Assessing the socio-economic impact of a zinc mine in South Africa through the application of digital tools: A case study

by V.J. Mahadeo[1], U. Govender[2,3], S. Ramparsad[4], and B. Genc[2]

Affiliation:
[1]The Research Institute for Innovation and Sustainability, South Africa
[2]School of Mining Engineering, University of the Witwatersrand, South Africa
[3]Vedanta Zinc International, South Africa
[4]Mandela Mining Precinct, South Africa

Correspondence to:
B. Genc

Email:
Bekir.Genc@wits.ac.za

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ORCiD:
B. Genc
http://orcid.org/0000-0002-3943-5103

Abstract

The study was intent on assessing the socio-economic impact of a zinc mine in South Africa through the application of people-centric digital tools using a case study research methodology. The global mining industry is undergoing significant technological shifts to modernize, improve operational sustainability, and align with the environmental, social, and governance (ESG) agenda. While the case study mine is a more modernized mine, continuous improvement around the 'social' pillar becomes critical, and to this end application of people-centered digital tools presented as the vehicle to understand community needs and impacts. Despite considerable annual corporate social investment by mines annually, the overall impact or social return on investment is marginally understood. Towards contributing to addressing this gap, digital ESG 'social-related' data gathering tools for mines decision-making were developed, including the training-needs assessment tool, community-social needs assessment, small, micro, and medium enterprise (SMME) communications and engagement tool, digital leadership competencies gap assessment tool, and change management blueprint, which further allowed for customization to the mining context. Hence, the novelty of this paper relates to applying digital tools to provide real-time information of the needs of a community, both socially and economically. The findings suggested that these digital tools enabled gathering of information for the establishment of regional and operational baselines towards enabling of social investment returns in relation to socio-economic transformation development interventions. These tools have been applied to a zinc mine context, with lessons and experiences obtained through this study, invaluable to the application of these digital tool in other mines in South Africa.

The study was conducted in September 2023 across five host communities, surrounding the zinc mine, in the Northern Cape region, with 120 participants involved in the application of three relevant community-related digital tools, which included the training needs, community-social needs, and SMME communications and engagement tools. It was evident that the digital ESG tools could be used for data gathering for the mine's informed decision-making and allowed for securing of insights on community needs in near real-time, and further proved practical for community use.

Keywords

ESG, digital tools, socio-economic transformation (SET), zinc mine, South African mining communities

Introduction

The ESG agenda has become an imperative across major industries worldwide, including the mining sector. The 'social' principle is highly relevant in mining as the sector is still a highly labour-intensive operation. The mining sector of South Africa contributed 7-8% of the national Gross Domestic Product and employed over 475,000 people, with a dependency ratio of 1:10 in 2022/3. Moreover, the mining sector supports more than 4.7 million livelihoods in the country, as per the Minerals Council South Africa's report (2023). Therefore, ensuring the socio-economic development and upliftment of host communities around regional mines are a national priority for economic growth. The subsequent section elaborates on the origins of ESG and its relevance to mining, why focusing on the 'social' narrative is important, and how implementing people-centric digital tools may improve an understanding of community needs and impact, and enable communication between mines and their host communities.

ESG agenda in the global and mining context

The ESG agenda was first used in the 2006 report of the United Nations (UN) Global Compact Initiative (Perrone, 2022), 'Who Cares Wins.' James Gifford devised the term in 2004 and described how investment decisions could contribute to a more stable and predictable market (Perrone, 2022).

'A better inclusion of environmental, social, and corporate governance factors in investment decisions will ultimately contribute to more stable and predictable markets, which is in the interest of all market actors.'

ESG describes a set of factors to measure the non-financial impacts of the activities of corporations (Ingebretsen, 2023). At ESG's core are 22 metrics and an expanded 34 structured metrics to align with the UN's 2030 sustainable development goals. As such, ESG grew out of investment philosophies clustered around sustainability and, after that, socially responsible investing. In turn, integration with strategy enables environmental stewardship, social responsibility, and governance quality (Fiscor, 2023):

- *Environment (E)*: signifies improvements in energy efficiency, reduction in carbon footprints, mitigation of greenhouse gas emissions, prevention of deforestation, preservation of biodiversity, efforts to address climate change and pollution, effective waste management, and responsible water usage.
- *Social (S)*: embodies standards for labour, compensation and benefits, diversity in the workplace and on boards, promoting racial justice, achieving pay equity, upholding human rights, managing talent, fostering community relations, ensuring privacy and data protection, prioritizing health and safety, overseeing supply-chain management, and addressing various human capital and social justice concerns.
- *Governance (G)*: encompasses the oversight of environmental and social aspects, including the composition and structure of corporate boards, strategic supervision of sustainability practices and adherence, executive compensation, involvement in political contributions and lobbying, and measures against bribery and corruption.

ESG was influenced by a company's actions and, more specifically, how the public perceives those actions. The significant increase in ESG investments from 2018 indicates the value in aligning with ESG values. Investment inflows into sustainable funds rose from USD5 billion in 2018 to more than USD50 billion in 2020 and nearly USD70 billion in 2021 (NJCPA, 2021). Midway through 2022, the global sustainable assets were valued at approximately USD2.5 trillion (NJCPA, 2021). As a result, ESG market leaders showed better performances with higher profits and lower interest rates, while laggards displayed underperformance in these aspects (Kujala et al., 2022).

Regarding mining, prioritizing ESG values directly correlates to corporate responsibility, the socio-economic transformation of surrounding mining communities, the environmental impact of extraction, and the mine's social license to operate within a region (Botts et al., 2023). While the focus of ESG may have been on the environment and governance in response to climate change, an analysis has found that social-related shareholder proposals rose by 37% in 2021 compared to the previous year (Pérez et al., 2022), suggesting that mines are prioritizing action around the social pillar, which can further bolster socio-economic transformation from the years of implementing social and labour plans (SLP).

The Mineral and Petroleum Resource Development Act 28 of 2002 (MPRDA) ensures that companies holding mining rights give back and invest towards socio-economic development of host communities, and to accomplish this objective of the MPRDA, SLP guidelines are provided (DMR, 2010). However, one should take note that mines may attempt through the SLP to address community needs, only to find communities still remain disgruntled. What becomes critical for mines is to get a 'real' understanding of those needs, and the potential impacts that they are making in this regard, which could be considered through the development of key and relevant indicators and assessing for understanding and impacts. The people-centric digital tools applied through this case study seeks to enable this need.

Problem statement

Social-related considerations within the mining context are essential because these directly influence the mine's ability to maintain a social license to operate within the region (Dikgwatlhe and Mulenga, 2023). The major mines in South Africa invested ZAR305 million in 2020/21 compared to ZAR1,278 million in 2021/22, representing a 76% increase. Figure 1 depicts the distribution of corporate social investment and social and economic development spending across the significant South African mining houses. The resultant socio-economic transformative impact of corporate social investment is unknown. Hence, companies cannot determine whether monetary inflows have resulted in socio-economic development within their mining communities.

**Note: This is a subsample as it does not represent the total mining industry investment in overall corporate social investment (CSI) and socio-economic development (SED) spending.*

CSI is a concept that seeks to align society's interests and expectations with the mining industry's goals and practices (Seloa and Ngole-Jeme, 2022). One of the ways that the mine can demonstrate its CSI is by conducting an environmental impact assessment and producing a social labour plan (Seloa and Ngole-Jeme, 2022). These mechanisms help identify, evaluate, and mitigate mining activities' environmental and social impacts and ensure the fair and equitable distribution of benefits and opportunities for the affected communities. Notably, SLP need to contain direct obligations to contribute meaningfully to the economic and social development of mine-affected communities (DMR, 2010). They are meant to benefit mining communities to ensure that impacted areas are not left destitute and impoverished by mining.

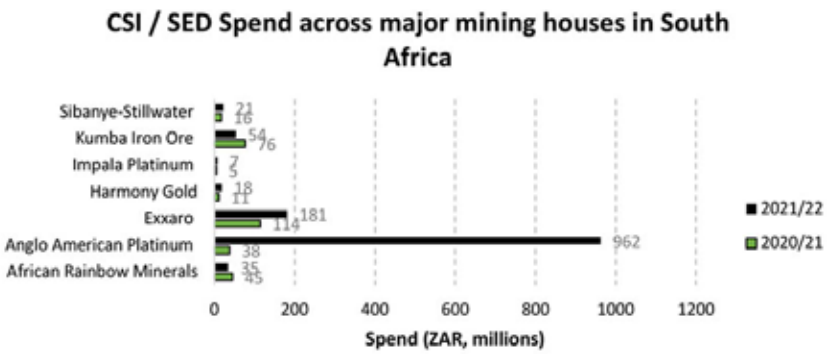

Figure 1—CSI and SED spend across major South African mining houses. Adapted from multiple sustainability reports

It becomes evident from the above that mines need data gathering tools for their decision making, and to understand the impact made in their host communities through their social investments.

The Minerals Council South Africa is a mining-industry employer organization that supports and promotes the progression towards sustainable mining in South Africa. Through regular and continuous engagement with its members, it has identified the need to develop people-centric digital tools to improve the accuracy and consistency of data capture between regional mines and their host communities. The Minerals Council South Africa, through the SAMERDI Successful Application of Technology Centered Around People (SATCAP) programme has supported the development of people-centric digital tools. These digital tools include a Training Needs Assessment, NGO/Community Social Needs Assessment, Stakeholder Engagement and Communications Tool, and Digital Leadership Competency Gap Assessment Tool. These digital ESG tools were developed to gain a deeper understanding of the socio-economic transformation needs of host communities and increase the accessibility to a broader target audience through the privacy of responding through mobile applications. For this study, the community-related 'social' tools are considered.

Research objective

The objective of this study was to determine if the ESG digital tools allow for data gathering for informed decision-making, using a zinc mine as a case study.

Research question

Mine closures are more detrimental than other industry closures because of the community's location. The geographically remote communities mean that the local community's dependency on the mine increases as levels of education, internet access, and employment decrease within the community (Cole and Broadhurst, 2021). 'With regulatory failure, the relationship between the livelihood of communities and mining activities is linked in a manner that creates a power imbalance where host communities become dependent on the mine for economic survival' (Maloisane, 2023). Lack of consultation and community involvement has led to the debilitating circumstances of these local communities because, even when solutions are being brought forward, they are not aligned with what the people need (Maloisane, 2023).

These community-related digital tools, namely, a training-needs tool, a small, micro, and medium enterprises (SMME) communications tool and a social-needs tool, were developed to be 'off-the-shelf' solutions for the South African mining industry.

This study aims to investigate the socio-economic impact of transformative investment from a zinc mine by applying these novel digital tools. The implementation of these digital tools within a zinc mining context in the Northern Cape employed a case study approach to validate, and ensure that each tool could provide insights into the following:

- Can the digital tools provide for gathering of information relating to the present and perceived future SMME needs?
- Can the relevant digital tool provide for an understanding of the host community's current and future social needs?
- Can the relevant digital tool allow for evaluating the community and SMME's training needs?
- Can the relevant digital tool allow for identifying alternative economies and industrialists that meet the Broad-Based Black Economic Empowerment (B-BBEE) criteria within mine communities?
- Can the relevant digital tool allow for measuring the level of engagement between the community and the regional zinc mine?

Value of this study

Application of digital tools were needed for:

- An easier and quicker method to gather data – rather than mine staff gathering data through interviews with communities.
- Have a wider reach in host communities, more cost effectively – which could be possible through a digital medium.
- To obtain objective community views, for securing of community 'real needs' – rather than community leaders providing perceived community need.
- Mines could obtain quick data analysis for their informed decision-making and understanding of impacts in host communities.
- Applying digital tools to measure socio-economic transformation baselines from the onset may enable improvement of corporate social investment returns.

Each digital ESG tool was designed to gather information, establish regional and operational baselines, and ensure the maximum return on social investment, specifically in socio-economic transformation development interventions.

This paper introduces a novel approach by applying digital ESG tools to measure key factors contributing to socio-economic transformation in mining communities. These tools offer several advancements, including a deeper understanding of the community's current and future social needs, which is essential for maintaining the mine's social license to operate. They allow for a rapid, near real-time assessment of material ESG issues, improving upon the traditional annual survey method. The tools also evaluate the training needs of both the community and SMME, measure the level of engagement between the community and the regional mine, and identify alternative economies and industrialists that meet B-BBEE criteria within mining communities. Additionally, they gather and respond to both present and future SMME needs, assess the digital capabilities of mine personnel in preparation for modernization, and provide a change management blueprint to guide the adoption of new technologies. This paper further contributes to the academic literature by validating these novel ESG tools and comparing their insights to traditional mining materiality assessments.

The study is relevant to the mining industry as it addresses critical aspects of socio-economic transformation, environmental responsibility, and the adoption of modern technologies, all of which are increasingly central to the industry's sustainability and growth. The mining industry often operates in remote regions, where communities face a variety of socio-economic challenges, such as poor infrastructure, environmental degradation, and economic vulnerability. This highlights how digital ESG tools can address these challenges by providing near real-time insights into community needs, engagement levels, and socio-economic conditions. Mining companies can more effectively align their operations with the long-term welfare of the communities they impact by measuring key indicators such as local training needs, community-business engagement, and alternative economic opportunities. This helps companies meet regulatory and social license-to-operate requirements, foster community resilience and support broader economic development goals. For the mining

industry, such tools enable proactive decision-making and strengthen relationships between mines and local stakeholders, which are crucial for maintaining operational stability and minimizing social risks.

Furthermore, the study delves into the practical application of digital ESG tools in the mining sector, focusing on their role in enhancing decision-making and preparing the workforce for modernization. These tools allow for faster, more dynamic assessments of ESG-related issues compared to traditional surveys, enabling mines to respond quickly to emerging community concerns. This is particularly relevant as the industry undergoes technological transformation, with digital tools playing a pivotal role in managing change. By identifying the digital readiness of workers, assessing alternative economies, and providing change management frameworks, mining companies can ensure smoother transitions to more modern, technology-driven operations. This relevance is underscored by the industry's push toward sustainability, modernization, and alignment with global ESG standards, which increasingly dictate access to investment and market competitiveness. Thus, adopting such tools is critical for mining companies to remain viable and responsible in today's socio-economic and environmental landscape.

Literature review

The literature review provides context on zinc mining from a global and African perspective, including examining the current socio-economic challenges mining communities face, particularly around zinc mines. The people-centric digital tools will be explored.

Current socio-economic transformation challenges facing South African mining communities

Key socio-economic challenges include health and safety risks posed by exposure to mining-related hazards, such as dust and chemicals, which can lead to respiratory and other health problems (Maloisane, 2023). Environmental degradation caused by mining activities, including pollution, deforestation, and habitat destruction, adversely affects communities reliant on agriculture and natural resources (Forget and Rossi, 2021). Employment opportunities in mining are often coupled with insecurity, wage disputes, high-risk working conditions, and a lack of local skills development, which perpetuate reliance on external labour (Cole and Broadhurst, 2021). Furthermore, income inequality can be exacerbated, as only a segment of the population benefits from mining-related employment or business opportunities, while others experience minimal economic improvement (Maloisane, 2023).

The arrival of mining investments often strains local infrastructure, including housing, schools, healthcare, and transportation services, making it difficult to provide adequate support to both mining and non-mining communities (Maloisane, 2023). Mining can also lead to the displacement and resettlement of communities, causing social and economic upheaval (South African Human Rights Commission, 2019). Land rights conflicts, particularly when traditional agricultural lands are claimed by mining companies, are another common issue (South African Human Rights Commission, 2019). Additionally, mining disrupts communities' social and cultural fabric, leading to the loss of cultural heritage and cohesion (Dikgwatlhe and Mulenga, 2022). Economic vulnerability is prevalent in mining-dependent communities due to fluctuating global zinc prices or mine closures, hindering efforts toward economic diversification (The Assay, 2022). Legacy issues, such as abandoned or poorly managed mines, also leave long-lasting environmental and health impacts on communities (South African Human Rights Commission, 2019).

This case study explores how adopting and implementing specific digital tools can enhance social investment returns and improve decision-making in the zinc mining industry. The industry has committed to long-term environmental, social, and governance (ESG) targets requiring active engagement with local communities. However, current methods do not provide near real-time insight into community sentiment regarding ESG initiatives. The use of digital tools can bridge this gap, enabling mining companies to understand and respond to community concerns more effectively.

Digital tools implemented at the zinc mine

Zinc mining in South Africa is predominantly concentrated in the Northern Cape, with the Khai-Ma region being of particular interest. This region has a population of 14,574 people, which reflects the small size and limited resource allocation across the province. The lack of economic diversification in the Northern Cape, particularly in remote areas, presents significant risks and challenges (UNCTAD, 2022). Like other mining communities worldwide, zinc mining communities in South Africa are confronted with numerous socio-economic challenges. These challenges vary based on location, the scale of the mining operation, and the policies implemented.

This study focuses on three community related digital tools, which were deemed to be more relevant to the zinc, modern mining context. However, the five digital tools represented in Figure 2 were developed using design thinking principles (Mahadeo et al., 2022). These tools enable an understanding of the effects, impacts and challenges of mining modernization on people in the minerals sector. The tools focus on the 'social' or 'benefits to

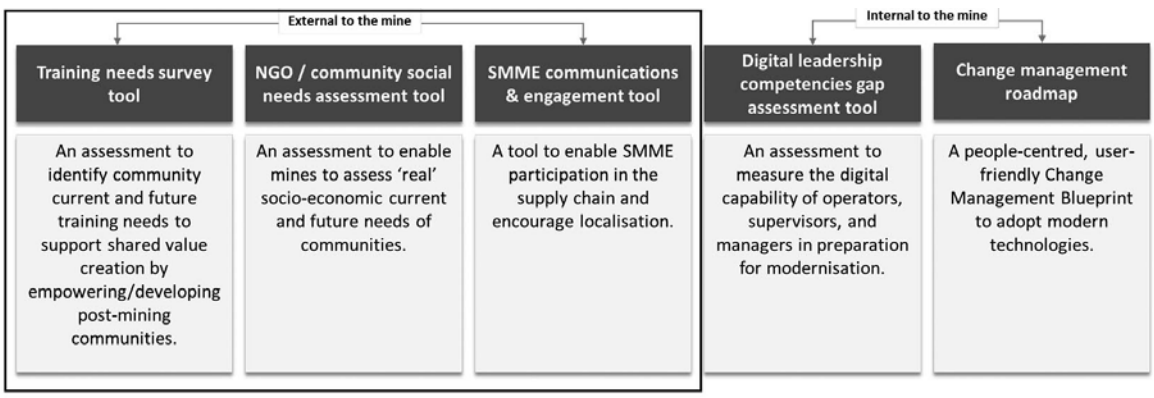

Figure 2—Digital tools developed to inform social transformation at the mines

people in mining' aspect. The tools were developed for the South African mining industry to adopt and embed in their operations freely. The purpose of each tool was to provide the mine with insightful information to assist in the decision-making process when considering development interventions for socio-economic transformation, digital training, and adoption of new technologies. From the five tools, only the three community related tools were piloted at the zinc mine for practical validation.

Based on the phase of modernization of the mine, deploying these tools was intended to ensure a new dimension of understanding for the mines and foster more inclusive decision-making proactively aligned to preparation for modernization and stakeholder relations. Hence, the digital tools sought to enable mines to gather data for informed decision-making, explicitly focused on community and employee needs, as per the developed tools.

Research methodology

Case study

The case study approach provides valuable in-depth and contextualized insights, particularly useful for exploring complex, real-world interactions in settings like socio-economic transformation in mining communities. By focusing on specific cases, researchers can gain a comprehensive understanding of nuanced dynamics, generating hypotheses and rich qualitative data that reveal stakeholder perspectives and motivations. This is especially beneficial in exploratory research where little prior work exists, as case studies can establish preliminary frameworks for future research. However, this approach has limitations, primarily in terms of generalisability; findings from a single or limited number of cases may not apply to broader populations, as they are often influenced by specific contextual factors. Additionally, case studies carry a risk of researcher bias due to subjective interpretation, which can affect objectivity and validity.

This study employed a case study methodology. Yin (2009) defines a case study as an empirical inquiry investigating a phenomenon in its real-life context. As such, multiple data collection methods are used in case study research, which involves an in-depth study of a phenomenon.

The case study methodology is applied (Figure 3).

Design principles

Figure 4 shows the process flow for the data inputs, processing, and analytics to achieve the desired outputs for the paper. Central to the success of data collection was the designated involvement of a community liaison office from the regional mine. The community liaison office was a central point in implementing the digital tools, data collection, and analysis of the results. Once the data were analysed, it was ordered according to key themes related to improving the understanding of communities' current and future needs and improving communications between the regional mine and the host community.

The study collected research data from the host communities, which were then analysed and interpreted through a process flow map. Digital tools were developed, and relevant social metrics were considered for the zinc mine. The digital tools used in the host communities included those relevant for external mine use, such as training needs surveys, NGO/community social needs assessments, and SMME communications and engagement tools. Internal tools,

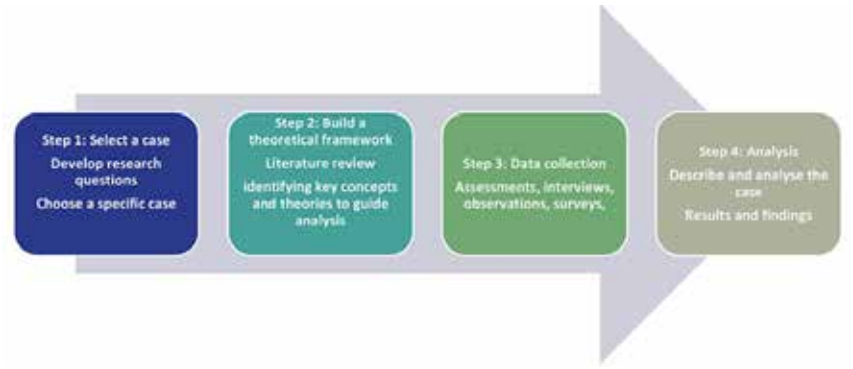

Figure 3—Case study methodology

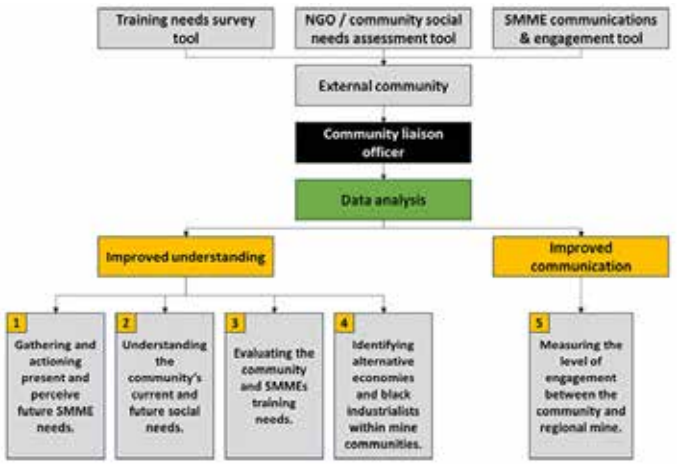

Figure 4—Process flow representing methodology

such as the digital leadership competency gap assessment tool and change management blueprint, will be applied to the zinc context in a follow-up study.

Pilot development at the zinc mine

The digital tools were piloted at a zinc mine in the Northern Cape, Southern Africa's Khai-Ma region, for verification and practicality for operational use at an active mine.

To understand the context-specific socio-economic challenges, businesses need to undertake a materiality assessment (Thao, 2023). This materiality assessment identifies, refines, and assesses significant ESG issues that might impact the business and stakeholders (GRI, 2023). These are then prioritized into topics, metrics, and targets to guide the company's ESG framework. Through an annual materiality assessment, the zinc business identified the social focus areas it needed to address as part of its ESG Framework. The metrics selected by the company are shown in Table I.

To seek community members' input into the ESG framework, the business currently uses manual approaches to survey completion and the Survey Monkey tool. The off-the-shelf digital tools allowed the company to improve its stakeholder engagement process and secure feedback from the community in a transparent and verifiable manner.

The digital tools developed aimed to improve the understanding between the mine and host communities and ensure an open and transparent line of communication between the parties. Subsequently, the digital tool focuses on enhancing data collection and is an additional feature in the engagement strategy with the mine and surrounding community. It is a means by which data can be collected from mining communities for further analysis and decision-making.

Data collection

The tools were demonstrated to the internal mine subject matter experts in September 2023. All comments and inputs were utilized to improve the tools. These comments included modifying wording to remove ambiguity, translating the survey tools into the Afrikaans language, and including the purpose of the surveys. The digital tools were deployed within the zinc mine itself. The target population for the pilot study was randomly selected through participants entering a community liaison office in five mining regions. The foot traffic into the community liaison offices of Onseepkans, Witbank, Pella, Pofadder, and Aggeneys influenced the research sample. Notably, the selection of the participants was randomized and not according to any specific criteria, apart from being a member of the targeted host communities. The importance of the community liaison officer was imperative in facilitating the completion of the assessments, whilst providing explanations to how to interpret the questions that were being asked on the survey tools. Without the community liaison officer, participation as well as the accuracy of the data collected would have been reduced.

The customized tools were presented internally to the organization and then launched externally for testing by the communities during October 2023. A public QR code was created to enable electronic completion of the assessments, and paper-based versions of each assessment were created for participants without internet access.

Challenges identified during this phase include too many input surveys for the community members to complete and the level of digital literacy required by older adults to complete the too-advanced survey. Table II shows the population size of the five targeted regions.

Data analysis and interpretation

No comparative data sets exist as this is the digital tool's baseline dataset. The research team engaged in deductive and inductive interpretation to identify key themes represented by the data, which can inform future decision-making (Bingham and Witkowsky, 2022). These themes were then categorized to maintain alignment with the survey questions and make meaning of the survey inputs received. The data interpretation and analysis process (Figure 5) reflects the process a mine would use to understand the data collected.

Table II

Population size per target location

Region	Population size
Onseepkans	*2 090
Witbank	349 076
Pella	*1 681
Pofadder	3 524
Aggeneys	*2 262
Total:	338 633

*Only census data from 2011 was available

Table I

Social-related metrics and targets for the mining company (Govender, 2023)

Metrics	Target (2027)
Put safety first in the community.	Elimination of safety-related fatalities.
Number of social incidents reported, investigated, and actioned.	100%
Human rights sssessment completed, and recommendations actioned.	100%
Local employment.	>95%
Local procurement.	>15%
Families impacted through skills development.	Train and develop 1 500 community members.
Community beneficiaries employed.	For every one job on-site, support two jobs off-site.
Women and children are uplifted through education, nutrition, healthcare, and welfare.	Positively impact 17 500 lives.

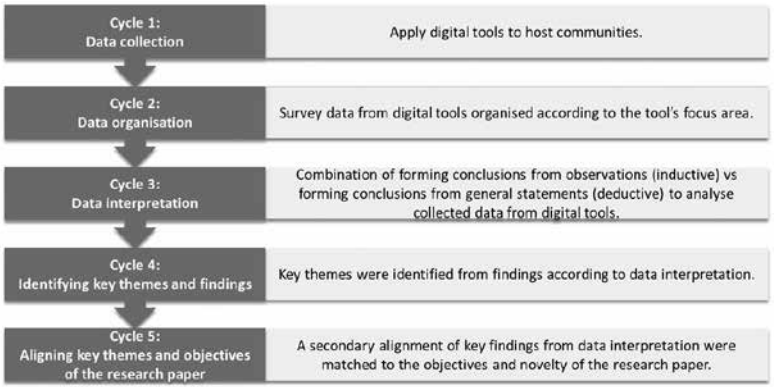

Figure 5—Data interpretation and analysis process

Results

The survey assessment results were categorized according to the specific outcomes described in the process flow diagram (Figure 5). As such, the interpretation of the data is presented according to the themes that follow here..

Note: This pilot test did not implement the Change Management Blueprint and Digital Leadership Competencies Tool. However, considerations for application arehighlighted in Section 5.

Research sample

The sampled dataset per tool is shown in Table III, with the highest number of participants completing the training needs survey (59 participants). The feedback from the community liaison officers was that aiming to implement all three surveys simultaneously was a challenging and complicated task for the community members.

Table III

Sample size per digital tool

Tool	Number of participants
Training needs survey	59
NGO community social needs assessment tool	33
SMME communications engagement tool	28
TOTAL:	120

Findings from data analysis and interpretation

The results depicted in the subsequent headings are interpretations of the data collected during the research study. The interpretation of the results aims to align with the research objectives already mentioned.

Synthesis of insights

The assessment results reflect insights that can be used to determine the regional mine's future development inventions. The key insights received per focus area are described in the following (a synthesis is depicted in Figures 6 and 7).

Figure 6 provides key insights into the role of SMME within a host mining community, focusing on business-related training, post-mine closure sustainability, and economic activities tied to mining operations. It highlights that 69% of SMME have received training in business planning (30%), finance (22%), and business management (19%), underscoring the importance of building core business competencies. To ensure sustainable income sources after mine closures, the top three industries identified are tourism and cultural attractions (19%), renewable energy (15%), and recycling or upcycling (15%), reflecting a shift towards diverse and environmentally conscious industries. Additionally, the primary economic activities that establish working relationships with the mine include agriculture, regenerative agro-processing, and re-forestry (30%), followed by catering (22%), and other activities (19%). These findings emphasize the significance of skill development, economic diversification, and collaborative efforts between the mining sector and local communities to drive long-term socio-economic transformation.

Figure 7 outlines the top five capacity development initiatives and alternative income sources relevant to post-mine closure planning in the host mining community. In terms of capacity development, the most readily available initiatives include

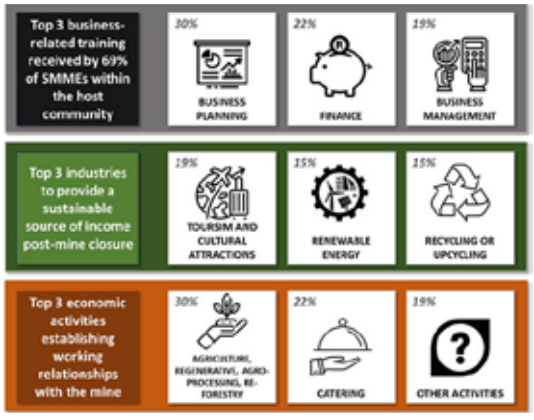

Figure 6—Summary of training, sustainable industries post-mine closure, and economic activities with host mine

Figure 7—Summary of readily available development initiatives and alternative sources of income post-mine closure

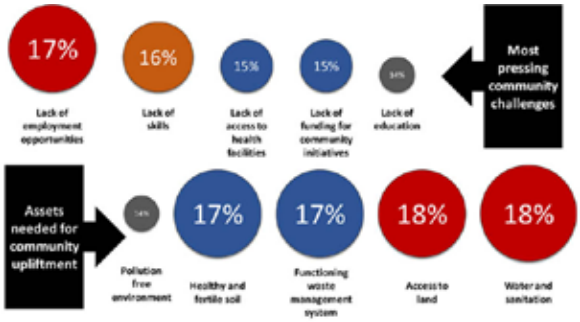

Figure 8—Host community challenges and needs

safety and risk management (10%), job readiness skills (8%), business management (7%), education and training (7%), and entrepreneurial skills (5%). These initiatives demonstrate a focus on building foundational skills and ensuring community readiness for employment opportunities within and beyond the mining sector. Furthermore, to ensure sustainable livelihoods post-mine closure, the top five alternative income sources identified are agriculture, farming and gardening (15%), sports and recreational facilities (15%), health facilities (15%), community halls (13%), and primary and secondary schools (11%). These findings highlight the importance of diversifying income sources and strengthening local infrastructure to support long-term socio-economic stability once mining activities cease. This approach encourages holistic development, preparing the community for a future without reliance on mining operations.

Gathering and actioning the present and perceived future SMME needs

The survey responses from SMME in mining communities provide critical insights into their access to financial support and their strategies for fostering socio-economic development beyond mining operations. Notably, 75% of SMME that applied for loans or grants were successful, with 66% using these funds to expand their businesses and 34% utilising them to hire additional employees. This demonstrates a strong focus on business growth and job creation. In alignment with broader community upliftment, SMME identified key alternative income sources post-mine closure, including agriculture, sports and recreational facilities, health services, community halls, and primary and secondary schools. These findings are consistent with previous data highlighting the importance of agriculture and local infrastructure in ensuring sustainable livelihoods post-mining. The results also underscore the community's drive to establish independent economic activities, addressing economic and social needs. Mining companies can leverage these insights to shape their corporate social investment strategies, supporting industries that align with community priorities and long-term sustainability goals.

Understanding the community's current and future social needs

To improve the effectiveness and impact of socio-economic development programmes, it is essential to have a deep understanding of the current and future social needs of the community being served. Figure 8 highlights the most pressing community challenges and the assets needed for community upliftment in a mining host community. The most urgent challenges identified by the community include economic inequality (17%), lack of infrastructure (16%), unemployment (15%), health services (15%), and education (14%). Correspondingly, the community identified key assets needed for upliftment, with priorities on employment opportunities (18%), improved infrastructure (18%), education facilities (17%), and healthcare services (17%).

When compared to previous insights, this data reinforces the themes of economic and social challenges, such as the need for job creation and better infrastructure, which were also highlighted by SMME. However, this new data emphasizes the immediate need for addressing unemployment and inequality, whereas the previous responses were more focused on leveraging financial support and alternative income sources post-mine closure, such as agriculture and education. Both sets of data underscore the importance of holistic socio-economic development, with the mining industry positioned to play a critical role in addressing these challenges through targeted community investments and support.

Evaluating the community and SMME training needs

To address the socio-economic needs of mining communities, it is essential to align training initiatives with the community's

long-term development goals. The community has already engaged in several capacity-building initiatives, with the top five most accessible training programmes focusing on safety and risk management (10%), job readiness skills (8%), business management (7%), community education and training (7%), and entrepreneurial skills (5%). Additionally, 69% of SMMEs in the host community have received business-related training, primarily focused on business planning (30%), finance (22%), and business management (19%). These initiatives provide a solid foundation for further economic development.

Comparing these findings with the community's identified needs for post-mine closure, such as job creation and infrastructure development, the mine can leverage existing skills to foster community-led economic activities. The mine can support sustainable business ventures by facilitating connections between individuals with complementary skills. This approach improves the mine's relationship with the community and enhances the long-term viability of socio-economic activities beyond mining.

Identifying alternative economies and industrialists that meet the broad-based black economic empowerment (B-BBEE) criteria within mine communities

Industrialists play a crucial role in fostering economic growth in communities following the cessation of mining activities, potentially becoming the primary economic drivers in these regions. SMME stand to benefit from industrialist schemes but often lack awareness of these opportunities. The regional mine can assist in identifying and supporting SMME with the potential to evolve into industrialists. Survey data reveals that 67% of economically active community members were unaware of the Black Industrialist Scheme. The community, however, has identified industries such as tourism and cultural attractions (19%), renewable energy (15%), and recycling or upcycling (15%) as sustainable income sources post-mine closure. Additionally, 11% of respondents expressed no interest in these industries, suggesting a need for further engagement to identify their specific training and development needs. These findings highlight a communication gap between mining operations and the community regarding available support initiatives, indicating the need for a targeted and consistent promotional strategy to maximize community participation in industrialist schemes.

Measuring the level of engagement between the community and the regional zinc mine

Measuring the level of communication between regional mines and host communities is essential to ensure mutual understanding of each stakeholder's needs and how these can be addressed through available tools and resources. Survey data (Figure 9) indicate that a significant majority of SMME, specifically 71%, report a lack of understanding regarding tender requirements. Furthermore, 85% of SMME find the process of uploading documents to the regional mine's vendor/procurement portal to be challenging, a sentiment echoed by all participants who stated that the portal's instructions were difficult to follow. Additionally, 85% of respondents are not actively monitoring the status of their applications on the portal, likely due to a lack of knowledge about how to navigate it—100% of participants reported not knowing where to access the portal or how to operate it effectively. While over 86% of SMME are registered with the Companies and Intellectual Property Commission and possess a tax number, many are not registered with the Workman Compensation or the South African Revenue Service and struggle to comprehend tender requirements. Among those SMME that maintain working relationships with the mine, key economic activities include agriculture, regenerative agriculture, agro-processing, and re-forestry (21%), followed by catering (14%), and other activities (14%). These findings suggest that while SMME possess the foundational prerequisites for engaging in service exchanges with the regional zinc mine, they lack the technical expertise required to navigate the vendor platform effectively. The portal's user-friendliness is a critical issue that needs addressing. Consequently, these insights indicate the necessity for the mine to enhance its mentoring efforts regarding the technical requirements of the vendor platform, facilitating the formation of mutually beneficial relationships.

Comparison with the zinc mines materiality assessment

The digital tools can provide a detailed perspective of most elements questioned within a mine's materiality assessment (refer to Table IV. They can also enable more instantaneous and regular feedback with host communities.

Recommendations

In considering the application of digital ESG tools within mining contexts, several critical learnings emerge that can enhance their effectiveness and community engagement.

First and foremost, running campaigns in collaboration with community leaders is essential, ensuring that these efforts are well-publicized and attended by a significant portion of the community. Such campaigns serve not only to explain the value of the tools but also to cultivate a compelling narrative around the potential benefits and outputs derived from their application.

Furthermore, community leadership plays a pivotal role in influencing and driving the uptake of surveys among local residents. By enlisting respected figures within the community, mines can foster a greater sense of trust and participation in the survey process.

Additionally, leveraging the technological assets available in community liaison offices is crucial for spurring further engagement. Providing access to computers and internet connections has proven essential, though it necessitates that

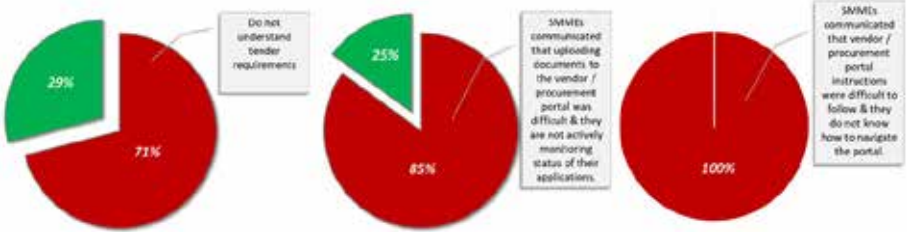

Figure 9—SMME engagement with host mine vendor portal

Table IV

Materiality comparison with digital tools

Mine Social Metric (Secured after annual materiality surveys)	Identified using the Digital Tool (secured during November 2023)	Justification for Response
Put safety first in the Community.	Yes	The community was keen to participate in safety and risk management training (10%) to prevent fatalities and injuries.
Number of social incidents reported, investigated, and actioned.	No	It is not included in the digital tools and is not highlighted by the Communities as an issue/concern based on the good relationship with the mines.
Human rights assessment completed, and recommendations actioned.	No	It is not included in the digital tools and is not highlighted by the Communities as an issue/concern based on the good relationship with the mines.
Local employment.	Yes	Skills development for business-related capabilities was favoured by 69% of the host community, where skills to improve their ability to create a sustainable business were favoured and tended towards business planning (30%), finance (22%), and business management (19%).
Local procurement.	Yes	Through the SMME engagement tool, 100% of SMME in the host community expressed interest in providing services to the regional mine. However, 71% voiced difficulty understanding tender requirements. Those who were successful provided agricultural, agro-processing, catering, and other activities to the mine.
Families impacted through skills development.	Yes	The training needs assessment survey provides insight into the specific skills development requirements desired by the host community and indicates that job readiness (8%) and entrepreneurship (5%) are crucial in ensuring sustainable economic activities to improve the living conditions of families.
Community beneficiaries employed.	Yes	The community social needs assessment tool indicates the success rate of SMME who applied for grant funding (75%) and the degree of awareness of Black industrialist schemes (33%) offered by the mine. The utilization of the specific funds tends towards expanding their business (66%) rather than providing immediate employment (33%).
Women and children are uplifted through education, nutrition, healthcare, and welfare.	Yes	The community social needs assessment tool provides insight into the specific needs and challenges the host community faces and what specific industries can lead to community upliftment.

participants travel to these offices, which can be a barrier to participation. To mitigate this, mines should strive to create curiosity and excitement within the community to encourage regular visits to the community liaison offices.

The average completion time for the surveys was recorded at approximately 15 minutes, which highlights the need for consideration of participant concentration levels across different communities. In light of low response rates, there may be merit in merging surveys to streamline the process and enhance overall participation.

The zinc mine provided for capped data (approximately 500MB per person, per month). However, it should be noted that data usage is another vital consideration. Despite the provision of Wi-Fi to the community, issues regarding data consumption remain pertinent. Figures 10 and 11 provide a visual representation of the data utilized for completing assessments and accessing resources, further emphasizing the need for careful planning in this regard.

Consideration of the exact data usage to complete the assessments is imperative for other mines wishing to apply the digital tools as free available Wi-Fi may not be offered to host community members.

In summary, the application of digital ESG tools in mining communities requires a nuanced understanding of local dynamics and the importance of community involvement. By incorporating these learnings, mines can enhance the effectiveness of their initiatives and foster more meaningful relationships with the communities they impact.

Considerations for tools implementation

During the testing of the digital tools, several challenges were identified that affected participant engagement and survey completion rates. Firstly, the use of multiple separate surveys contributed to survey fatigue, resulting in decreased participation. To address this issue, it is recommended that the mine consolidate these into a single, integrated tool that encompasses all necessary surveys.

Additionally, participants reported a lack of motivation to complete the surveys, citing the excessive number of questions and concerns regarding data usage as significant barriers. To improve this, the mine could customize the tool by focusing on key questions that provide essential information, thus streamlining the process.

Furthermore, the implementation of the survey necessitated considerable physical presence, explanation, and micro-management by mine representatives, highlighting the importance of active engagement and support to facilitate effective responses from community members. Many participants in the SMME communication and engagement survey also experienced fatigue Hence, regular forums could be established to foster ongoing community engagement, manage expectations, and minimize distractions.

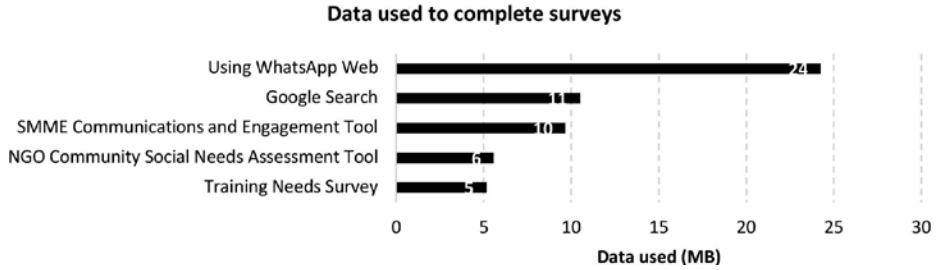

Figure 10—Comparison of the data used to complete each assessment

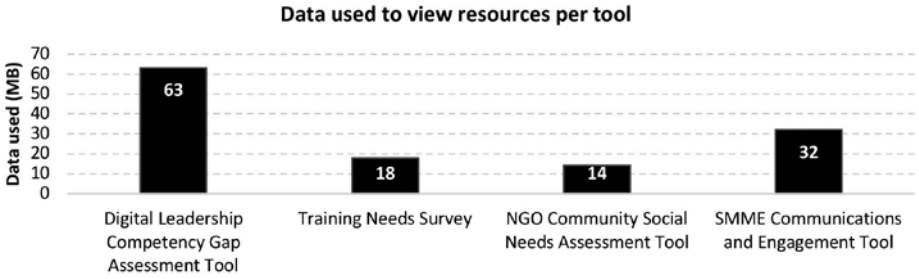

Figure 11—Comparison of the data used to access resources for each assessment

The presence of nested questions and pop-ups was noted as a potential hindrance to completing the survey and fully absorbing the presented content.

Considerations before implementing the digital tools

Work sessions with pilot sites revealed stakeholders' need to understand the integration of the technology initiative into the overall strategy and operational structures. A company-wide digitization journey map is deemed necessary. Concerns were raised about the readiness of specific operations for technology adoption and the absence of assurance from the company regarding an integrated plan.

The progress of other initiatives and priorities affects the digitization journey, requiring a thorough understanding of contextual factors when the project team is established. Participants found that, what started as a beneficial project quickly became a burden, negatively impacting commitment. The larger organization requires reassurance about the specific project's intent and expected behaviour.

Projects consistently overlook a thorough review process, neglecting the plan, do, check, act (PDCA) cycle, which is necessary for quality improvement. Before launching new initiatives, projects need to facilitate knowledge-sharing to prevent repeating mistakes. The industry must disseminate insights, avoiding recurrent failures. Industry forums should promote learning and encourage participation. Reflecting on experiences is essential for averting future challenges and holding the organization accountable for the reasons behind project failures.

Past initiatives influence the perceived likelihood of success and establish the framework for gauging future success. Before embarking on the change process journey, it is essential to reassess the resource plan, acknowledging the distinction between current practices and desired actions. The recent change management approaches and methodologies are crucial in this phase to ensure cultural alignment.

In a follow-up study, the two other digital tools will be validated within the context of the zinc mine. These tools were intended to improve the understanding of the social and training needs of the external communities and the engagement between potential suppliers. Additionally, the tools were meant to measure the digital capability of the workforce (i.e., digital leadership competency) and prescribe a roadmap for adopting modern technologies within the mining operation (i.e., change management).

Conclusion and implications for mines

The metrics and targets selected by the mining company for the social aspect of ESG criteria align closely with community expectations as highlighted in the survey, particularly regarding job creation and training to leverage the benefits of mining and foster local entrepreneurial opportunities. Based on the insights gathered from this study and the lessons learned from the pilot initiatives, several key considerations emerged to guide future development interventions and facilitate ongoing dialogue with the host community.

Firstly, the expansion of local SMME has the potential to significantly increase job availability, thereby enhancing the living conditions of community members through a multiplier effect. Secondly, enhancing the quality of primary and secondary education is essential to uplifting the community's skill base and addressing existing skill shortages.

Additionally, the community strongly desires access to fertile land for agricultural activities, recognizing that such endeavours could provide a vital source of income and sustenance following mine closure. Despite the awareness of agriculture's potential, current agricultural activities remain minimal. Furthermore, while there are established solid waste disposal and recycling depots, the overwhelming majority of community members (96%) do not view these as viable sustainable economic activities post-mining. A similar sentiment is reflected in the perception of tuckshops and spaza shops, which, despite their presence, are also not seen as sustainable economic options after mining ceases.

Notably, 14% of SMME reported having working relationships with the mine however, the survey results do not clarify what the 'other' category entails, indicating a need for follow-up discussions to explore how these relationships can be further developed and supported. Unanimously, community members reflected a misunderstanding of the tender application portal, which can motivate strategic intervention from the regional mine.

Importantly, these digital tools, though proven beneficial in gathering socio-economic insights, have not previously been applied to host communities in this manner. Recognizing that mining contexts vary significantly and that each mine is at a different stage of modernization, the lessons learned from the zinc mine may be applicable to other operations facing similar circumstances. A uniform approach is not advisable, rather, the digital tools should be adapted according to the unique context and specific needs of each mine. Continuous learning and adaptation remain essential, and organizations should leverage these insights to successfully implement digital tools that facilitate rapid impacts and advance social transformation within mining communities.

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Abbreviations

B-BBEE	Broad-based black economic empowerment
CIPC	Companies and Intellectual Property Commission
CSI	Corporate social investment
ESG	Environmental, social, and governance
GDP	Gross domestic product
MB	Megabytes
MPRDA	Mineral and Petroleum Resource Development Act
PDCA	Plan, do, check, and act
SATCAP	Successful application of technology centered around people
SED	Socio-economic development
SET	Socio-Economic transformation
SLP	Social and labour plans
SMME	Small, micro, and medium enterprises
UN	United Nations

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