Latin America and sub-Saharan Africa, and especially in rain forested areas.

In Latin America there was interest in using the tool to identify areas where mining could take place and where it should not. This would also mean using the tool to forecast impacts which are likely to materialise or not in different geographies.

Currently, ASMSpotter works with open-pit mining operations only. However, through the use of visual proxies, the solution could be advanced and further developed to also detect other types of mining.

The team is also interested in using ASMSpotter to explore the role of ASM mining in terms of deforestation and other impacts.

FEASIBILITY OF APPLICATION IN THE DRC

Implementation of the system in the DRC is not under consideration for the time being. However, local interviews confirmed that the system might be very useful for government authorities to map mining activities. In addition, LSM companies and industry associations have shown interest. Should the system be considered for the DRC, local civil society should also be involved to support collection of information locally, potentially contributing to ground-truthing.

LIMITATIONS

Given the early stages of development and application, the identification of limitations has been restricted to a few factors. From a technical point of view, humidity and clouds can inhibit usage and make it harder to detect ASM activities. Activities taking place close to water sources, such as along rivers, can also make it harder to detect ASM.

The usage of the system also presents a specific risk of data gathered through ASMSpotter being misused or leading to rights infringements. For this reason, the use of the technology solution is paired with the advisory and expertise of consultants which can guide users in how to best use the data, and reduce the negative impacts and risks of misusing the data. ASMSpotter comes as a package that includes the technological solution, user guides and modules that govern the application and use of the tool.

INTEROPERABILITY

The team reported that they often receive requests in terms of interoperability of their solution. The specific files from ASMSpotter can be exported as geo-referenced files and integrated in geographic information systems. In general, the team assesses that developing interoperability is feasible and will ultimately depend on the specifications and requirements of the client's or user's system.

ADAPTABILITY, SCALABILITY AND SUSTAINABILITY

The solution is currently applied and tested in forested areas. However, interest has been shown by large-scale mining operations in other topographies, including the Sahel and sub-Saharan Africa. While there are challenges with recognising changes in patterns in arid areas, these can be overcome by the usage of proxies such as transport infrastructure or increase in population to enable use in other topographies.

For sustainability and scalability, it would be crucial for regulators or industry initiatives to promote its implementation. The following limiting and enabling factors also apply:

- Access to satellite images in a certain area.
- Time and resources to collect training data, this may represent the most significant requirement for scalability, since the AI software needs to learn on large datasets. The labelling of training data takes place manually and between 500 and 1000 images are required to start a new application of the software.
- The geographic scope is less of an issue in terms of expansion; however, there are links to some of the other factors such as topography, availability of satellite images and resources to collect training data.
- The cost of scaling is estimated to be about €150,000 per new topography and mineral, however some scaling economies could be identified over time.
- By including more and more regions and types of ASM, the AI will learn to generalise, so progressively less and less training data will be needed to fine-tune the models.

DataStake and the Consolidated Autonomous Due Diligence Framework

ABOUT

BetterChain focuses on scalability and sustainability of the due diligence process. It aims to achieve this by building the capacity of upstream supply chain participants to meet expectations set by the OECD Due Diligence Guidance. The company has developed information management processes and systems for local stakeholders to collectively and dynamically document risk and impact of the mining and minerals trade sector.

The framework incorporates a triangulated KYC process, structured description of risk management systems deployed along the supply chain, as well as evidence of risk identification, assessment and mitigation. All resulting information is organised in a standardised format for smelters and refiners to secure audit readiness. For BetterChain, access to reliable data is central to efficient risk management, which is at the core of due diligence processes. With the resulting information serving broader investment, international development and CSR objectives beyond compliance, the company's core assumption is that upstream due diligence activities can be funded through unlocking data value. When scaled, this approach can support end-to-end supply chain due diligence and facilitate targeted engagement to solve local development challenges.

Main components of the BetterChain model include:

- Consolidated Autonomous Due Diligence (CADD), which was developed with support from the European Partnership for Responsible Minerals. CADD is designed as a public and open-source framework to organise and compile information available to any stakeholder in resource-rich countries. Standardised data helps raw material producers in their compliance strategy and aligns global reporting on provenance risk and supply chain impact. It is primarily intended for risk management and community feedback in the mining and minerals trade sector.
- DataStake[24], a microservices application built on a MERN stack, provides information management systems for business and civil society actors in CAHRAs. With all users organising their respective information along the common format built into DataStake, the application facilitates consolidation and dynamic analysis. By providing direct utility to local stakeholders, DataStake incentivises consistent reporting by all parties, which enables secure sharing of information between them. The Code of Risk mitigation for ASM engaging in Formal Trade (CRAFT) Assessment and Sustainable Mines Program developed by the Alliance for Responsible Mining (ARM) are also being built in DataStake.

VALUE PROPOSITION

The framework was conceived to unlock information readily available to stakeholders present in-country, from mining companies and cooperatives to government and development actors, so that it can be leveraged as part of exporters' efforts to comply with applicable standards and regulation. The approach incorporates a continuous improvement component in that all outputs are rated, and users can monitor progress in each category over time. DataStake's founders have expressed the conviction that information consolidated continuously from 10 local organisations carries more value

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[24] https://datastake.io/

than the annual report of an international expert. To guarantee this value, the following factors and actions are considered:

- Reliability of the information is based upon:
    - Systematic deconstruction of risk assessment into objective, close-ended questions
    - Multiplicity of providers of the same information
    - KYC checks on information providers (including conflicts of interest and information collection process)
    - Under development: random check audits of information providers, rating model for information providers
- However, CADD does not assume that buyers and other stakeholders requiring access to due diligence data will systematically trust actors providing information. In this regard, the application achieves standardisation of assessment and audit checks by international experts, so that they can be directly reconciled and compared with local stakeholders' continuous feedback.

KEY STAKEHOLDERS

Supply chain actors themselves (cooperatives, comptoirs), local CSOs, government institutions, international programs and initiatives active locally – all are seen as potential information sources and contributor to the due diligence process.

HOW IT WORKS

Datastake works as an information management portal for its users, who all become potential information providers and contributors to due diligence activities. The system comprises two modules: one for supply chain participants (which incorporates the CADD framework) and another module for what BetterChain describes as Auxiliary Information Sources (AIS). While CADD was initially built on OECD Guidance Annex II risks, the DataStake implementation of CADD covers a much larger spectrum, for several reasons: (1) the need to detail further some of the risks included in the Annex II (e.g. money laundering), (2) development of more specific criteria on human rights violations (e.g. modern slavery categories, sexual and gender-based violence), (4) the recently-announced collaboration to incorporate CRAFT, (5) interest in other datasets expressed by stakeholders.

Besides supply chain participants or their consultants, users may be CSOs or government institutions[25]. At this stage, AIS are organisations which have been vetted and trained by the BetterChain team so that the questions being asked are clearly understood and contextualised. Data is compiled primarily through a browser on a laptop, so the system is not an on-the-ground data collection tool. Information aggregators (users) collect information from their network (identified in the system) or may record information on notebooks while visiting sites themselves.

In DataStake, information is organised into subjects; locations, stakeholders, events and subjects can be linked. The system can then recognise information provided on the same subject by multiple users, and support comparative analysis. Each user has full control over the information compiled in the system. Sharing with other users is subject to approval and is handled via information sharing projects and a publication feature on the platform. Thus, DataStake facilitates mapping of the data chain of custody and the identification of primary sources of information.

Data outputs are tailored to each client's requirements. These currently focus on:
- Supply chain due diligence compliance reporting (for mineral and metal buyers)
- Mine site risk summary and management planning

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[25] Contribution by government actors has yet to be demonstrated as of this report

- Supply chain mapping / trade relationships
- Incident monitoring
- Localised SDG performance

CURRENT APPLICATION

CADD framework development started in 2019 and DataStake development started in February 2020, when it became apparent that the complexity of spreadsheet-based reporting processes could not support CADD deployment. The application went live in September 2020, with test implementation starting in the DRC, Burkina Faso and Sierra Leone.

- Beta users
  - 3 exporters (3TG)
  - 2 international traders (3TG)
  - 4 civil society organisations
  - 1 consultancy firm
- Subjects
  - ≈ 200 mine sites
  - ≈ 100 supply chain actors
  - ≈ 150 events

FEASIBILITY OF APPLICATION IN THE DRC

The system is currently being implemented in the province of Ituri. Factors influencing the success of local implementation have included:

- The establishment of a local and independent mechanism which can verify the information being shared through the system.
- Considering the involvement of state authorities, which includes ensuring their access to the information on the platform. However, the system is designed so that access to information should always be authorised by information holders.
- Ensuring clear responsibility in terms of management of the risks identified.
- Local NGOs involved needing a certain level of financial resources to sustainably engage.
- Ensuring clear difference between overarching due diligence, including traceability information, and sole traceability services.
- Support for the expansion of the system with development agency funding and downstream companies.

MEASURED IMPACT / SUCCESS FACTORS

As the system is still at its early stage of implementation, limited impact can be measured so far. Specific success indicators are:

- Number of DataStake active users (in-country stakeholders leveraging the solution to improve their information management)
- Number of data clients (number of global users seeking data from DataStake users)

Another important success factor identified concerns the definition of incentives for data aggregators, meaning that the data should be helpful for them as well. In the case of CSOs, the

system has helped local NGOs to organise the data they were already collecting and make better use of it, such as using it for their own reporting to donors and for proposals.

In addition, DataStake aims to help reduce due diligence costs, which can represent a direct incentive for illegal trade. DataStake also seeks to disintermediate the narrative of local stakeholders. Finally, it also aims to promote synergies with development programmes to leverage their actions and insight as part of due diligence efforts, for example, connecting peacebuilding activities undertaken in a conflict affected mining area to that location's risk management planning.

LIMITATIONS / LESSONS LEARNT

The main challenges identified so far include:

- Designing the questionnaires for data collection so that they are easily understood and used. Information aggregators need to be able to understand exactly what kind of information is being sought.
- Unreliable connectivity, especially linked to bad weather conditions, make remote working with local partners more challenging.
- Local confusion about the different technology / innovative solutions being proposed to the sector, so stakeholders might not immediately grasp the expected positive outcomes and ultimate purpose.

INTEROPERABILITY

Custom APIs can be developed, and this is a model which DataStake will actively pursue. Currently the application integrates with Kobo Toolbox (offline data collection system) and Power BI (Data Client data processing). DataStake can also incorporate IPIS mine data. Other integrations being discussed actively include digital payment data, data from alternate chain of custody tracking systems, and downstream chain of custody systems.

ADAPTABILITY, SCALABILITY AND SUSTAINABILITY

With EPRM support, the CADD was specifically designed as an OECD Guidance upstream implementation framework which can be applied globally, irrespective of mineral. The data standardisation approach implemented by DataStake supports easy adaptation to new contexts. In practical terms, each new country or mineral may involve specific sets of questions at location assessment, supply chain identification, or shipment identification stage. As a result, the main adaptations required involve the development of a structured template and customisation of data output. An example of this adaptation process was the incorporation of CRAFT standards as part of ASM Producer monitoring, which involved building CRAFT risk management principles into the questionnaires available to users.

In terms of scalability, DataStake was designed to achieve greater scale, following the founders' experience with other due diligence programs for ASM. DataStake aims to generate incentives for stakeholder participation in the data economy through provision of information which they can use to raise their profile or attract new forms of funding. The underlying idea is that data users should pay for the data, supporting not only the costs of the platform but also contribute to the efforts of information providers and aggregators. The long-term funding model has not yet been defined but consideration is being given to applying transaction and/or subscription-based fees. However, once the system is built, its maintenance costs are limited.

Interactive Voice Response

ABOUT

Interactive Voice Response (IVR) is a mobile phone-enabled training tool that aims to bridge language, distance and literacy gaps. It allows customised training to be delivered by phone at a time convenient to the user.

Solidaridad started their gold program in Ghana in 2012 with the objective of promoting inclusive mining. Initially they aimed to implement the Fairmined standard and support producers to meet the certification criteria. However, they found that the Fairmined criteria were too ambitious to be met in one step and therefore worked with the Alliance for Responsible Mining to develop the Code of Risk mitigation for ASM engaging in Formal Trade (CRAFT) which is a continuous improvement tool based on the OECD Due Diligence guidance and adapted to the ASM sector. Through their work they focus on building the capacity of the ASM gold supply chain actors to comply with the CRAFT requirements in the short term and the Fairmined Standard in the medium to long term. They apply a train the trainer approach where they train key people at the mine sites who are then expected to train others. Training content includes all the central topics of the CRAFT requirements including health and safety, labour conditions, mercury use, environmental management, etc. IVR was implemented before the COVID-19 pandemic as a tool to expand training outreach. IVR is a useful tool for miners to access information easily, as all they need is a simple phone, with no smartphone or internet connection required.

VALUE PROPOSITION

IVR is a solution to upscale education for miners on responsible practices and reach more individuals. The tool was also used to educate miners on COVID-19.

KEY STAKEHOLDERS

The key stakeholders for IVR's implementation include:

- Minerals commission at national and district level (governmental institution responsible for mining). The approval of the local / national regulator and of the institution responsible for the sector is essential as they need to be aware of what is being implemented and what information is being shared with miners
- Ghana National Association of Small-scale Miners (GNASSM) – crucial in gathering phone numbers of miners
- Mines management
- Telecommunication companies
- CSOs

HOW IT WORKS

IVR was implemented as a complementary tool for education using the following process.

1) A baseline survey was conducted, which also served to understand whether miners would be open to mobile education. Other themes in the survey included the type of mobile phones used by miners, type of network, level of knowledge on major issues, language being spoken by the miners, what time of the day they would like to receive information (since miners would need to attend a phone call and it might not be easy for them to do so while working during the day), and frequency of IVR calls.
2) Using the baseline data, Solidaridad prepared the content and information to share with miners through the IVR. This included preparing questions and providing answers.

3) All content was then translated into local languages.
4) An arrangement was then made with telecommunication providers so that they can send the information to miners. The providers receive a commission.
5) Information is sent to miners at the suggested times. Miners receive a call from an automated message which asks questions. Miners respond by pressing phone digits and based on their response they are provided with training content and answers to key questions.

CURRENT APPLICATION

The IVR tool has been implemented in the ASM gold sector in Ghana for 3 years and it has reached 4069 users. Given its focus on education, the current application has contributed to improving the knowledge of users on responsible mining practices.

FEASIBILITY OF APPLICATION IN THE DRC

While IVR is not yet being considered for the DRC, the lack of reliance on an internet connection clearly represents an advantage for this application in the DRC context. It also has potential to enhance the capacity of operators along the ASM supply chain. Another advantage within the DRC is the presence of initiatives such as the Comité Provincial de Suivi des activités minières (Provincial Committee of mining activities in Sud-Kivu), which could support the implementation of the IVR tool in the region of Sud-Kivu, for example. In terms of challenges, the implementation of the IVR would still need to manage some instability in mobile network coverage. It would also need to find ways to incentivise the engagement of ASM operators and manage any negative influence of actors without an interest in the improvement of mining practices.

MEASURED IMPACT / SUCCESS FACTORS

As IVR is just one of the tools used to deliver their work, Solidaridad have not been measuring the impact of the IVR application alone. However, over recent years they have noted an overall increased level of awareness and understanding of responsible mining practices.

In terms of success factors, the importance of the baseline assessment for tailoring the solution to the needs of the miners was highlighted.

LIMITATIONS / LESSONS LEARNT

The main limitation encountered is that educational tools like the IVR only provide information and often do not follow up on the practice after the training. This can lead to persistent gaps in mining practices which cannot be addressed by one-off training. The tool is therefore seen as a complementary tool to, for example, training of trainers.

INTEROPERABILITY

The solution is not interoperable with other systems at this stage. Linkages with other solutions are being considered and could be explored further.

ADAPTABILITY, SCALABILITY AND SUSTAINABILITY

In terms of adaptability, the IVR tool can easily be adapted to new minerals, geography and stakeholder groups. However, this would require proper engagement with the new stakeholders involved and certain level of customisation of the training content to ensure it fits the needs of the new users.

The IVR tool can also be easily scalable in terms of price, number of users and geographic scope. Since the solution does not depend on internet connection, it can function in areas with poor or no internet coverage but does require mobile network coverage.

Ensuring funding and defining a solid business model are essential for achieving greater scale, improving viability and enhancing impact. Sustainability is often a challenge for solutions like the IVR and should be planned from the start. Solidaridad are currently studying three potential strategies to cover the ongoing costs of implementing the IVR solution.

1) Governmental funding for the initiative. This represents the most desirable solution as it is the responsibility of the government to provide the information communicated through IVR. As the tool's development has been largely completed it would be relatively straightforward for a government institution to pick up and continue implementation.
2) Engage telecommunication providers as funders through CSR and community investment programmes.
3) Develop an incentive scheme for mine management where increases in production are linked to payment for IVR use at the site.

Kufatilia

Kufatilia - Dashboard of incidents in Eastern DR Congo

ABOUT

Kufatilia is a tool developed by IPIS for Congolese CSOs to report and monitor incidents in eastern DRC in a transparent, independent and participatory way. The scope of incidents reported is in line with Annex II of the OECD Due Diligence Guidance on Responsible Minerals Supply Chains, including mining accidents, violence, child labour, environmental degradation, corruption and roadblocks. Incidents can be reported through mobile phones by sending a simple text to a local line with no smartphone required. The incidents are then managed by local CSOs who access the reports from the online incident database. Kufatilia provides a solution to the lack of systematic incident data collection in mineral supply chains such as in the gold sector in eastern DRC. Before the application of Kufatilia, local CSOs were reporting incidents without any systematic approach to collating data, monitoring their resolution and informing international stakeholders.

VALUE PROPOSITION

Kutafila provides systematic incident data collection and serves as a tool for Congolese CSOs to follow up on incidents.

KEY STAKEHOLDERS

Local CSOs represent the principal stakeholder group whose role includes the promotion of the incident monitoring tool among mining communities, ensuring follow up on each incident and taking actions for resolution. Mining communities and stakeholders are also important as contributors to the reporting of incidents

HOW IT WORKS

1) Anyone with a mobile phone and network can send an SMS with the word 'Kufatilia' to dedicated local lines on Airtel (+243974729100), Orange (+243850291251), Vodacom (+243824443391) or WhatsApp (+16475033558).
2) The first SMS will trigger a survey to facilitate the reporting of the incident. The survey can be anonymously filled in Swahili, Lingala, French, or English.
3) Reimbursement paid to the person submitting the incident for the airtime spent by sending the SMS.
4) The Congolese CSOs who have partnered with the initiative have access to the online incident database so that they can validate, follow up and evaluate all incidents. Incidents are then tagged as resolved, in process of resolution, unresolved or persistent.

CURRENT APPLICATION

Kufatilia was launched late 2018 and it is currently being implemented in the eastern provinces of the DRC, in particular in Haut-Uele, Ituri, Nord-Kivu and Sud-Kivu. Much information about Kufatilia's current application is available directly from the online dashboard. For the period between 01/01/2019 and

Status

Unresolved 29.8%
Resolved 37.4%
Persistent 19.8%
Monitoring 12.9%
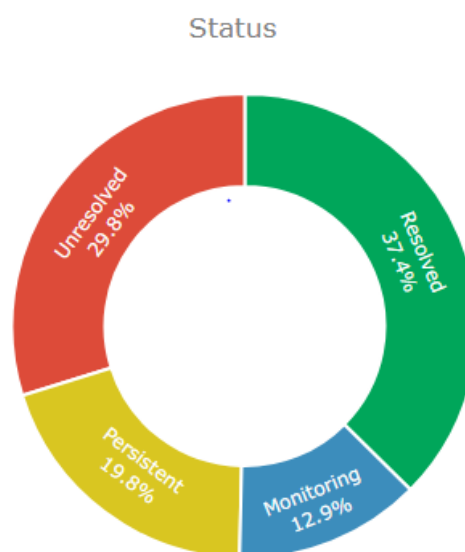
22/03/2021 there were 2387 incident reports submitted using the tool by 399 different users, the breakdown of incident status is shown in this graph from the online dashboard.

The categories of incidents reported were:

       a.   Violence or theft:790
       b.   Mining related: 713
       c.   Child labour: 323
       d.   Environmental issues: 156
       e.   Corruption or fraud: 143
       f.   Other: 136
       g.   Roadblock

Currently, about 25 local civil society organisations have access to the Ulula platform to review, manage and monitor the incidents and risks being submitted. Although the dashboard is publicly available, the details of each incident will be accessible only to the CSOs using the Ulula platform. While the public value of some of the information is recognised, the system aims at protecting confidentiality to allow for a more efficient and protected environment for the local CSOs involved in managing the risks, as ultimately the tool is for their benefit.

FEASIBILITY OF APPLICATION IN THE DRC

Kufatilia is already implemented in the DRC. During the research, selected local stakeholders have been interviewed to share feedback. It was reported that the system should and could be open to even more NGOs locally to allow more extensive risk monitoring. Also, the information collected could be more proactively discussed with local authorities to support advocacy activities to further address and mitigate some of the risks. In terms of limitations, while Kufatilia provides a platform to report incidents, it does not currently address some risks related to conflict financing and risks linked to the origin of minerals. It was suggested that more attention could be put towards monitoring these risks too.

Local stakeholders have also reported that collaboration with local supply chain actors should be explored given their responsibility to address the risks identified.

MEASURED IMPACT / SUCCESS FACTORS

The main metrics for measuring the success of the solution are the number of incidents reported and resolved. At the time of developing this report, almost 40% of the incidents were tagged as resolved in the online dashboard and the number of incidents being reported has been increasing since the start of implementation.

In terms of factors influencing success, the fact that the solution is based on SMS and requires a simple phone with no internet access increases its accessibility. However, users need to be able to read and write to use the SMS system. CSOs who then manage the incidents need internet access to enter the Ulula platform and visualise the incidents. The engagement of the Congolese CSOs and their ownership over the solution and process represents another important effectiveness and success factor.

Kufatilia could continue to be utilised during the COVID-19 pandemic as incidents are submitted remotely by mobile phone.

LIMITATIONS / LESSONS LEARNT

There are some limitations linked to existing infrastructure in eastern DRC and in particular network coverage. While coverage is increasing and gradually improving (including more and more people owning a smartphone), the reliability of the network is still unstable at times.

The engagement of local stakeholders has been central to the success of the incident tracker. It has also taken time for some stakeholders to truly understand their scope of work, for example at some stage of engagement, local stakeholders and CSOs have received comments from police institutions about the increased scrutiny on the supply chain and trade operations.

In addition, where the security levels are particularly unstable, it has been challenging for CSOs to manage and monitor some of the risks (e.g., in Nord-Kivu).

INTEROPERABILITY

The model uses datasets which are easy to export and have potential to link to other systems. Interoperability has not been explored in detail at this stage as this would be based on demand. At the same time, the confidentiality principle descried above could potentially limit the data which could be exported.

ADAPTABILITY, SCALABILITY AND SUSTAINABILITY

As the system is not mineral specific, it could be easily adapted to different requirements. The solution is quite solid and now that the system is set, maintenance costs are limited to the fee for the Ulula (platform provider for the incident dashboard), the airtime credit to reimburse people submitting reports, and the support fees for CSOs to conduct incident follow-up activities on the ground.

In a new location, most resources would be taken up with developing the CSO network and informing stakeholders of the system, as they are the key users.

In terms of activities, implementation in a new location involves:

- Recruiting up to 10 CSOs in a given area and providing two-days' training as part of their onboarding process
- Setting up the campaign for the promotion and dissemination of the incident reporting system
- Guarantee a lumpsum value for the CSOs responsible for following up incidents. This is a lump sum instead of a fee per incident as IPIS did not want to monetise the management of incidents. This lumpsum value also depends on the budget and funding available.

The current model depends on external funding to cover the limited ongoing costs. IPIS have attempted to engage telecommunication companies for support with this, with limited success so far.

Local accountability and security also affect scalability and application, meaning that local stakeholders should take ownership of the process seriously and it is important that it should be safe for them to do so.

In terms of geographical scope, IPIS is currently exploring opportunities to deploy Kufatilia in Katanga where cobalt is produced. Finally, while expanding Kufatilia in the DRC would be less costly than moving to other geographies, it could also be replicated in other countries.

Matokeo

ABOUT

Matokeo, which means 'impact' in Swahili, is a mobile-based solution developed by IPIS and Ulula to help monitor the social, environmental and human rights impacts of artisanal mining in eastern DRC. Matokeo aims to give artisanal miners and their communities a voice through reliable data collection about the impact of mineral supply chains. By responding to regular short mobile surveys, the miners can help downstream actors measure and understand the local impact of mineral extraction. Responding to the surveys is free (through automatic mobile credit reimbursement), anonymous and confidential. Matokeo will build on the partnership between IPIS, Ulula and a network of more than 20 Congolese CSOs formed to deliver the Kutifilia incident reporting and monitoring system summarised above.

VALUE PROPOSITION

The main objective of Matokeo is to build a robust citizen-centred database of respondents for human security, labour and environmental impact monitoring in the mineral supply chains in eastern DRC. IPIS and Ulula hope to be able to reduce the costs of data collection while offering robust continuous monitoring of major human rights impacts such as forced labour, child labour, gender violence, mercury use, and so on. Matokeo is not a certification or traceability system, instead the organisations aim to integrate it into existing mechanisms to create better data loops and support the voices of miners throughout existing mineral supply chains and traceability mechanisms.

HOW IT WORKS

Matokeo uses the numbers collected through the Kufatilia system to push surveys to incident reporters, allowing continuous impact monitoring which does not rely on incidents being reported. The team expects to send surveys out once every month.

IPIS and Ulula are also working on a further way to collect respondent phone numbers. Anyone who sends the word 'Matokeo' to a local Congolese phone number on Airtel (+243974729100), Orange (+243850291251), Vodacom (+243824443391) or WhatsApp (+16475033558) will receive an SMS stating the daily international market price for one gramme of gold. This information, which is already publicly available on the internet, can reinforce the bargaining power of miners and traders when negotiating price of artisanal gold (which varies in quality and purity) as a percent of the world price for gold. People who use this service will be added to the list of potential respondents for the impact monitoring surveys.

KEY STAKEHOLDERS

Informants along the mineral supply chain.

CURRENT APPLICATION

The system is developed and the official launch was planned within 2021. As a result, little data is available in terms of limitation and success factors.

FEASIBILITY OF APPLICATION IN THE DRC

Given Matokeo was not yet launched at the time of developing this report, only initial reflections were provided by local stakeholders. First, it was raised that the information collected should be properly contextualised during the data analysis. Second, besides providing pricing information as an incentive to participate in the surveys, local traders would also benefit from accessing a diverse

group of buyers. Third, once collected the data should be accessible to local authorities responsible for managing the impacts and risks identified.

ADAPTABILITY, SCALABILITY AND SUSTAINABILITY

Given the phone numbers are collected through Kufatilia, the implementation of Matokeo comes at limited additional costs. In this respect, the opportunities in terms of adapting and scaling the solution are similar to those of Kufatilia, as the system is already built, so it would simply be a matter of developing the contacts network in new locations.

Minexx

ABOUT

Minexx's digital platform MineSmart uses digital payments and blockchain to enhance transparency in mineral supply chains to benefit miners, traders, buyers and governments. Through the platform, Minexx facilitates trade while managing compliance requirements, information from involved parties and supports access to finance. In terms of payments, it digitalises trading transactions by recording payments and transferring funds from traders to miners.

In practice, Minex offers the following services:

- MineSmart – a operating system for ASM with access for co-ops, traders and buyers
- Minexx Trace – OECD aligned upstream assurance mechanisms including blockchain traceability and due diligence
- Minexx Payments – Digital payments via integration with mobile money providers and banks
- Minexx Financing – Access to capital for traders, cooperatives and miners through partnership with funds and banks
- Compliance: KYC and Anti-Money Laundering requirements, other requirements in line with the OECD Due Diligence Guidance
- Equipment and services marketplace (electricity, insurance, equipment, any other service that miners and traders would not have easy access to)
- Capacity building and financing: e.g., in 3Ts supporting semi-mechanisation of operations., support identification and mitigation of risks beyond OECD Due Diligence Annex II risks.

The platform can be accessed via desktop and mobile applications. Miners are also able to interact through SMS.

VALUE PROPOSITION

Minexx aims to become the trade facilitation platform between miners, the government and buyers. For each party, the main added value can be summarised as:

- Miners and cooperatives: formalisation tools and access to finance, and more value-added traceability process.
- Government: since the trade transactions are recorded it represents a tool for increasing revenues. Specific minerals value propositions include driving demand for investment (3Ts) and creating a formal trading route (gold).
- Mineral buyers: access to minerals and creating a more transparent supply chain whilst meeting the demands of regulators and conscious consumers.

Minexx's mission is to benefit miners first and foremost, so at this stage there is less focus on downstream companies. However, some companies have been engaged to ensure the information is also useful to them.

HOW IT WORKS

Cooperatives and mine operators use the MineSmart platform to manage operations at mine sites. Once partners are using MineSmart they are eligible for other Minexx products including Minexx Trace, Minexx Payments and Minexx Financing.

Minexx Payments integrates with mobile operators and banks. For each transaction, cooperative or mine operators can transfer the payments to miners. Payments to miners are currently managed through team leaders who are then responsible for distributing payments among the other miners;

in the future the aim is to be able to pay all miners directly. The onboarding of miners for digital payments also includes training for users.

The platform is linked to a blockchain solution so that every time data is recorded into the system it is also captured on the blockchain which records compliance information.

KEY STAKEHOLDERS

Defining key stakeholder groups beyond the three broad categories (miners, government and buyers) largely depends on the country and mineral in scope. In general, it has been reported that the government and institutions responsible for the regulation and functioning of mineral supply chains are central to the success of the platform. The government should also be highly involved in any buying scheme and they are continuously engaged to ensure they support and can provide feedback on the system. Larger or smaller traders should also be engaged according to the mineral in scope. However, engaging local traders who might not own a laptop can become challenging.

CURRENT APPLICATION

In 2019 Minexx began a pilot in the 3T sector in eastern DRC, originally working with local traders, mostly ITSCI members. During this pilot they have facilitated $250,000 of trade transactions, involved 1-2 local traders, 50 different mining teams and 1 buyer to date.

Minexx is currently undergoing the OECD alignment assessment, so that they can confirm their chain of custody is in line with the requirements of the OECD Due Diligence Guidance.

Minexx is rolling out the platform with a number of operators in the gold sector in other African countries.

FEASIBILITY OF APPLICATION IN THE DRC

Based on local interviews, the implementation of Minexx in eastern DRC is not yet well known. Given the scope of the solution, it clearly represents an opportunity to diversify due diligence solutions available to supply chain actors, however the challenge of due diligence costs borne by artisanal miners should be addressed. The digital payment element of the solution is another clear advantage, reducing money laundering risks and overcoming the challenge of physically transporting large amounts of cash. However, its success depends on several factors:

- Extending the mobile networks around mining areas, as many lack coverage.
- Including complementary financial services such as savings accounts. There are clearly several opportunities in this respect given the limited presence of financial institutions around mining areas.
- Extensive campaigning to raise awareness and train the community to use mobile money and digital payments and tap into the opportunity to extend this payment modality beyond the transactions linked to mineral trade.
- Developing a partnership with local authorities, supply chain actors and civil society for the implementation and monitoring of the system.
- Costs for miners and local traders should remain viable.

MEASURED IMPACT / SUCCESS FACTORS

Minexx reported the following metrics for measuring future success:

- Miners being paid regularly and on a monthly basis
- Improved access to services, equipment and marketplace
- 500,000 miners on the platform by 2025

- 100,000 head torches available to miners
- 1 billion dollars increase in government tax revenues
- Improving health and safety records at mine sites, and being transparent about incidents and fatalities (noting the under-reporting trend at present)

Minexx would also like to support alternatives for child labour. Some data in the platform could potentially raise red flags in terms of child labour, for example by observing fees paid to miners and detecting non-recorded subcontracting agreements.

One factor influencing success is that Minexx benefits from pre-existing relationships and engagement with banks and the government in the DRC. It was built on team members' previous experience in the energy sector, using mobile payments through the distribution of solar panels in eastern DRC, where miners were among their clients.

In addition, in respect of the 3Ts sector in the DRC, ITSCI has already laid the foundations for promoting formalisation with the established paper transactions representing a first level of formalisation.

LIMITATIONS / LESSONS LEARNT

During application in the 3T sector in eastern DRC, the following challenges have been identified.

- The complexity around each mine site and operation, with many people and entities involved. This also generates numerous taxes, both licit and illicit.
- Logistics and road infrastructure remain a limitation especially when combined with high levels of insecurity.
- Managing relationships with the different parties involved.
- The need to overcome the habitual use of cash.

INTEROPERABILITY

The system was built to be interoperable and is already integrated with another blockchain platform (Finboot). As the technology develops, Minexx are keen to explore synergies with systems using satellite images or Ulula, for example.

ADAPTABILITY, SCALABILITY AND SUSTAINABILITY

The Minexx model is designed to be sustainable, and the whole value chain has been considered in its development. The platform is built to be integrated within trade transactions and will be sustained by fees linked to each transaction. The fees will cover the trade facilitation, management of compliance and the operating system. Minexx presents itself as an alternative to third-party due diligence schemes because it aims to integrate due diligence within the trade transactions. Most significant investment is required at the initial stage when the platform is being set up, which requires significant efforts in terms of stakeholder engagement and onboarding.

Minotor™

ABOUT

Minotor™ is a mine site activity mapping, measuring, and monitoring service for remote inspection of mining sites around the world. It uses satellite imagery combined with the company's precision 3D mapping, change detection, and object recognition technologies to provide weekly, monthly, and/or quarterly mine site status updates on key operational, market, and ESG metrics such as estimating the volume and area of mining stockpiles, waste dumps, tailings dams, and excavations for open cast mining operations. Additionally, the service provides up-to-date, quantitative, and independent 'patterns-of-life' and environmental mapping through time, to reveal the evolving operational foot-print of a mine, the proximity to and extent of surrounding community settlements, land-use, and natural habitat. Furthermore, the service provides market intelligence on the status of mining operations, such as volumes of stockpiled material, to mine managers, regulators, and metals traders. In addition, through their solutions, Terrabotics can monitor industrial mining emissions. Emissions sensing, monitoring and measurement from satellite remote sensing platforms is in the early stages of R&D, trialling and testing, yet progressing as more capable satellites are launched each year.

The most important themes include reduction of risks to the environment and people and reduced footprint, through management of risks once identified. The technology was also well adapted to the COVID-19 pandemic as it uses remote sensing, which is a safe and non-intrusive way of mapping and monitoring remote sites, without requiring regular contact or travel for people.

The technology helps to monitor changes over time, and it helps identifying patterns over the life of a mine. Some examples of changes being monitored include population expansions and increased proximity to mining areas or identification of environmental sensitivities and risks (e.g., monitoring of tailings) or identification of illegal mining activities.

VALUE PROPOSITION

Minotor™ aims to increase transparency across the supply chain for natural resources by providing objective observations and measurements from an independent data source, regular data collection, ability to scale amount of data collected, use of automated technologies and transforming and analysing data. It can also represent an important tool for regulators or companies themselves to verify self-reported data or improve self-reporting.

KEY STAKEHOLDERS

Lately Terrabotics have received increased requests for their technology from investors and shareholders who are increasingly looking into ESG risks and impacts; and mining companies, who in some instances have requested support to respond to the pressure of investors (such as disclosing the existence and location of current and legacy mining tailings storage facilities around the world).

HOW IT WORKS

Example of application for large copper-cobalt mines in the DRC.

Their standard process follows three steps:

1) Baseline mapping (collect all baseline information from the satellite images, including pits, visible environmental impacts, population, water sources, etc.).
2) Based on data collected, create modelling and scenarios (i.e., risk materialisation). This step provides more data analysis and interpretation of the data collected through images. This is

part of the added value by Terrabotics as they provide not only the data but technical analysis of it as well.

3) Monitoring (looking back and forward). The technology allows to collect both historical data (where available) and to make forecasts for the future. An example of monitoring in the DRC concerns increases in population close to a mine, where Terrabotics could foresee an increased risk of clashes between the community and the mine. By providing this information, risks can be properly managed and mitigated. Ensuring proper handling of the risk is critical, however, as misuse of information could result in negative outcomes and present a rebound effect to the positive gains of the technology solution.

CURRENT APPLICATION

Terrabotics has provided solutions since 2013. The number of users will depend on the sector, and the number of companies using their solution from new sectors is rapidly growing. There is no limit to the number of mining companies, or operations that could be included. The way the data is presented is flexible, it can be defined by the client, it can be through online dashboard, downloadable image or excel files, API, etc.

FEASIBILITY OF APPLICATION IN THE DRC

The system has already been used for mapping and monitoring small- and large-scale mining operations around the world (in Botswana, Burkina Faso, Guinea, Liberia, Namibia, South Africa, and more). It has specifically been applied to large-scale mining in the DRC to help model risks associated with planned mine and tailings dam expansions in proximity to growing nearby settlements. In this respect, it has been considered as a potential additional contextual input to aid understanding artisanal and small-scale activities in the region.

MEASURED IMPACT / SUCCESS FACTORS

Terrabotics have worked with several mining companies providing analysis of satellite images, supporting risk identification, management, and monitoring. In terms of investors engagement, they have provided verification and objective evidence on ESG performance of mining companies. The solution can, in a timely manner, uncover differences between truth on the ground and information being reported by publications or local media. In one example they were involved in a project to correct the number and locations of mine tailings dam around the world for investors, as disclosed by mining companies.

LIMITATIONS / LESSONS LEARNT

Some of the challenges which have been identified include:

- Limited functionality in cloudy weather. This might undermine the quality of optical images or the availability of continuous data, which for monitoring purposes would represent sporadic gaps. Radar satellite imaging technologies are not affected by cloud, and are therefore used as a complementary data source.
- The need to be aware of legal licensing and regulations around sanctions when supplying data to legal entities within the DRC. For example, because of the U.S arms embargo on the DRC, images from U.S.-owned satellites cannot be used or be provided to DRC registered stakeholders. In this case, data sources originating from other nations can be used.
- The nature of a hands-off solution. Where the remote aspect of the solution presents its advantages to provide a wide-area and regular oversight, ultimately it is most effectively used in combination with at least periodic on the ground assessments to fully assess and understand risks, as part of a complete package.

INTEROPERABILITY

Terrabotics is keen to cooperate with other solutions. They know that their solutions work best when complemented with other data sets, such as ground collected data from field visits and/or ground sensor networks, which provide the possibility to compare and calibrate information. Based on the need they could combine their datasets with others using standard APIs and/or ad hoc workflows.

ADAPTABILITY, SCALABILITY AND SUSTAINABILITY

Terrabotics has developed significant experience in upstream extractive operations and they have provided Minotor™ in many different locations to date. They have also developed a standard workflow for adapting the solution to new locations.

It is foreseen that more and more data will be available and that the technology in this field will keep improving and be able to provide more accurate information. It will remain a service provided to interested parties, but it can really serve both the public and private sectors.

Terrabotics believes in the scalability of their solution. Entry prices are reducing, and they acquire physical and cloud computing power as needed. The aim is to eventually capture a near-real-time assessment of the whole supply chain for specific industries, particularly supply chains that rely on heavy upstream and extractive industries. They are also incorporating sensitive ESG factors, to further enhance financial decision-making. Further growth is planned and Terrabotics have capacity to quickly scale-up to cover new geographical areas in response to client demand.

CONCLUSIONS

These conclusions are grouped into three broad themes – (1) the scope for the technology sector to support responsible minerals production and sourcing, (2) the applicability of technology solutions within the DRC context, and (3) industry-wide lessons and considerations when exploring the integration of technology solutions into responsible minerals production and sourcing.

1) The scope for the technology sector to support responsible minerals production and sourcing

The solutions identified through this research were developed by, or in partnership with, organisations operating within the minerals sector to address common challenges with responsible mineral production and sourcing. **The developers are seeking to use technology as a tool for impact across issues including**:

- Facilitating due diligence and responsible sourcing processes to ensure compliance with industry recognised standards by increasing efficiency of data collection, incident reporting and traceability of minerals.
- Providing improved tools for local stakeholders to collect data including remote (geospatial) data, monitor and manage risks and share information with supply chain partners.
- Scaling impact by reaching more stakeholders and partners through common platforms for sharing data and knowledge.

Different levels of maturity are present among the initiatives and solutions outlined. The mapping shows that some organisations have well-established technology solutions based on previous and ongoing application while others are at the development or piloting phase. The journey to mature application and demonstrable use case can require technology solutions to show flexibility and adaptability to context-specific needs.

2) Applicability of technology solutions within the DRC context

- **Factors which currently might limit the application of technology solutions** include unequal access to basic infrastructure such as electricity and internet access, or cost barriers for such services.
- **Solutions which have engaged local stakeholders, including government are more likely to be successful**.
- **In the DRC, solutions which are not dependent on mobile and data connectivity appear to be more resilient**. Simplicity and ease of access to technology applications are considered to be central success factors for more than one initiative included in the report. Given the infrastructure and energy access limitations, this represents a major consideration in the DRC context.

3) Industry-wide lessons and considerations for the integration of technology solutions into responsible minerals production and sourcing

- **Engagement of local stakeholders from the outset is essential, including local government, supply chain actors and CSOs.** Although most of the initiatives described in this report are promoted by international organisations, the importance of working with local

stakeholders is widely recognised as being the only guarantee for the effectiveness of any solution, and also to ensure the solution creates value locally.

- **Implementing technology solutions based on strong foundations of established processes and behaviours for responsible minerals production and sourcing is essential.** This requirement does not undermine the role of technology solutions, it instead reinforces the importance of the preconditions that must be met before any application can realise its full potential.
- **Industry-wide application to test potential benefits of interoperability among different technology solutions is possible under certain conditions** which can be summarised as:
  - (a) Having a clear process for different solutions to be brought together and supported in their implementation.
  - (b) Ensuring producing countries' co-creation and early engagement.
  - (c) Focusing on end-to-end solutions and being clear on the value delivered to all supply chain actors.
  - (d) Identifying a group of first mover-companies willing to promote an industry-wide solution.
  - (e) Identifying an industry association that is willing to endorse a set of specific solutions to test interoperability and benefits to users.

RECOMMENDED FURTHER RESEARCH

This research is presented in the hope it provides new and relevant information for the mineral and technology sectors. During the research a number of opportunities have been identified to drill down further into some of the elements analysed. Considering this, Levin Sources would make these recommendations for further work on this topic.

1. Work with a narrower scope in relation to specific minerals or mining locations to further engage some of the technology solutions providers included already in this report with a view to establishing detailed practical use cases and recommendations on specific technological solutions.
2. Engage existing initiatives in the DRC and support partnerships to build on already established processes. This should include solid engagement with stakeholders on the ground and expanding the mapping of existing initiatives (not only those that are technology based).
3. Explore the role of industry associations in identifying what data captured by technology solutions could bring value to different actors along the supply chain.
4. Expand the research to include mobile money solutions, including those currently operated by Congolese financial institutions.
5. Further research into the practical application of some of the solutions by large-scale mining (LSM) operations.
6. Map all technology solutions against the different due diligence steps to clearly understand where they fit in the broader due diligence process. Clearly identify how information derived from each of the solutions could answer specific transparency questions downstream users have around certain minerals.

Annexe: Map of technology solutions

This annexe summarises all 19 technology solutions mapped during the research for this report. While the range of initiatives and their applications are broad, all those included in this report were selected based on the following criteria:

- Current application or potential for application in the DRC mining sector
- Existence of publicly available information
- Relevance of the technology solution according to the five categories below

The technology solutions identified were mapped against five overarching categories:

1. Responsible sourcing and due diligence initiatives using technology
2. Chain of custody and traceability
3. Data collection and surveys, risk monitoring, incident reporting and impact measurement
4. Technology solutions for education on responsible mining and sourcing (e.g., health and safety training, etc.)
5. Geospatial (satellite intelligence)

The information included in this annexe is based predominantly on publicly available information.

The initiatives are presented in alphabetical order and *not by relevance*.

Legend:

	Source of information confirmed		Source not clear / not available

Application / Technology	Due diligence system	Data collection, impact monitoring	Traceability	Education	Geospatial (satellite intelligence)	Already implemented in the DRC	Currently outside of the DRC
ASMSpotter		■			■		■
Better Sourcing Program	■	■	■			■	■
Blockchain Responsible Sourcing network			■			■	▨
Cobalt Blockchain			■			■	▨
Consensas						■	▨
Datastake	■	■				■	▨
Everledger			■			▨	▨

Application / Technology	Due diligence system	Data collection, impact monitoring	Traceability	Education	Geospatial (satellite intelligence)	Already implemented in the DRC	Currently outside of the DRC
Geotracebility (Optel)			✓			▨	▨
GOTS			✓			✓	
Interactive map of artisanal mining exploitation in Eastern Congo		✓				✓	✓
Interactive voice response				✓			✓
Kufatilia		✓				✓	
Matokeo		✓				✓	
Minespider			✓				✓
Minexx						▨	▨
Mintrax			✓			▨	▨
Ravara Community	✓						
Terrabotics		✓			✓	✓	✓
Ulula		✓				✓	✓

[ASMSpotter](#) *(Case study available in the main report)*	
Implemented by	[Dida Gmbh](#), [Levin Sources](#)
Funding model	The funding model includes four approaches: • Cost sharing with existing programmes / initiatives • Public tenders • Partnership as service to LSM • Co-financing to improve the functionality and application Recently awarded the Microsoft AI Award, under the [#ASMGrandChallenge Prize.](#) Feasibility study between September 2019 and March 2020 funded by ESA.

ASMSpotter *(Case study available in the main report)*	
Technology type	Machine learning software to identify and map changes in artisanal and small-scale mining activity using satellite imagery.
Description, including objectives and scope	ASMSpotter helps public authorities and industry (large-scale mines, buyers, etc.) to effectively and continuously identify, monitor and assess the direct, indirect and cumulative impacts of artisanal and small-scale gold mining (ASGM) over large geographic regions by automating the detection of ASGM sites through the application of machine learning and computer vision algorithms to satellite imagery. Product options: • Map and track ASM • Alert system • ASM monitoring / baseline data Specific issues that ASMSpotter addresses: • Dearth of data on the scale and impacts of ASM • ASM globally is predominantly informal and un(der)regulated (70-80%) • ASM is primarily located in developing and low-middle income countries, where resource constraints hamper monitoring, a crucial tool for improving regulatory compliance • Despite providing a livelihood for millions (40 million directly and 100-200 million indirectly), ASM is commonly associated with negative social and environmental impacts • Poor understanding = poor policy making = sub-optimal enabling environment to incentivise formalisation of activity = vicious cycle of informality How ASMSpotter provides a solution: • Automating ASM impact monitoring to reduce costs and time spent • Providing early alert mechanism for regulatory non-compliance e.g., overlay of data with cadastral information • Quantifying scale and production of mining activities in given areas • Identifying and classifying mining operations (including proxies for illicit activity), population, production, spatial impact, mining types etc. • Evaluating the evolution and trends of the sector to better inform appropriate policy / program design • Improving global data on ASM's value to the global economy for advocacy purposes • Re-directing programmatic resources into support and improved enforcement measures that contribute to sector formalisation ASMSpotter solution combines machine learning technology with human ASM expertise to analyse the data in the context of the sector and its characteristics.

ASMSpotter *(Case study available in the main report)*	
Geographical coverage	Pilot project implemented in north-eastern Suriname, dominated by rainforest. Currently looking for application in other countries.
Mineral focus	ASM gold at this stage.
Results and achievements (where available)	The solution is still at its early stages with one pilot completed in north-eastern Suriname.
Sources / further reading	https://www.artisanalminingchallenge.com/semi-finalists/asmspotter

Better Sourcing Program (BSP)	
Implemented by	RCS Global
Funding model	Funded by private sector clients and partnerships with public funded programs.
Technology type	Due diligence and traceability (powered by Geotraceability)
Description, including objectives and scope	The BSP program is an upstream assurance mechanism focusing on the validation of 3TG minerals exports in compliance with global regulatory requirements. RCS Global works as a third-party verifier in the implementation of the BSP program, which focuses on: • Delivering accurate information needed for continuous improvement of upstream trading chains through the mitigation of risks. • Securing delivery of analysed data packages in flexible formats to meet client's risk management and positive impact generation objectives. The scope of BSP includes the following risks and impacts: human rights, security, working conditions and safety, environment, legality / legitimacy, community, and chain of custody. The product works through the following components: • Supply chain evaluation – a recurring due diligence assessment of all upstream actors in the supply chain (cooperative, mine site, operator, traders, exporters, etc.) and the material flow. • Digital monitoring – permanent on-site, smartphone-based monitoring of incidents, risks and socio-economic community impact by trained field agents employed by RCS Global Group. • Digital traceability – continuous electronic traceability from mine site to point of treatment or point of export to ensure provenance and prevent supply chain contamination – the blockchain solution is powered by GeoTraceability). • Data verification – data is verified, managed, and securely stored by the RCS Global Systems Team. • Data reporting platform – visual, easy to use, secure online dashboard that can be shared with purchasers and external stakeholders to demonstrate responsible sourcing.

[Better Sourcing Program](#) (BSP)	
	Key advantages: • Identification of responsible raw material sources for purchasers • Market access and facilitated investment for responsible producers and traders • Monitoring and measurement of continuous improvement data for community impact in and around production sites Data collected is in alignment with the Responsible Minerals Initiative (RMI) Responsible Minerals Assurance Process (RMAP), but the systems are flexible so as to adapt to various standards and legislative requirements.
Geographical coverage	The DRC, Rwanda
Mineral focus	3TG minerals, Cobalt
Results and achievements (where available)	RCS Global reports that smelters receiving their validated material have been successfully audited by the RMI (RMAP).

Blockchain responsible sourcing network	
Implemented by	Launched by RCS Global, together with a consortium of companies including IBM, Ford Motor Company, LG Chem and others.
Funding model	Not publicly available
Technology type	Blockchain
Description, including objectives and scope	The Responsible Sourcing Blockchain Network (RSBN) is an industry collaboration utilising blockchain technology to support responsible sourcing and production practices from mine to market. Built on the IBM Blockchain Platform, assured by RCS Global Group and powered by the Linux Foundation's Hyperledger Fabric, the RSBN blockchain platform is designed for cross-industry adoption. The solutrion provides traceability and verification of responsible sourcing practices from mine to market through end-to-end supply chains, and is accessible to companies throughout the global value chain. Focus industries include (but are not limited to) automotive and electronics, including their supply chains and the mining sector. A governance board representing members across these industries is being formed to help further ensure the platform's growth, functionality, and adherence to good practice principles. The network's blockchain has moved beyond proof of concept and is on course to become commercially operational. To join the RSBN, companies complete an on-boarding assessment against the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas, as well as additional responsible sourcing good practice standards and

Blockchain responsible sourcing network

	compliance verifications. Vertically integrated participants complete an on-boarding assessment both at headquarters and at participating asset levels, verifying the respective member's responsible sourcing management systems and practices on the ground.
Geographical coverage	The DRC – the pilot took place at Huayou's industrial mine site.
Mineral focus	Cobalt
Results and achievements (where available)	Not publicly available

Cobalt Blockchain	
Implemented by	Cobalt Blockchain Inc. (COBC), is a Canadian resource company with an exploration and development business including cobalt assets in the Democratic Republic of the Congo (DRC). Senior management have extensive experience working in the DRC, in exploration success, and in the licensed trading of certified conflict-free, child-labour-free minerals.
Funding model	Funder by shareholders, where the significant ownership is split as follows: • 12% management and board • 24% IBK Capital (Principals) • 5% Portal Capital's Green Energy Fund • 3% AlphaNorth Asset Management
Technology type	Blockchain (using Mintrax)
Description, including objectives and scope	Cobalt Blockchain Inc. (COBC) focuses on three main areas: • Mining and metals trading – specifically on two fronts: expanding its metals trading business in the DRC to include what they define as 'conflict-free' cobalt, copper, tin, tantalum & tungsten (3Ts) via its existing trading platform; and building a portfolio of the same conflict-free mineral properties. This expansion in the DRC is to address the growing global need for conflict-free cobalt in technological applications, such as batteries in electric vehicles. • Conflict-free minerals - the COBC team has extensive experience in impact-focused certification to ensure socially responsible mining, primarily for commodity trading in tin, tantalum and tungsten, and intends to translate this experience into the provisioning of conflict-free cobalt and other metals. • Blockchain certification - COBC and its partners have developed and are deploying a proprietary blockchain-based certification protocol to be piloted on COBC's own cobalt operations. While continuing its metals trading and mineral operations, COBC will also explore the possibility of using this platform for other operations - such as, for example, for diamonds and gold - which require conflict-free assurance.

Cobalt Blockchain	
Geographical coverage	The DRC – the region between Kolwezi and Lumbubashi
Mineral focus	Cobalt, copper and 3T minerals
Results and achievements (where available)	Supply and off-take agreements are in place for 40,000 tons per annum of cobalt concentrate. COBC is also commissioning a cobalt hydroxide plan in the DRC. There is limited publicly available information with respect to results from the blockchain solution.
Sources / further reading	COBC : The Key to Ethically-Sourced Cobalt from the DRC

Consensas Platform	
Implemented by	Consensas Ltd. and IMPACT
Funding model	Government of Canada funding was in place during the application of the system for the Just Gold project. For future and potential funding models and data value, the following options are considered: • Retroactive payments – downstream companies can make payments to supply actors for the provision of data. • Data fee – companies may apply a data fee along the supply chain, which is paid to individuals for the provision of data. • Community investment – companies may choose to use the system to collect monitoring and evaluation data to make targeted community investment and address challenges. • Reducing inefficiencies – data collected can lead to the identification of inefficiencies in the supply chain which can then be addressed.
Technology type	Due diligence, impact monitoring, traceability
Description, including objectives and scope	Consensas and IMPACT bring together their combined expertise in mineral supply chains, natural resource management, development and human rights, cryptography, and building systems that scale. Their system aims to take into account the needs of artisanal miners, communities, and governments, to ensure that the solution is appropriate and realistic for upstream actors. Based on their experience they operate on the principles that an appropriate and sustainable solution requires an approach that: • Encourages upstream actors to formalise. • Engages with all stakeholders and partners. • Identifies the incentives to sustain improved practices for miners and traders in the artisanal mining sector. • Provides a cost-effective way to share the data along the supply chain. The Consensas platform uses data provided by upstream actors. This data is primarily accessed by mid and downstream actors. All data entries on

Consensas Platform

	the platform are digitally signed by the authors, with multiple automated and manual methods of verifying its accuracy. The system enables participating actors to input and share validated data. This includes transactional data, such as the quantity and value of the commodity being sold, as well as due diligence and know-your-customer information, for example relevant ownership and permitting information. Companies can also access monitoring and evaluation data directly from supply chain actors and the broader community to better understand the impact their sourcing practices are having on individuals and communities. Supply chain entities using the system can set specific permissions to: • Determine what data can be inputted and shared by each user • Re-publish to Artificial Intelligence (AI) platforms • Integrate with SQL databases and publicly to a blockchain
Geographical coverage	The DRC – Ituri province
Mineral focus	Gold
Results and achievements (where available)	The solution was used during the implementation of the Just Gold project, where all supply chain actors had access to data from the entire supply chain, up to the mine, including socio-economic data. Additionally, impact data collected along the supply chain, allowed buyers to understand how the Just Gold project is affecting the local community.
Sources / further reading	https://www.consensas.com

Datastake and Consolidated Automated Due Diligence Framework (CADD) *(Case study available in the main report)*

Implemented by	BetterChain
Funding model	Currently working on donor funding
Technology type	Due diligence platform and data collection, including traceability component powered by GeoTraceability (Optel)
Description, including objectives and scope	BetterChain works to transform data into a valuable resource for incentivising full mineral supply chain transparency. The BetterChain framework incorporates an assessment system for reliable upstream data, including traceability, risk management, KYC data and supply chain documentation, as well as a blockchain-based accountability mechanism. Once a supply chain link from mine to brand is established end-users can access mine-level data, which creates a potential reward mechanism for compliant miners to offset due diligence costs. When scaled, this approach can directly support end-to-end supply chain due diligence and facilitate targeted engagement to solve local development challenges.

Datastake and Consolidated Automated Due Diligence Framework (CADD) *(Case study available in the main report)*

	BetterChain focuses on empowering upstream actors in the long term to ensure they will be able to independently address due diligence requirements through a continuous improvement process. The main components of the BetterChain framework include: • Consolidated Autonomous Due Diligence (CADD), which is a public, open-source framework developed to organise and compile information available to any stakeholder in resource-rich countries. Standardised data helps raw material producers in their compliance strategy and to align global reporting on provenance risk and supply chain impact. It is primarily intended for risk management and community feedback in the mining and mineral trade sector. • The Datastake platform, which supports sharing of and access to information in remote geographies, where risk and opportunities are often hard to monitor. It also helps local businesses and NGOs to organise their data. Datastake allows users to identify local sources of information on a given subject or query any location for first-party observational data, eliminating the need for costly and subjective third parties.
Geographical coverage	The DRC
Mineral focus	Currently focusing on gold
Results and achievements (where available)	Currently in initial implementation phases
Sources / further reading	https://medium.com/betterchain

Everledger	
Implemented by	Everledger
Funding model	Service-based fees
Technology type	Traceability, blockchain, artificial intelligence, internet of things
Description, including objectives and scope	An independent technology company that helps businesses surface and converge asset information, using secure technologies including blockchain, AI and IoT. About the technologies applied: • Blockchain – blockchain technology allows data to be recorded securely and unalterably as an asset (such as a diamond) moves along the supply chain. By converging this record with other technologies, the Everledger solution can create a unique digital identity for the asset and make it available to all stakeholders. Everledger's platform is built on the fundamentals of private blockchains, where firms need

Everledger	
	the ability to share data securely and apply smart contracts, while also retaining privacy. Data is divided into privacy tiers, so a stakeholder can withhold sensitive data attributes, while allowing transparency on others. The solutions are designed for businesses and consumers, enabling businesses to streamline processes while providing consumers with transparency. • Artificial intelligence – since 2017 the Everledger platform has been using artificial intelligence (AI) to analyse data sets, helping customers meet both documentation requirements (for example by the Kimberley Process) and associated smart contract obligations. • Internet of Things – by capturing production, transport and environmental data in real-time (for example temperature sensors, tamper detectors), Internet of Things (IoT) technology can help reveal the full story of an object. When coupled with blockchain, this information becomes immutable, private and transparent. • Intelligent labelling – intelligent labelling allows the information associated with a physical object to be securely surfaced and converged. In this way it captures the lifetime story of an object from origin to end customer. Everledger intelligent labels link the digital and real worlds using NFC, RFID, the physical structures of an object (such as fiber or pattern structures), and synthetic DNA. • Nanotech – nano-sized particles are finding more and more applications in object identification. Everledger platform aggregates these technologies to surface secure data about an asset. Partners such as Gübelin are already advancing the technology to authenticate and surface the provenance of diamonds and gemstones.
Geographical coverage	Not specified online, likely engaged in the DRC
Mineral focus	Diamonds, gemstones
Results and achievements (where available)	Engagement with industry initiatives and key stakeholders such us: • OECD • RMI • Global Battery Alliance • Alliance for Advanced Transportation batteries • Global Blockchain Business Council Other sustainability commitments include: • Working to achieve the sustainable development goals • Carbon footprint reduction
Sources / further reading	https://www.everledger.io/our-technologies/ https://www.everledger.io/insights/

GeoTraceability	
Implemented by	Optel

GeoTraceability	
Funding model	Service based fees
Technology type	Traceability, blockchain, artificial intelligence (AI), and the Internet of Things (IoT)
Description, including objectives and scope	The GeoTraceability platform leverages technologies such as its GeoTraceability solutions, blockchain, artificial intelligence (AI) and the Internet of Things (IoT) to provide end-to-end traceability from raw materials to the consumer. Main features: • End-to-end granular traceability, from the artisanal small-scale miner (ASM) to the consumer • Easily integrated, system-agnostic platform • Solutions designed to adhere to GS1 standards • Serialisation, aggregation and vision inspection tools • Reporting and decision-making tools • Life cycle analysis to minimise environmental footprint • Brand protection through counterfeiting and diversion prevention • Compliance with applicable regulatory requirements Based on GS1's Electronic Product Code Information Service (EPCIS) standards, OPTEL'S GeoTraceability solution provides supply chain visibility for accurate identification, capture and sharing of data related to products, stakeholders, locations, assets and services. Their software as a service (SaaS) offer gives clients on-demand access to Optel's expertise to develop, deploy and view data. The cloud-based data collection and traceability tools work either online or offline, making them suitable for use in remote locations. The GeoSurvey mobile tool allows users to fill out a questionnaire from an inventory of preconfigured questions and to gather field information such as socio-economic data, field characteristics, work practices, project activities and behaviour. The GeoTrace tool, available in both mobile and desktop versions, traces the raw materials and products along their journey through the supply chain.
Geographical coverage	30 countries worldwide including the DRC
Mineral focus	Applicable to all
Results and achievements (where available)	The GeoTraceability solution was implemented at the Nyamurhale project in the DRC. Gold originating from Nyamurhale is now conflict-free and conforms with national and international transparency initiatives as well as OECD due-diligence standards for every part of the supply chain with no requirement for permanent online operation. Additional impacts included improved administrative and financial capacities for the cooperative, as well as safety and mining effectiveness on site.
Sources / further reading	[Case Study: Optel's GeoTraceability Solutions Change The Game For Artisanal, Small-Scale Miners (ASMs)](#)

GOTS	
Implemented by	[IBES Good Governance Solutions](#)
Funding model	Collaboration with donor-funded programme during pilot implementation. The solution is estimated to cost 0.5% of the value of the traded goods.
Technology type	Traceability
Description, including objectives and scope	GOTS MineralTrace provides a technological platform and auditing/certification framework that implements a secure trade documentation and proof of origin system over the mineral/precious stones supply chain, following an open-market approach. The GOTS MineralTrace solution supports formalisation of artisanal small-scale mining, raw material trade documentation, proof of origin and improvement of mineral royalties' collection. The aim of GOTS is that small-scale miners get better prices for their production, governments receive the tax revenue due, and industries in importing countries can reliably audit that their supply chains conform to local and international due diligence law. Real-time monitoring of traded minerals from certified mine sites allows on-the-ground assessment to identify compliant trade of gold and precious stones. Data can be collected in the field and then uploaded to the cloud once the device is in range of internet access. Data is accessible only to trade participants.
Geographical coverage	The DRC
Mineral focus	Gold
Results and achievements (where available)	The GOTS Mineral Trace for Gold has been piloted and implemented in the DRC. The solution managed to trace and document a significant amount of gold trade during its implementation (150 trading transactions in 4 months). They engaged with four cooperatives, two mining operations and four active exporters.
Sources / further reading	[Case study: GOTS Goldtrace solution for Certified and Fair Gold Trading Chains in conflict-affected and high risk areas](#)

Interactive map of artisanal mining exploration in eastern DRC	
Implemented by	IPIS
Funding model	Public / donor funded The 2016-2018 mapping of artisanal mining sites in eastern DRC was funded by the International Organization for Migration (IOM) in the DRC through the United States Agency for International Development (USAID)-funded Responsible Minerals Trade (RMT) project. Case studies were funded through a Conflict Research Fellowship of the SSRC for the LSE-based Conflict Research Programme.

Interactive map of artisanal mining exploration in eastern DRC	
Technology type	Mobile data collection – surveys with enumerators
Description, including objectives and scope	The interactive webmap displays more than 2400 artisanal mining sites in eastern DRC and more than 800 roadblocks. Since December 2016, the IPIS teams have visited more than 500 artisanal miners in eastern DRC, gathering data that has been added to the interactive webmap. IPIS also integrated other datasets gathered during its projects in the region, including data on roadblocks. IPIS has developed a tutorial to help users navigate the open data that has been made available together with the map. The data is available both through the [webmap](#) and published analytical reports. Key features of the webmap include: • Filter selection (e.g., focus on minerals, specific risks, etc.) • Count of all filtered mines • Search for specific features • Local trade flows • Context • Access to the data through [Open Data](#) The main method for data collection is the use of open-source mobile data collection software (called open data kit), where questionnaires are inputted and data is collected by a team of enumerators. Data collected includes: • Information about armed interference in eastern DRC's ASM sector • Comparison of armed conflicts with interference at mining sites • Socio-economic impacts, including mobility, data on cooperatives, women and distribution of revenues • Economic indicators related to mineral trade • State control and formalisation of the ASM sector
Geographical coverage	DRC, specifically eastern DRC
Mineral focus	Gold, tin, coltan, diamonds, tungsten, copper, other
Results and achievements (where available)	Number of visited mines: 2,398 Total number of workers (estimate): 348,000 Mines with interference observed: 984
Sources / further reading	[Mapping artisanal mining areas and minerals supply chains in eastern Congo](#) https://ipisresearch.be/mapping/webmapping/drcongo/v5/#-3/28/5/2/1/

[Interactive voice response](#) *(case study available in the main report)*	
Implemented by	Solidaridad
Funding model	Donor funded

Technology type	Interactive voice response (IVR) – training through mobile phones
Description, including objectives and scope	The IVR platform, which is compatible with basic feature and android phones and allows the target audience to receive pre-recorded messages in real time without the need for face-to-face contact. It is being used to educate artisanal and small-scale gold miners on responsible mining practices.
Geographical coverage	Ghana
Mineral focus	Gold
Results and achievements (where available)	Increased reach to miners for awareness raising and training on a number of responsible mining practices and sustainable production topics. 1,325 miners and workers trained.
Sources / further reading	https://www.solidaridadnetwork.org/supply-chains/gold

Kufatilia (*case study available in the main report*)	
Implemented by	Developed by IPIS in collaboration with the Expertise Centre on Mining Governance (CEGEMI) and powered by Ulula.
Funding model	Funded by the European Partnership for Responsible Minerals (EPRM)
Technology type	Incident reporting and monitoring
Description, including objectives and scope	Kufatilia is a tool for Congolese CSOs to report and monitor incidents in eastern DRC in a transparent, independent, and participatory way. The scope of incidents reported is in line with Annex II of the OECD Due Diligence Guidance on Responsible Minerals Supply Chains, including mining accidents, violence, child labour, environmental degradation, corruption, roadblocks, etc. Incidents can be reported through mobile phones (no smartphone needed). The incidents are then managed by local CSOs who can access them from the incident online database.
Geographical coverage	DRC
Mineral focus	Not focused on any mineral, it addresses all ASM mining communities.
Results and achievements (where available)	Between November 2018 and December 2019 504 incidents were reported. Reports have increased throughout this time. At the time of analysis, of all incidents received 29% were resolved, 62% being resolved/ addressed, 6.5 % classified as persistent incidents and 3% not resolved.
Sources / further reading	Final report on incident monitoring 2018-2019 Kufatilia dashboard

Matokeo (*case study available in main report*)

Implemented by	IPIS and Ulula
Funding model	Recently awarded the Microsoft AI Award, under the [#ASMGrandChallenge Prize](#)
Technology type	Impact monitoring
Description, including objectives and scope	Matokeo, which means 'impact' in Swahili, is a mobile-based solution to help monitor the social, environmental, and human rights impact of artisanal mining in eastern DRC. Matokeo aims to give artisanal miners and their communities a voice through reliable data collection about the impact of mineral supply chains. By responding to regular short mobile surveys, the miners can help downstream actors measure and understand the local impact of mineral extraction. Responding to the surveys is free (through automatic mobile credit reimbursement), anonymous and confidential. Matokeo will build on the partnership between IPIS, Ulula and a network of more than 20 Congolese CSOs formed to deliver the Kutifilia incident reporting and monitoring system summarised above. The main objective of Matokeo is to build a robust, citizen-centered database of respondents for human security, labour and environmental impact monitoring in mineral supply chains in eastern DRC. IPIS and Ulula hope to be able to reduce the costs of data collection while offering robust monitoring of major human rights impacts such as forced labour, child labour, gender violence, mercury use and so on, through continuous monitoring. Matokeo is not a certification or traceability system, instead the organisations hope to integrate it into existing mechanisms to create better data loops and support the voices of miners throughout existing mineral supply chains and traceability mechanisms
Geographical coverage	DRC (eastern)
Mineral focus	Not focused on any mineral, it addresses all ASM mining communities.
Results and achievements (where available)	Although IPIS and Ulula have been collecting social, environmental, and human rights impact data over the past two years, the official launch of Matokeo with automatic recruitment of participants through mineral pricing information by SMS, is scheduled for mid-2021.
Sources / further reading	https://www.artisanalminingchallenge.com/semi-finalists/matokeo

[Minespider](#)	
Implemented by	Minespider
Funding model	Service-based fee
Technology Type	Blockchain traceability solution
Description, including objectives and scope	Minespider's vision is to provide end-to-end traceability in minerals supply chains, while ensuring data security and reliability. The Minespider Protocol integrates existing upstream due diligence solutions with an open protocol to transmit data downstream beyond

Minespider	
	points of transformation to reach the companies who then benefit from a secure raw material supply chain. The Minespider Protocol will be composed of encrypted certificates stored in a decentralized database that are purchased using the Minespider ERC20 cryptocurrency called SILQ. These certificates are produced, encrypted, and sold via a DApp. Every purchase of an encrypted certificate will be associated with an amount of material shipped that will be registered in the Ethereum blockchain.
	The data is organised in three layers:
	- Public– visible to anyone - Transparency – visible to supply chain actors - Private – visible only to data owners
	When adapting the technology to a specific company or supply chain the following steps would take place: (1) Process mapping and data points definition, (2) Understanding the specific case and applicable scenario, (3) implementation, which can vary substantially depending on existing processes for traceability and due diligence, or whether these processes are missing and hence need to be built together with the technology.
	The first pilot with a tin mine in Peru has highlighted the challenges of depending on all companies in the supply chain to guarantee the solution's value. Based on this limitation, Minespider have revised their approach and the technology to ensure their digital certification system can work even if not all the companies in the supply chain take part. In practice, now the certificate is linked to the material and if an actor in the supply chain decides not to participate, it will show as a gap on the actor, but will not affect the digital certification of the material.
	The sustainability of the model is still being defined. Ideally traceability should be included in the cost of doing business but in practice costs are still rarely distributed fairly across supply chain actors. Minespider see the use of blockchain as having the potentialto enable a solution where no one company or individual alone bears its costs, but all participants pay a small share. Finally, the technology once it is built and functional will not represent the major cost, which instead lies in the business processes.
Geographical coverage	Peru and Rwanda to date, but could expand to further countries based on funding.
Mineral focus	Tin
Results and achievements (where available)	Currently implementing pilot projects in Peru and most recently in Rwanda for a tin smelter.
Sources / further reading	https://www.minespider.com/blog/do-supply-chains-need-blockchain

Minespider

Minexx *(Case study available in the main report)*	
Implemented by	Minexx
Funding model	Not explicit from publicly available information
Technology type	Internet of Things, blockchain for transparency and traceability, Digital payments
Description, including objectives and scope	Minexx deploys blockchain technology and digital payments to secure and transform the value chain for strategic minerals (tin, tantalum, tungsten, cobalt and gold) with the aim of increasing traceability, transparency, and trust.
Geographical coverage	DRC
Mineral focus	3TG, cobalt
Results and achievements (where available)	Not available online

Mintrax	
Implemented by	Mintrax JV, a joint venture of Cobalt Blockchain Inc. and DLT Labs Inc
Funding model	Not available online
Technology type	Blockchain traceability
Description, including objectives and scope	The current MINTRAX blockchain platform is built on IBM's Hyperledger Fabric framework. The platform is designed to be transparent, immutable, and secure. A future version is envisioned to incorporate an asset-based token component, hybridised using a public chain such as Ethereum, tied to socially responsible benchmarks in the supply chain ecosystem. The technology has three main characteristics: • Compliant – in line with the OECD Due Diligence Guidance. • Transparent – enables end-to-end sharing of transactional data for all participants via a permissioned blockchain, with information available from mineral source to end-user while preserving contractual confidentiality. • Secure – it is based on distributed ledger technology, which is inherently more resistant to conventional security risks because the distributed and interlocked nature of the blockchain database record makes it immutable.
Geographical coverage	The DRC
Mineral focus	Cobalt

Mintrax	
Results and achievements (where available)	Not publicly available, but Mintrax partners with Cobalt Blockchain, DLT Labs and BetterChain.

Ravara Community	
Implemented by	Ravara and Levin Sources
Funding model	Licensing model
Technology type	Due diligence online platform
Description, including objectives and scope	The Ravara Community is an online platform streamlining due diligence across the supply chain. It is designed to be accessible to small companies, including ASM organisations, enabling inclusion and interconnectivity which are critical elements for implementing due diligence in the industry. Each vendor registers, goes through a KYC and validation process and can then use the platform to manage their due diligence system, take assessments against industry standards, and share documentation with suppliers and clients. Assessments are reviewed by a specialist third-party (Levin Sources), who provides recommendations and a roadmap for improvement. Companies update their profile on an on-going basis, to show continuous improvement. The platform also acts as a social network, where companies can search and find trusted partners to do business with. The solution integrates with other tools, including a traceability platform and supplier management system.
Geographical coverage	Worldwide
Mineral focus	Not focused on specific minerals
Results and achievements (where available)	The platform is still in its pilot phase
Sources / further reading	https://www.levinsources.com/what-we-do/services/due-diligence-solution-ravara

Minotor (*case study available in the main report*)	
Implemented by	Terrabotics
Funding model	Service based fee
Technology Type	Remote sensing, satellite intelligence
Description, including objectives and scope	Minotor is a 4D Mine Volumetrics and Area monitoring solution. It uses satellite imagery combined with 3D mapping technology to provide a mining stockpile and excavation monitoring dashboard for open cast mines. Additionally, it provides intelligence on the status of mining

Minotor (*case study available in the main report*)	
	operations, such as volumes of stockpiled material, to mine managers, regulators and metals traders. In addition, through their solutions Terrabotics can monitor industrial mining emissions. Flaring and emissions sensing, monitoring and measurement from satellite remote sensing platforms is in the early stages of R&D, trialing, and testing. Terrabotics use the following core technologies: 3D terrain mapping - Smart change detection - Image super resolution - Geometrical and spectral object classification
Geographical coverage	Worldwide, has worked in the DRC
Mineral focus	Applies to any mineral
Results and achievements (where available)	Refer to case study for more information

Digital tools for project affected community engagement (PAC) and impact measurement	
Implemented by	Ulula.
Funding model	License / subscription fee
Technology Type	Community engagement and impact measurement
Description, including objectives and scope	Ulula is used by mining companies to enhance corporate responsibility by adding value to community relations and engagement. Through simple mobile phones and advanced analytics, the solution amplifies project affected community (PAC) member voices to provide more relevant and reliable data on sentiment, social license to operate (SLO) and help measure the impact of PAC investments. The solution can be used throughout the mining life cycle to mitigate risk and monitor social impact. The Ulula platform can serve for: - Automated surveys - Grievance management - Mass broadcasts and alerts
Geographical coverage	Brazil, South Africa, Chile, Peru, Tanzania, Kenya, Mexico, the DRC
Mineral focus	Not focused on any specific mineral, it addresses all ASM mining communities.

Results and achievements (where available)	Example of some of their projects implemented: • PAC engagement and grievance mechanism in Brazil, South Africa, Chile, and Peru • Mapping of the socio-economic and human rights situation of artisanal and industrial mining in north-west Tanzania • Impact measurement of the gig economy on women in Kenya and Mexico • PAC perception and social conflict in mining communities in Peru