Sustainable adoption of technology: A people-centric approach within the South African mining industry

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Understanding and clarifying the critical success factors (CSFs) that either support or inhibit the sustainable adoption of technological solutions, is required to improve the maturity of change leadership in the South African mining industry's (SAMI) modernisation journey. Technology is seen as an enabler for solving the everyday problems of multiple stakeholders within the mining value chain. Previous work has been conducted in the Successful Application of Technologies Centred Around People (SATCAP) programme of the Mandela Mining Precinct and at the Gordon Institute of Business Science towards demystifying these CSFs, which leads to the successful design, selection and diffusion of technologies within the context of modernisation. The technologies deployed in the SAMI's operations must be purposeful and ready to serve the industry's multiple stakeholders' needs and realities. The diffusion process should be people-centric, facilitating upskilling and reskilling, as skills transformation is required for the sustainable adoption of technological solutions. Mature change leadership is needed and practised intentionally and systemically; this approach will ensure that the diffused technologies achieve their purpose, namely value creation. Considering the CSFs within a people-centric change approach will accelerate the SAMI's modernisation journey, and leverage technology as an enabler of change. The sustainable adoption and diffusion of purposeful technologies as the means will accelerate the SAMI's various stakeholders into a modernised world of work.

Keywords: Change leadership, change management, critical success factors, decision to adopt, diffusion of technology, modernisation, operational readiness

INTRODUCTION

Staying competitive amid constant turbulence and disruption is a big challenge for business leaders. At the same time, capability is needed to stay ahead of change, and leading the change, as noted by Kotter (2012). The South African mining industry (SAMI) is grappling with the impact of constant turbulence and disruption and economic challenges on production levels, profitability, and sustainability. These turbulent factors include volatile exchange rates, high inflation, and frequent power outages due to the country's persistent energy crisis and electricity costs, which have increased by 12.8% year-over-year in early 2024 (Lourens, 2024). The global mining industry has also experienced dampened commodity prices, with decreased economic growth and demand in platinum group metals due to growing demand for electric vehicles. Apart from external economic and infrastructure pressures, business operations in the SAMI are experiencing operational challenges and declining resource grades, resulting in deeper underground mining operations and a spike towards higher operational costs.

The flip side of the coin is the need for critical minerals, providing the substantial opportunity to be the supplier for the global just energy transition. Critical minerals are further essential for the functioning of modern technologies. However, the critical minerals supply chain is at risk as the worldwide demand to meet net-zero and sustainable development goals increases (Dou *et al.,* 2023).

The SAMI's commitment to modernisation

Despite these challenges, the SAMI remains a key contributor to the mining and minerals value chain – a strategic pillar of the South African economy, and a significant source of employment. As reported by the Minerals Council South Africa (Baxter, 2023). In 2023, the SAMI employed 479 228 people, contributed R85.8 billion in taxes and added R444.2 billion to the country's gross domestic product (GDP) (Lourens, 2024). In the quest to remain competitive and respond to the demands, Rodger Baxter highlights the required changes. He states that digital transformation is imperative and a key enabler for the mining industry to achieve its business value drivers. These drivers include enhancing safety, health, security, production volumes, workforce, and leadership capability. In the case of the SAMI, the digital transformation journey will require bespoke innovations that will address old mining infrastructure through retrofitting and interoperability (Baxter, 2023). Statistics released by the Minerals Council (2023), revealed that the mining industry is one of very few sectors in South Africa that is adding jobs in the prevailing economic climate. The sector created 15 500 more jobs in 2022, lifting total employment to 475 560 in the sector (Minerals Council South Africa, 2023).

The SAMI has embarked on a modernisation journey that is defined as "a process of transition and transformation of the mining industry of yesteryear and today to that of tomorrow"(Minerals Council South Africa, 2021). A partnership was established between the Minerals Council of South Africa (MCSA), the Department of Trade and Industry (DTI), the Centre for Science and Innovation (CSIR) and Mining Companies to bring about change in the technological space and modernise the industry (Le Roux, 2021). A report presented by the World Economic Forum and Accenture in 2017 calls for urgent action to SAMI and provides a big opportunity for modernisation as imperative for leadership. The sustainable adoption of various technological solutions is seen as the enabler of unlocking value. The report explains that digital technologies can help South African mining businesses unlock ZAR153 billion in value by 2026, about 51% of the current mining size. This will increase the mining sector's contribution to GDP by 2%. Other benefits include increased output, reduced personnel costs, improved asset utilisation, reduced downtime, and fewer health and safety incidents (Macnamara, 2023).

Modernisation is closely associated with concepts such as the fourth industrial revolution (4IR) as popularised by Schwab (2016) who was the founder and chairperson of the World Economic Forum. The concept of modernisation, and specifically 4IR, would alter the way we conduct work. The impact of 4IR in the mining industry has already changed the face of mining as mining companies demand the supply of internet of things (IoT) services to enable underground self-guided vehicles (Bechtsis *et al.*, 2017), sustainable green solutions in the supply chain (Majerova and Das, 2023) and improved modelling, data analytics and monitoring (Ghorbani *et al.*, 2023). Besides the technological impact on our work context, Schwab (2016) provides thoughtful insights, and states that 4IR has enabled new physical possibilities. IoT combines physical and digital applications, referring to cars, houses, and hotels. Automation will bring prosperity and create new jobs, but it also impacts public institutions, as the public voice can be expressed and act with or against government systems, challenging top-down approaches to regulations. Modernisation of the mining industry may involve mechanisation and automation and is considered the path that will change processes, technologies, skill sets, and the social and environmental impacts associated with current mining practices (Singh, 2017).

Positive triggers for change

Zulu *et al.* (2021) encourage the mining industry to leverage these positive triggers when introducing technologies. Technology acceptance, adoption and diffusion can create value by enhancing worker safety, increasing cost and process efficiency, achieving environmental sustainability and enabling data-driven decision-making. The opportunity therefore exists to extend the longevity of our industry and the benefit of strengthening the value chain. Ntsoelengoe (2021) highlights that "the modern mine will have to act nimbly in integrating advanced technologies into every step of the value chain – from

detecting and exploring minerals, to advanced extraction and real-time digitalised procedures overseen by an empowered workforce. The buzzwords 'digitalisation' and 'people-centred modernisation' have also been adopted in this sector. The term 'Industry 5.0' was coined to represent a new phase of industrialisation and builds on the technological advances of Industry 4.0. The stronger focus on human centricity, sustainability, resilience, personalisation and customisation, and bioeconomy was identified in the scoping study completed by Müller and van Dyk (2024) and presented as the shift of human-machine collaboration, indicating a focus from economic value to societal value and well-being. The shift towards sustainability in the adoption of technology requires a people-centric approach to change leadership, as proposed by Botha *et al.* (2024).

Despite this positive push, the SAMI's technology adoption and diffusion rate remains significantly below expectations. These technologies also do not generate value. Macnamara (2023) refers to the dismal findings mentioned at the Electra Mining Africa Expo 2022 by Motilal, and noted that digitalisation adoption has been low, slow and fragmented in the SAMI. The opportunity presented by Accenture and World Economic Forum (2017) to unlock value will not be realised as current skill shortages are evident in advanced analytics needed to fast-track the unlocking of the potential value in digitalisation. If technology diffusion and adoption stay low, the potential for value creation of multiple stakeholders will continue to be elusive, and the modernisation journey will fail to be purposeful. Business leaders should leverage these positive triggers as the expectation for sustainable mining practices increases. The need for change is clear, and the opportunity is looming. How we respond depends on who we are and our level of maturity to practise change leadership within a modernised context.

The SAMI has reacted positively and placed people-centred change management at the core of the modernisation process, as it is believed that a holistic approach is desirable for modernisation initiatives to serve this purpose (MCSA, 2019). The people-centred approach is envisaged within the context of the fourth (and almost the fifth) industrial revolution. It is driven by the SATCAP research program, seeking to understand how people relate to each other and with technology in this process of modernisation. Through the SATCAP program at the SAMERDI research unit, the quest for people-centred design is advocated, exploring the social agenda of modernisation, states Ramparsad, the SATCAP program leader (Le Roux, 2021). The SATCAP research conducted by Stanz *et al.* (2020) shared the importance of change management as it can enable the adoption of new technologies. Still, the ineffective implementation thereof may contribute to hindrances or inhibit acceptance. Ineffective change management creates further resistance and lack of trust, instead of enabling mining companies in their journey to modernisation (Stanz *et al.*, 2020).

People-centric change leadership

Kotter (2012) refers to accelerators needed for organisational transformation, introducing a new dual system, a strategy process - such as the SAMI's modernisation journey or the technology decision and the technical diffusion process - and then a strategy network of change leaders. This dual network system will work in symbiosis to drive value creation. The change network will be doing the strategic change leadership work and leading the change management process. While the strategic network will deal with the modernisation and technology roadmap, Carreño (2024) noted this need to modernise traditional change leadership approaches and recommended including a more continuous and iterative approach to change, reflecting the agile and lean methodologies instead of a linear approach. Müller *et al.* (2019) advised that the SAMI required a more modern and exponential approach to change management when reflecting on the traditional practices employed in the SATCAP programme's initial research programs. The participative employee-driven approach is now advocated as it is evident that leading transformation requires inspiring others, communicating effectively, and motivating the organisation to adopt and internalise new behaviours (Botha *et al.,* 2023 and 2024). Sustainable adoption will be achieved by internalising new behaviours and practising people-centric change when deciding on and diffusing technologies. Kotter (2012) advises that adopting change leadership principles will produce movement and inspire change, speak to the reason and the heart, explain the why and want to, enabling a push through barriers. Change leadership will further include the collective to reduce the obstructive view.

This paper aims to clarify how people-centred change leadership would accelerate the sustainable adoption of technological solutions. People-centred change leadership is seen to identify the strategic and contextual realities and infer the CSFs to be considered to accelerate the sustainable adoption and diffusion of purposeful technologies within the SAMI's modernisation journey and value chain. It also explains how leaders can leverage these CSFs in developing a systemic, yet iterative change journey and create value by adopting people-centric change leadership principles, methodologies, and practices for technology adoption and diffusion. The goal is to encourage mining operations to move beyond focusing on technology adoption but accelerate towards technology diffusion and value creation for multiple stakeholders in the value chain. Ultimately, the intent is to facilitate a shift in behaviour among leaders, helping them to practise people-centred change leadership to diffuse technology as a means towards modernisation and value creation, rather than an end goal. This paper will reflect on the previous work in the SATCAP program at the Mandela Mining Precinct and the GIBS. The focus is on understanding the inhibitors and associated CSFs identified in documented studies (Botha *et al*., 2023 and 2024; Ntsoelengoe, 2019; Stanz *et al*., 2020) and strengthen the understanding through the SATCAP researchers' explorative field work. Key insights will be consolidated and presented to enhance the knowledge of change leadership and change management practices within this context.

RESEARCH METHOD

This research entailed exploratory study that focused on a discovery approach, which included determining the influencing factors found in literature about the research topic, collecting data from participants and inferring a model based on the research findings (Saunders and Lewis, 2018). According to Soiferman (2010), this approach supports the qualitative research method, which is considered a rigorous method for exploring the relevant research factors in depth. According to Saunders and Lewis (2018), exploratory research aims to pursue new insights and assess topics from a new perspective. An inductive exploratory approach was selected as no specific framework was evident in the literature against which to test the acceptance of technology solutions in the mining industry. Creswell (2003) argues that when research focuses on the 'what' question, like this current research, it is recommended that it be conducted as exploratory research due to the flexibility this provides and its ability to acquire in-depth answers to the research question posed.

Research question

The research aimed to answer the principal research question: What are the CSFs to be considered for the adoption of new technologies?

Research aim

The research aimed to understand the inhibitors and enablers which influence decision makers in mining companies to commit to adopt and implement technology solutions across the mining value chain. The research further aims to consider the various inhibitors and enablers to inform a change management blueprint through the inclusion of relevant CSFs during the conceptualisation phase and then throughout the change management process. The questions posed aim to explore the system in which South African mining companies operate and to understand the factors that influence the sustainable adoption of technology-based solutions across the mining industry. Research questions were designed to explore factors that enable and inhibit technology adoption in the SAMI.

LITERATURE REVIEW

Definitions

To contextualise the process of technology adoption and diffusion within modernisation journey, the following definitions are relevant:

- **Technology** refers to devices and systems used to solve real-world problems (Andersson *et al*., 2016). In a general sense, we define technology as the invention, design, or discovery of something

that serves a particular purpose from a purely materialistic standpoint without needing humankind to be responsible (Carroll, 2017).

- **A people-centric approach** is a design that includes impact assessments in the field of environmental, social and governance (ESG), which are done together with a change management blueprint to be used to adopt modern technologies (MMP, 2023).
- **Technology readiness** is society's propensity to accept and use new technologies at home and work to achieve goals (Parasuraman, 2000).
- **Sustainable adoption** in the SAMI modernisation context can be defined as 'Being accountable for decisions to adopt technology, leading and enabling the diffusion process, and accelerating value realisation for the multiple stakeholders in the value chain' (own definition).
- **Change management** is defined as "the process of continually renewing an organisation's direction, structure, and capabilities to serve the ever-changing needs of external and internal customers" Moran and Brightman (2000) and at a project level "The application of processes and tools to manage the people side of change from a current state to a new future state so that the desired results of the change are achieved" (Hiatt and Creasey, 2012).

Characteristics of sustainable adoption

Adoption can be defined as an act of taking up ownership of an object or entity (Ghazizadeh *et al.*, 2011). Lozano (2022) states that sustainability, in the context of successful change management, refers to the ability to maintain and continuously improve upon the changes implemented within an organisation over the long term. It involves ensuring that the benefits of the change are enduring, and that the organisation does not revert to old practices once the initial change efforts are completed. This requires planning for the change management work to be done to institutionalise the practice or even improve it. Sustainability transformation seeks to create long-term value for a business or organisation while considering ESG practices (Sancak 2023). Sustainable adoption can therefore be explained as taking ownership of the decision to adopt the implementation process and the impact of deploying a technology, to see it through and derive the value of the technology. The sustainable adoption of technologies embodies the zero-harm mindset of SAMI. It aligns with the findings of Trawick and Carraher (2023), who attributed the success of sustainable adoption to the integrative approach used and the resulting value derived from implementing these technologies.

Inhibitors and enablers for technology adoption

Ntsoelengoe (2019) identified inhibitors and enablers impacting technology adoption in the SAMI and informing what to plan for during the change process. The unit of analysis selected was the decision-makers in the SAMI, executives, senior managers, and senior operational managers who are directly involved with introducing innovative technology solutions to their business. Table 1 reflects on these factors that inhibit the adoption of technology solutions in the SAMI.

Table 1. Factors which inhibit the adoption of technology in mining (Ntsoelengoe, 2019)

Inhibitors	Details of factors that prevent technology acceptance
Low technology readiness levels*	There was low impetus from mining companies to accept low readiness level technology, which was associated with high risk of introducing an unproven technology into an operational business value chain.
Capital funding	This pertains to the lack of funding, a definite inhibitor for introducing technology solutions in the mining environment.
Digital skills	The lack of required digital skills necessary for executing technology functions. Relevant digital skills such as computer, engineering, chemical, analytics and coding as part of preparing for the fourth industrial revolution and adopting technology solutions.
Behavioural change	The individuals' mindsets and perceptions about the benefits of technology solutions. Technological change influences social and behavioural changes, and acceptance will fail if the individuals' behaviour does not change.

*Low technology readiness levels in this context refers to the technology's maturity level.

The enabling factors were defined as those that make it possible for decision-makers to adopt the technological solutions, thereby supporting the adoption of modernisation. These factors are presented in Table 2.

Table 2. Factors which enable the adoption of technology in mining (Ntsoelengoe, 2019)

Enabling factors	**Details of the factors**
Research and development	Research and development were required to develop appropriate technology solutions, which involved testing, developing, and demonstrating that a technology solution was suitable for providing the solution.
Funds dedicated for modernisation	Most respondents agreed that capital funding was an essential part of modernisation and that funds dedicated to technology adoption enable the investigation of appropriate technologies to drive value for the business.
Information systems (IS) infrastructure	Some of the respondents highlighted the importance of having the enabling information systems infrastructure necessary for equipment communication and successful utilisation of technology solutions.
Organisational culture	Innovative culture that enables a collaborative environment where information is shared and where employees are encouraged to discuss their ideas.
Business ethics	Some respondents mentioned that mining companies were expected to demonstrate ethical conduct.

The inhibitors and enablers presented in Tables 1 and 2 are a combination of strategic, organisational, and human factors, and the effectiveness of the change network. Pelders and Schutte (2021) focussed on barriers (inhibitors) and facilitators (enablers) of technologies in mining, as presented in Table 3.

Table 3. Barriers and facilitators to successful implementation of new technologies (Pelders and Schutte, 2021)

Barriers (inhibitors)	**Facilitators (enablers)**
Premature application of technology Initially high or unexpected costs Employee attitudes or resistance to change Fear of job loss as a result of the technology Suspicion of management motives Poorly engineered work systems Technical failures Poor ergonomics Inadequate human-machine interface design Inadequate training or skills New health and safety risks created Poor implementation, planning and control Difficult mining conditions	Optimal design of equipment Human-system integration Technology appropriate to work system Technology maturity Usability Operator acceptance Knowledge transfer Training and support Communication and coordination Ownership of the technology or work system by the workforce Worker involvement Trust in the technology Quantified benefits Common vision

The factors in Tables 1, 2 and 3 reflect organisational factors and technology factors but also aspects of human factors which inhibit or motivate technology adoption. During the decision-making phase, the planning to display mature change leadership and initiate the change management process will have to identify the risk of these factors and mitigate the plans

Human Factors as inhibitors or enablers

Human hardwiring

Adoption decisions are driven by human factors, being impacted by the inhibitors and enablers, and described as our tendency to accept or resist change. The concept of resistance is explained by Kotter (2012) as operating from a survival mindset. The identified inhibitors and enablers can either activate the survive or thrive channel in decision-makers, as explained by Kotter (2012), and demystify what the CSFs should be. Sustainable adoption should act as an accelerator for modernisation and be considered when crafting a change leadership and change management plan. A people-centric approach can

capitalise on the opportunity provided by human nature, to not only resist change but to also be opportunity-seeking. Moderate survival levels keep people alert, but inflated survival impacts opportunity-seeking through an activated thriving channel.

Attitude towards using technology

Attitude towards using technology (ATUT) is a person's overall affective response towards using a chosen technology (Venkatesh *et al.*, 2003). The ATUT level can be negatively triggered if the perception is created that introducing the technology might exacerbate the risk in the specific environment. One can infer that the external changes might be outpacing our internal ability. Sustainable adoption, therefore, will have to move the industry from a survival paradigm (and be a hostage of the past) towards one that thrives because of the intentional focus on providing change leadership.

Performance expectancy

The decision to adopt based on "the degree to which an individual believes that using the system (technology) will help him or her to attain gains in job performance" (Venkatesh *et al.*, 2003). If decision makers do not see the benefit of using a technology and as a result, can perform better, the performance expectancy remains low and the behaviour (to adopt or not to adopt) remains undesirable.

Technology readiness (people)

Typical technologies being adopted during the period of 4IR, also known as Industry 4.0, include technological advancements in wireless technologies, robotics, quantum computing to analyse big data, 3D printing, artificial intelligence and nanotechnology (Ayentimi and Burgess, 2019). Adopting digital transformation is among the top ten megatrends expected to impact the business ecosystem, comprising business, government, society and culture (Ernst and Young, 2015). Technology readiness studies in various industries as guided by Parasuraman and Colby (2015), attribute the propensity to accept technology to a person-centric set of generic factors perceptions are explained within the classifications in Table 4.

Table 4. Technology readiness dimensions (Parasuraman and Colby, 2015)

Dimension	**Sensemaking**	**Impact**
Optimism	A positive view of technology and a belief that it offers people increased control, flexibility, and efficiency in their lives	Motivator
Innovativeness	A tendency to be a technology pioneer and thought leader	Motivator
Discomfort	A perceived lack of control over technology and a feeling of being overwhelmed by it	Inhibitor
Insecurity	Distrust of technology stems from scepticism about its ability to work appropriately and concerns about its potentially harmful consequences.	Inhibitor

Technology readiness represents a gestalt of mental motivators and inhibitors that collectively determine a person's predisposition to use new technologies and can be measured. Technology readiness is seen as an individual-level characteristic; it does not vary in the short term and does not change suddenly when exposed to a stimulus. Higher readiness levels are correlated with higher adoption rates of cutting-edge technology and more intense usage of technology with greater perceived ease in doing so (Parasuraman and Colby, 2015). Interventions for technology adoption will benefit to reinforce the motivators and reduce the presence of the inhibitor.

Technological readiness is measured through frameworks like the TRI 2.0, and it assesses two positive motivators—optimism and innovativeness—and two negative inhibitors—discomfort and insecurity. The TRI 2.0 is an indicator to measure technology-related behavioural intentions regarding technology adoption (Parasuraman and Colby, 2015). The introduction of technology will have different impacts on different people. The change management approach should make provision for the various levels of individual readiness of either the leaders or the team members, strengthening the importance of adopting a people-centric approach when introducing technology.

Kirrane *et al*. (2016) identified factors that influence readiness as being perceived management support, organisational, situational or psychological factors. Choi and Ruona (2011) explored the psychological conditions for individuals to be ready for planned organisational change; readiness is attributed to individuals experiencing a culture of learning, whose beliefs are altered about the necessity of the change and the likelihood of its success.

Leader readiness

Singh (2017) made it clear that the people in the mining industry must change to secure sustainable business, but a positive change does require the leaders to change the realities of the industry. This can be interpreted as being cautious of "too much talk and not enough action". "The capacity to lead change, will be the key requirement for mining modernisation and change initiatives to deliver on the sustainability agenda" (MMP, 2023). Change initiatives in mining are, however, highly dependent on a holistic approach as any change requires employee engagement and a leadership style which includes operational levels in decisions, as stated by Bezuidenhout and Schultz (2013),"If the leadership is not experienced as mature enough to enable their employees to cope with change, upheaval, and to remain engaged throughout the change process, the stability and prosperity of the organisation are in jeopardy".

Consistent reporting, however, identified that the speed of adoption by followers at mining operational levels is far below the requirements to modernise the industry (PWC, 2023). Hermanus *et al*. (2015) previously ascribed the slow rate of technological change to the aptitude of the industry to be slow with the adoption of change initiatives, methodologies, and practices in general. The inefficiencies in leadership and a lower readiness level of leaders in the SAMI, were raised as other reasons for slower change, as innovations such as 4IR are dependent on a more modern leadership style and improved practices, as reported by Uys and Webber-Youngman (2019). Research further stated that the current dominant leadership style does not fit the new envisaged modernised mining industry. Uys and Webber-Youngman (2019) and Boloko (2018) explored perceived leaders' inefficiencies during the change process and noted a severe lack of specific change leadership competence within the South African leadership competence repertoire. With the current perceived inefficiencies at the operational level as a backdrop, the mining industry's future is planned for in full force, and the dependence on operational leaders for implementation is looming.

Organisational Factors

Strategy

Zulu *et al*. (2022) highlight the lack of strategy as a significant adverse driver for SAMI in modernising, and challenge leaders to become strategy drivers. To achieve the modernisation goals set by the SAMI, policymakers and leaders must adopt the principles, methodologies, and practices of human-centric design and people-centric change management to lead the value creation process intentionally and beyond. The PWC report on digital transformation in the SAMI (PWC, 2023) states that technology investment is deliberate. A focus is placed on delivering on commitments made to shareholders and communities; defining work across the mining value chain, finding, mining, treating and trading; carbon neutrality, renewable mines, improved resource and data-driven business strategies incorporating digital enablers. The focus is on measurable value creation, i.e., tracking the real-world benefits. The decision to adopt and diffuse technologies is driven by realities such as the older mines, which can struggle with digital transformation (legacy systems), and new mines, on the other hand, which are designed with digital in mind upfront. Reports on the lack of qualified resources speak to the need for upskilling and reskilling and resistance to change from the workforce, referring to the need to rethink our strategic approach to technology adoption processes (Bouckenooghe *et al.*, 2009).

Value drivers

Innovation will significantly make businesses sustainable with the impending technological revolution (Jacobs and Webber-Youngman, 2017). Various internal and external factors influence the adoption of technology solutions in the mining sector. These key value drivers, identified by Iacovou *et al*. (1995), highlight the primary benefits that encourage mining organisations to embrace technological innovations. Lane *et al*. (2015), concluded that mining companies are driven by three core business

imperatives when adopting technology: enhancing safety and health across working environments, improving efficiency and productivity to reduce costs, and promoting environmental sustainability. Despite these motivations, the decision to adopt technology has often been constrained by cost-saving measures, leading to capital restrictions—particularly in South Africa, where low profit margins have further limited investment, as Lane *et al.* (2015) noted. There is broad agreement that mining companies must take responsibility for identifying, assessing, and integrating technology solutions within their existing operational value chains. Return on capital employed is a critical metric for allocating and distributing capital to sustain business operations. However, this financial measure also challenges technology adoption, as the risks associated with selecting appropriate solutions can deter investment. The primary value drivers for adoption and determined by Lumadi *et al.* (2024) in mining are safety improvements, efficiency and productivity increases, operational cost reductions, and environmental sustainability.

Innovation decision process

Innovation adoption decisions in organisations are traditionally made by senior management, expecting employees to use the innovation ultimately. The decision-makers based on Rogers' (2010) findings, undergo an internal process referred to as the innovation-decision process. This process may lead decision-makers to adopt technology innovation, which is also defined as making complete use of it. Innovation decision has been described as a five-step process that involves decision-makers first obtaining knowledge about the innovation technology and establishing attitudes toward adopting or rejecting the innovation, followed by implementation and, lastly, confirmation of the decision. The stages of the innovation decision process are shown in Figure 1.

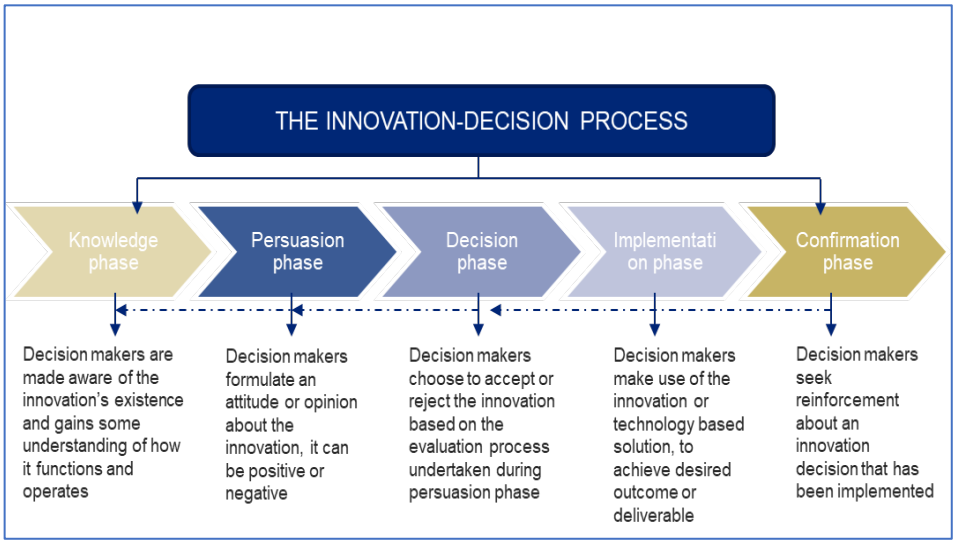

Figure 1. Innovation-Decision process (Rogers, 2010).

The main idea of the theory is that four elements influence the spread of a new idea: innovation, communication channels, time, and social system. A key observation within this process is that the decision-makers dictate and lead the innovation process and the implementation decision. The social system, key stakeholders and needs are not reflected within the model as represented above.

Mining companies in the SAMI are forced to adopt cutting-edge digital technologies and innovations to improve safe working conditions and remain competitive, efficient, and responsive to changing market conditions, including volatile commodity cycles. The adoption of technology can be understood through fundamental models like the one proposed by Iacovou *et al.* (1995), which highlights three key factors influencing adoption that are outlined below:

- **Perceived Benefits:** Mining companies drive the adoption of digital technologies when they

recognise clear advantages, such as improved safety and health, increased efficiency, cost savings, enhanced decision-making, or improved customer experience. These benefits justify investment in mine digitisation and change in company strategy.

- **Organisational Readiness:** An organisation's ability to adopt new technologies, including a digitally enabled workforce with relevant skills and know-how, digital-enabled technical infrastructure (e.g., wireless backbone), and enabling systems and processes.
- **External Pressures:** Businesses often face external pressures from competitors, customers, suppliers, regulatory bodies, and industry trends. These forces push organisations to embrace digital transformation to maintain relevance, comply with regulations, and meet market demands.

Upskilling and Reskilling

Lumadi *et al*. (2024), identified acceptance in the mining industry as being impacted by training, funding, executive sponsorship, employer-employee relations, research and development, change management and communication. Technology skills requirements were classified as either skills-biased, routine task-bias or complex task-biased. The skills requirements increase when the type of technology to be adopted moves towards complex changes. Bezuidenhoudt *et al*. (2021) highlight the impact of the skills revolution as it impacts the mining industry, being seen as a type of industry entering the automation sphere. The impact on jobs on manual levels is of concern as the typical manual jobs are at risk when being automated without upskilling the current workforce. The future of work is seen as becoming a reality where more complex and analytical skills will replace manual skills. The 2025 World Economic Forum job report predicts that, on average, workers can expect that two-fifths (39%) of their existing skill sets will be transformed or become outdated over the 2025-2030 period. Analytical thinking remains the most sought-after core skill among employers, and seven out of 10 companies do consider it essential in 2025. The other sought-after skills include resilience, flexibility and agility, along with leadership and social influence.

Digital literacy and competence

The SATCAP researchers consistently identified the need for digital literacy skills and competence requirements at various levels in the SAMI. The capacity to use and integrate technologies leads to proficiency and competence to provide the requisite leadership for the SAMI modernisation journey (Mahadeo *et al*., 2022); Botha *et al*., 2023) (Figure 2).

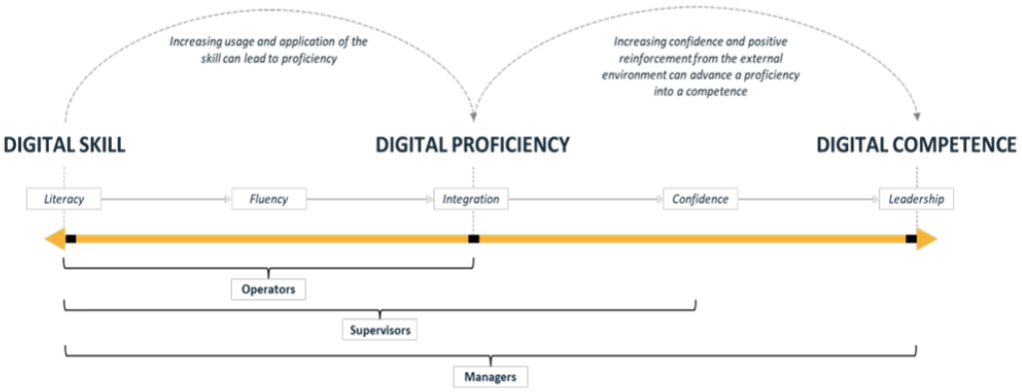

Figure 2: Digital Competence Assessment Tool for SAMI (Mahadeo et al*., 2022).*

Sustainable adoption of technologies does require contextualising and scoping the technology, organisational and human landscape. Change leadership provides the acceleration to identify and acknowledge the inhibitors and create an enabling network of accelerators to overcame inhibitors. Mature change leadership within SAMI provides the impetus to adopt technology to create value for multiple stakeholders and consider the context and the content of the change.

FINDINGS

The SATCAP Change Management Blueprint, which is discussed in the recommendations section in detail, was applied in three South African mines in different modernisation phases. The participant mines included a modern zinc mining company, a more modernised platinum mining company and a gold mining company, involved in modernisation efforts. The Change Management Blueprint was applied before, during and after the respective adoption processes and learnings consolidated. Table 5 reflects the case study of learnings.

Table 5. Considerations prior to SATCAP Change Management Blueprint implementation (Botha et al.*, 2023)*

Considerations	Description
Skills and training on technology	The mine operation needs to consider the skills needed, training and knowledge that is relevant for a specific technology, and if these are lacking or limited, put in place training and development plans. Upskilling, reskilling, new skills development becomes essential for new technology adoption.
Literacy levels and digital literacy	Consideration must be made of the literacy levels of the users of the specific technology. Digital literacy is key for digital transformation.
IT infrastructure and systems and funding	Sites may be willing to undertake the adoption of new technologies but there may not be sufficient information technology (IT) infrastructure (both hardware and software); or opportunity for integration with existing systems. Mine operations need to consider the technology support structures that are required for adoption of the new technology. Funding for licensing etc. must be considered.
Environmental considerations/ working conditions	It is necessary to understand the environment in which the technology will operate. Conditions such as the physical environment need to be assessed (e.g., narrow, low stopes, confined, dusty, hot, and wet working conditions). Furthermore, for example, inputting data may be cumbersome and clumsy, and if personal protective equipment is to be removed, such may create unsafe working conditions.
Unions and DMRE/ Stakeholder inclusion	Agreement, buy-in, inclusion and support are needed from all stakeholders, including unions, regulators and employees. Health and safety risks and concerns should be addressed. Lack of stakeholder engagement leads to resistance to the acceptance of the change. There may be demands for increased job levels and pay for new skills/higher skilled jobs (current job profiles do not include use of digital devices and digital literacy skills). Individual employees are also concerned that technology will track and monitor their actions with negative consequences. Compliance and regulatory issues need agreement prior to further engagement.
One-size fits all approach	Mine conditions, environments and contexts vary, so mine operations cannot use the same product/system on every mine – even shafts have different needs.
Change management process	A change management process is needed for the adoption of modern technologies. Leadership should own, drive and support change in the organisation and the technology adoption strategy.
Safety protocols	Protocols need to be updated, communicated and trained to enable safe use of technology.

The review of a shift boss logbook implementation process confirmed the importance of acknowledging the considerations identified in Table 5, and the post-implementation learnings are categorised below:

Enablers:

- Consistent application of change management and people participation throughout
- Readiness level of mine overseers as a key role player in diffusing the technology
- The decision to introduce the technology solution slowly allows for resistance to be reduced
- Good infrastructure and support system should be available
- Integrated approach with upskilling and reskilling to enable understanding and usage

- Careful consideration of hand-held units and a fit-for-purpose selection
- Risk management methodology and system defined initially, and legislative requirement included
- System is built on a set of routines and provides behavioural guidance

Inhibitors:
- Paper and technology applications are still required for legal compliance, thus running a dual system
- Management may be reverting to the old ways because of the known
- Lack of digital literacy is still a concern and influences the diffusion process

The review of implementing the SATCAP community engagement tools and the ESG integrated dashboard and learnings was recorded as presented in Table 6. The learnings inform the organisational factors considered to successfully diffuse the SATCAP tools as reported by the mining implementation project team of SATCAP work package 3.1 in 2024.

Table 6. Learnings and considerations after SATCAP community project implementation

Consideration	Description
Leaders' ambition	• Strategy execution is needed to support managerial effectiveness. • Personal agendas need to be set aside to allow for transformation. • Leaders need to lead with intent and purpose. • ESG requires a focus on social transformation. • Adopt a proactive approach. • Follow a risk-based process. • Establish communities of practices. • Provide for leader sponsorship.
Change requirements	• Change is a structured process. • Make data-driven decisions. • The data behind ESG is becoming more important. • Understand the detail of the data. • Research data needs to be actioned. • Innovation is unavoidable. • Leverage technology for community/small, medium & micro enterprise (SMME) engagement.
Organisational design and structure	• Fully competent and integrated team needed to be available. • Community liaison officers (CLOs) needed to be appointed on a contractual basis. • CLOs were trained to understand and act as change agents. • CLOs have a voice (informed) for communities and SMME. • Campaign needed to be structured. • Facilitated the input of data and information into the dashboard (source the information) is needed. • CLOs have local knowledge to facilitate knowledge sharing.
SAMI industry learnings	• SATCAP tools can be implemented – it is possible! • What we do with the information is key; this should lead to decisions. • Measure the impact year on year – develop a baseline.

RECOMMENDATIONS

Change leadership approach for the SAMI

Technology adoption and value creation can further be enabled or inhibited, depending on the change leadership approach of the diffusion process.

People-centric approach

A people-centred design approach is explained as inclusive of impact assessments in the field of the ESG, are done together with a change management blueprint to be used to adopt modern technologies

(MMP, 2023). The people-centred design practice requires designers to focus on four key aspects, namely (1) People and their context; (2) Seek to understand and solve the right problems, the root problems; (3) Understand that everything is a complex system with interconnected parts; (4) Initiate small interventions to prototype, test and refine to ensure that their solutions truly meet the needs of the people they focus on (Norman *et al*., 2022). In guiding a people-centric approach to design and adoption, Graetz (2000) states that "against a backdrop of increasing globalisation, deregulation, the rapid pace of technological innovation, a growing knowledge workforce, and shifting social and demographic trends, few would dispute that the primary task for management today is the leadership of organisational change". The gap to be closed should be understood by every individual 'living' in this outer world (MMP, 2019). Technological advancements and 4IR have at their heart the stakeholder principle, and leaders will be required to ensure that the benefits of transformation are as much a public good as a private gain. The SAMI's modernisation efforts will, therefore, be as much a design effort as an adoption effort to lead the change with people moving centre-stage.

Human-centred design

Adopting human-centred design (HCD) aims to create value by viewing people as collaborators and enhancing their role by placing more importance on human intelligence. The focus is on upskilling and reskilling workers and placing a greater responsibility on supervising the systems and reducing mundane tasks (Muller and Van Dyk, 2024). Including stakeholders is related to the successful adoption of new technologies associated with modernisation, and people-centric design processes are recommended. Involving users in all stages of technology development has social and economic benefits (ISO 9241-210, 2010). HCD is "an approach to interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, and usability knowledge and techniques. This approach enhances effectiveness and efficiency, improves human well-being, user satisfaction, accessibility and sustainability; and counteracts possible adverse effects of use on human health, safety and performance." The HCD process is iterative, and includes the following steps (ISO 9242:210, 2019):

- Plan the human-centred design process
- Understand and specify the context of use
- Specify the user requirements
- Produce design solutions
- Evaluate the design

Adopting a stakeholder principle

Schwab (2016) advises that 4IR has at its heart the stakeholder principle and leaders will be required to ensure that the benefits of transformation are as much a public good as a private gain. Marwala *et al*. (2017) explains that the economic law of supply and demand is a fundamental law of economic trade, where the demand determines the price. If the supplier is not willing or cannot supply at the acceptable price, there is no trade. Therefore, as the context of mining changes, the demands on leaders will change, or there will be no trade. Modernisation in the mining industry embraces the stakeholder principle, and co-creation in identifying needs and designing solutions is encouraged (MMP, 2023). Pelders and Schutte (2021) noted that worker participation in equipment development can improve user acceptance and product quality. Workers from all organisational levels in mines were reported to be excluded from equipment design, and stakeholders identified barriers including the experience of workplace culture (reference made to leadership, trust, training, performance, and remuneration factors). Human-centred design approaches and independent platforms for engagement on equipment design requirements were recommended.

Enable collective change leadership

Leading change is associated with the work of Kotter and von Ameln (2019), who suggest moving from traditional change methods in technology adoption towards accelerating with leaders building networks inside organisations. Edmondson (2002) proposes that change leadership be transferred to work teams, and learning will become a function of leading change in a psychologically safe environment. The change landscape is moving from the individual to the collective and the collective

efficacy should be noted to navigate change (Bandura, 2000). Therefore, the drive for technology adoption and diffusion cannot depend on executive decisions, as the appetite for technology sometimes manifests in the middle and junior ranks. A more collective approach to leading the digitisation and modernisation journey calls for collective change leadership.

Communication with stakeholders throughout the diffusion of innovation

Rogers (2010) researched more than 508 diffusion studies and coined the 'diffusion of innovation' theory for adopting innovations among individuals and organisations. This theory explicates "the process by which an innovation is communicated through certain channels over time among the members of a social system". The well-known innovation adoption curve was conceptualised. The identification of the need of the various types of adoption was explained by Kotter (2012). Innovations are seen to prefer a challenge. Early adopters want to understand why. Early majority adopters require proof. Late majority adopters need commitment. Laggards need time.

Change management fundamentals

Change management is a relatively young discipline drawing on diverse bodies of knowledge, including psychology, behavioural science, social science, organisational development, project management, process management and neuroscience (Hiatt and Creasey, 2012). As an emerging discipline, change management focuses on those individuals affected by the change, how their adoption and proficient usage of the changes (may it be technology, practices, work cycles) affects them as individuals, but also how they do their jobs. A successful change management journey contributes to the achievement of the initiative's targeted results.

During the implementation phase of planned change, Weiner (2009) advises that the change management process should assist with the individual's readiness for change. Readiness refers to the member's shared *commitment* to implement the change and shared belief in their collective capability to do so. It can be stated as change efficacy derived from the motivators and inhibitors. When organisational readiness for change is high, organisational members are likelier to initiate change, exert more significant effort, exhibit more remarkable persistence, and display more cooperative behaviour. The result is more effective implementation. The opposite of readiness for change is resistance to change. Readiness for change within the context of the SAMI's modernisation would require commitment from all affected participants and the collective commitment. Choi (2011) identified the causes of many organisations' inability to achieve the intended results from their change efforts, as an implementation failure, not in the innovation or initiative itself. Innovation and change efforts fail because the change leaders often underestimate the central role of individuals in the change process.

Adopting a systems approach

The SAMI can accelerate its transformation journeys, whether digital technology transformation, strategy execution or culture change, if the technological adoption is being dealt with systemically. Knowing the baseline, understanding conditions and working within the stages or readiness are some of the learnings shared by Kotter (2012). Therefore, sustainable adoption of technological solutions requires considering the input (the baseline of what is happening and needs to be considered), the transformation process (what and how the technology is diffused), and the output (the value creation —did we purposefully solve the required problem), all of which feed into the new reality. A systems approach to change management involves viewing an organisation as a complex system of interrelated parts, where changes in one part can affect the whole. This approach emphasises the importance of understanding the interdependencies and interactions between different components of the organisation during the change process (Boikhutso, 2013). According to Lozano (2022), the key aspects of sustainability in change management include:

- **Long-term vision:** Establishing a clear vision for the future that aligns with the organisation's goals and values. This helps ensure that changes are implemented, supported, and maintained over time.
- **Embedment in culture:** Integrating new practices, behaviours, and attitudes into the organisational culture. This means that change becomes a part of the daily operations and mindset of the organisation, rather than being seen as a temporary initiative.

- **Continuous monitoring and improvement:** Regularly assessing the changes' progress and impact to identify improvement areas. This involves setting up feedback mechanisms, performance metrics, and regular reviews to ensure the change remains effective and relevant.
- **Adaptability:** Building the capability within the organisation to adapt to future changes and challenges. This includes fostering a culture of innovation and continuous learning and equipping employees with the skills and knowledge needed to manage change effectively.
- **Leadership and support:** Ensuring that leaders and managers remain committed to the change and provide ongoing support to their teams. This includes offering guidance, resources, and reinforcement to sustain the momentum of the change efforts.
- **Stakeholder engagement:** Keeping stakeholders engaged and informed throughout the change process and beyond. This helps to maintain their support and buy-in, which is crucial for the long-term success of the change.

Change enablement network

Recent directions in technology adoption state that change management will require nurturing an exponential mindset, "which involves unlearning much of what you've learned, and keeping in mind that what got you here won't always get you where you want to go" (Finett, 2019). It is advised to move from system 1 (fast, automatic, frequent, emotional, stereotypic, subconscious) to system 2 (slow, effortful, infrequent, logical, calculating, conscious) in the way change is planned.

The implication for a change management practice in the technology adoption journey is the ability to spend more time planning for the change in system 2, to respond exponentially and have more time with people versus the technical side of the change (Kahneman, 2011). The focus of change management should, therefore, not be on following a linear approach but rather on reflecting the drive towards exponential organisations. Linear-type organisations never disrupt their own internal procedures and processes as they lack the tools, attitude and perspective to do it. It is observed that they scale and remain what they are, to do what they were built for; therefore, even the introduction of technology will result in what is referred to as "the innovator's dilemma" (Ismail, 2014). In the exponential type of organisation, the impact (or output) is disproportionally large – at least 10x larger – compared to its peers. Because of the use of new organisational techniques that leverage accelerating technologies, they are built upon information technologies that take what was once physical in nature and dematerialise it into the digital, on-demand world (Ismail, 2014). Therefore, the world of change management can either be behind the exponential mindset or be part of the growth in the approach taken.

The requirements for exponential change management start with the manner in which we conceptualise the technology adoption process. Conceptualisation and contextualisation require disciplined thought and disciplined action to accelerate the flywheel, as explained by Collins (2024). The thought should include multiple stakeholders, value creation, collaboration, communication, people-centricity, and human-centred design. This refers to mindset and behaviours. Leaders' actions should be strategic and intentional, aligned with the modernisation purpose and reflect the maturity and capability levels expected at a senior managerial level. With disciplined people, thought and disciplined action, the adoption process will lead to diffusion within an organisation reflecting readiness. Disciplined people refer to us, how we contextualise what we do. Thoughtful, purposeful, stakeholders in mind. Caring about the people inside and outside the business and being sensible within the realities of where we operate.

When crafting a change management journey to support the sustainable adoption of technology, centred around people, it should be intentional. When executing our plans, the focus on people-centricity and human-centred design should move to centre-stage. Current hierarchical organisational structures, designed to be reliable, repeatable and controlled, will have to work with a change network to facilitate this exponential change and be more agile, adaptable, and designed for speed (Kotter, 2012).

SATCAP Change Management Blueprint

Towards lending support to the key organisational factors, with the potential for addressing thereof, the SATCAP programme has developed a Change Management Blueprint to enable change processes

for the adoption of modern technologies, with CSFs; and an ESG Impacts Lens Dashboard, consisting of three domain-specific dashboards, noting that this includes the Change Impact Evaluation (IE) Dashboard, which considers gauging of impacts on people, organisation, and technology for the adoption modern mining technologies. The Change Management Blueprint informs the key indicators for the Change IE Dashboard.

The Change Management Blueprint is comprised of five stages, namely: prepare, plan, pilot, roll-out, and support (3PRS) (Figure 3). The blueprint consists of various Excel templates to be populated by the user. User-guidelines, templates and videos are available on the Mandela Mining Precinct website.

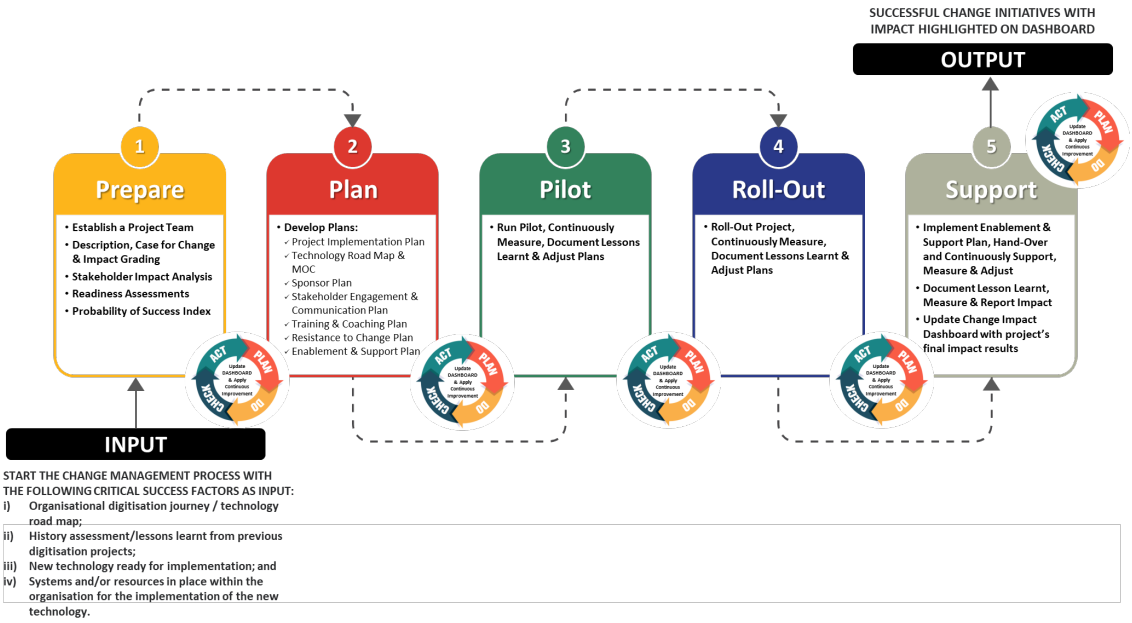

Figure 3. 3PRS Change Management Blueprint.

Critical Success Factors needed as input for a successful change management process

Field research completed through the SATCAP change management process confirms these realities and notes the importance of adopting an integrated approach to technology, process, and people readiness. The SATCAP change management research completed during the development of the Change Management Blueprint and its verification within the mining industry has identified some key factors necessary as input for successful change initiatives. The success of a change management process is influenced by the availability or confirmation of the following critical factors before the change management process starts:

(1) The availability of the **organisation's digitisation strategy** or **technology roadmap** that indicates where this specific modernisation project or technology will fit in the larger strategy.
(2) The availability of **documented lessons learnt from previous digitisation initiatives** so that the change management team can incorporate the learnings into their preparation and planning for the specific modernisation project or technology adoption initiative.
(3) Confirmation that the **technology**, system or tool to be adopted are in fact **ready for the change** management process. The specific technology, system or tool must be ideally on Technology Readiness Level 9 before the change management project should commence.
(4) Confirmation that any and all **support systems**, related technologies and resources needed to enable and support the specific technology, system or tool's adoption within the organisation are in place.

If any of the above critical factors are not available or confirmed before the change management process starts, then the success of the change management process will be compromised. These critical factors impact all five phases of the change management process as stated in the 3PRS Blueprint. By ensuring

that these factors are available or confirmed, it will set the change project up for success. If not available or confirmed before the project starts, then conscious decisions must be made that will impact the change management plans to reactively try to compensate, which could lead to extended timeframes, additional costs or even an unsuccessful change initiative.

Change leadership maturity CSF (5D)
Key organisational leadership factors that support or inhibit the acceptance of technological solutions for mining modernisation were identified under the following topics representing 5 **Ds in change leadership maturity.** The executive decision to adopt needs to consider the factors listed in Table 7.

Table 7. The 5 Ds of change leadership maturity

Decision to adopt	*Leaders will make intentional decisions:* • To include the **contextual realities** of the **multiple stakeholders** in the mining value chain • To include the **reason** for adopting the specific technology in executive decision- making • To identify the **value drivers** with the perceived benefits and the **value to be realised** • Solve the multiple stakeholders **population's problems and work with their realities** (who do we serve, and in which priority) within the value chain • Involve careful consideration of the perceived **level of readiness**, referring to the level of **maturity of the technology**, the perceived risk and the ease of implementation • Provide for the **cost implications** of the technology and the effort required to research and develop (Ntsoelengoe, 2019) • Decision of selecting **purposeful technologies** to solve problems
Direction leadership	*Leaders will adopt a people-centric approach for sustainability:* • Mature change leaders will provide direction and set the context for **adopting a people-centric** approach with sustainable deliverables as an end in mind • The direction will clarify the intent of **collaboration with stakeholders** during the decision-making process. Collaboration requires on involvement and not just consulting. Directional leadership will guide the way the diffusion process is done, facilitate collective stakeholder engagements and diffuse purposeful technologies within the social context • Seeks to create long-term value for a business or organisation while considering **ESG** practices (Sancak, 2023) • Moving people from **'have to' towards 'want to'** and reducing the reliance on activating the "survival channel but rather moving to the thriving channel," as per Kotter (2021)
Design leadership	*Leaders will be designing the capacity of the organisation:* • Organisational structure to include a **dual network** of hierarchy and a change network • Integrated processes to ensure **integration of technology** into current business processes and routines • Communication and learning technologies to **enable capability development;** and • Providing an **enabling social environment** across the value chain to realise value for multiple stakeholders • Design for **data integrity** and reduction of data waste (clarify what we really need, to make purposeful decisions and who do we serve with selected solutions) • Provide for **technology infrastructure** and IT capabilities (Ntsoelengoe, 2019)
Developmental leadership	*Leaders will be developing the capacity of people to adopt the technology:* • The capability of the organisation for the **future world of work** • Skills and capacity of **technology users** and supporters to enable value to be derived from the technology • **Readiness of the organisational structure** to deal with operational realities and at the same time enable technology adoption through a collaborative change network (Kotter, 2012) • **Readiness of the leaders t**o commit to adopting technology within the context of sustainable mining and in the presence of mining realities (Singh, 2017) • Leaders' readiness to display **mature change leadership**, provide the context for the modernisation journey, and sponsor the diffusion process • **Readiness of users** to adopt the technology being diffused and turn the inhibitors into motivators • **Development of digital literacy, proficiency and competence** (Mahadeo *et al.,* 2022)

Deliver leadership value	*Leaders will be keeping themselves accountable to deliver value:* • Adopt a structured **change management** and innovation acceptance communication methodology, enable adoption and proficiency in using technology solutions (Rogers, 2010) • Practise **change leadership principles**, striking a balance between execution and future visions (Kotter, 2012) • Integrate purposeful solutions to common problems throughout the value chain; and create **value for the collective, not the critical few** • **Ensure value creation** and not merely adoption of technologies (Müller and van Dyk, 2024) • Ethical practices to predict and plan for the future of jobs to mitigate the impact and risk on people's futures • Identify the value drivers first, and then carefully decide if the technology will serve the indented purpose (Lane *et al.,* 2015) • Diffuse technologies to enable change, and create a flywheel for growth (Collins, 2024)

In the SAMI context, change management focuses beyond the project or user adoption of the technology solution but rather on the initial adoption decision (as made by senior leadership in the context of modernisation and the ESG integration) and then how to lead change to derived value across the value chain through adopting a people-centric diffusion process enabled by change methodologies and change networking capabilities. A change network is envisaged to accelerate the modernisation journey by consciously focusing on the people side of change.

Measuring the value realisation process as CSF
Executives' adoption decisions are influenced by the value drivers, the maturity of the technology, and the level of readiness of the people to whom the technology will be diffused. Enabling data-driven decisions will add to SAMI's change maturity in making decisions and providing direction in the design, development, and delivery of value. Continuous tracking of the progress throughout the adoption and diffusion process provides a communication tool to use data for change leader decisions.

A Change IE Dashboard was developed to gauge impacts relating to change as a result of the adoption of new technologies. The Change Management Blueprint was foundational for the dashboard inputs. The Change IE Dashboard was developed using Power BI software. The data sources for the dashboard include integration and links from the Change Management Blueprint and an Excel Blueprint. The Change IE Dashboard comprises sub-dashboards with 17 key indicators. The key indicators considered in the Change IE Dashboard relate to the following sub-dashboards:

- **Organisational:** aims to gauge how the technology projects are tracked in terms of impact on business processes, safety and financials.
- **Technology:** aims to gauge the level of readiness in adoption of new technology within the organisation, including leadership readiness, organisation readiness, technology readiness and policies, procedures and process readiness.
- **Change management process:** aims to assess the peoples' readiness in terms adoption of change and gauges awareness of new technology, desire for new technology, knowledge of new technology, ability to use new technology and support for new technology.
- **People:** aims to assess peoples' engagement with new technology and implementation thereof, and gauges the number of people using new technology, people using new technology versus baseline, proficiency in using new technology and peoples' satisfaction using new technology.
- **Project:** aims to gauge the level of each project implementation and success thereof in terms of planning and introduction of the new technology project in the mine environment, and measures whether the project was on time, within scope, of acceptable quality and within budget. Additionally, this group of indicators provides a summary of the success factors for successful adoption as per the Change Management Blueprint in terms of implementing the new technology and its adoption in the mines. It provides a measure of the CSFs in place to facilitate the successful adoption and assesses the level of accomplishment of the five phases for implementing the Change Management Blueprint (3PRS).

CONCLUSION

Critical success factors need to be considered when conceptualising the change impacting the adoption decision. The CSFs identified in the SATCAP Blueprint model facilitate a combination of organisational, technological and human factors integrated into a people-centric approach. The practical application of digital technologies reflects supportive and inhibiting factors.

The leadership maturity requirements are reflected through the 5D process, reflecting the critical decisions to be made by leaders on the direction, the design of an enabling structure and change network, the development of capabilities, and the delivery of the modernisation mandate. The organisational factors influencing successful adoption centre around people are observed as following this 5D pattern and should be considered as risk factors if not intentionally practised.

The integration of these systemic enablers, namely the organisational structure design, leadership capability, technology strategy, stakeholder inclusion, integration throughout the value chain, skill levels within operations, culture impacts and various readiness levels (i.e., technology, people, processes, etc.), will accelerate the value realisation process.

The process commences with the recognition of the significance of leaders in establishing the context for change, coupled with a strategic alignment. This necessitates a leadership capability to effectively shape the contribution of the intended technology as an integral aspect of the modernisation journey. Establishing the appropriate context calls for a comprehensive approach that transcends mere operational requirements, encompassing the ESG mandate and its contributions to the mining value chain. The technology strategy should be resourced through a strategic and a change network, running a dual system.

The strategic integration of technological solutions as a facilitator/enabler for sustainable mining must encapsulate the rationale, objectives, and value proposition associated with the intended technologies. If technology is deemed a strategic imperative, a structured framework to facilitate its implementation is essential.

The application of stakeholder needs necessitates the consideration of various stakeholders and the value that is both needed and provided within the strategy. Technology initiatives conventionally begin with managerial information systems (such as dashboards and data) to address the requirement for data-driven decision-making. Concurrently, it is imperative to acknowledge stakeholders at the operational level and ESG collaborators, considering their diverse needs during the selection and prioritisation of technologies. Embracing an inclusive stakeholder approach demands effective change leadership.

The sustainable adoption of technologies encompasses their integration across the entire value chain and aligns the modernisation journey with intentionally chosen technologies.

The maturity, readiness and capability levels of the organisation, technology, leadership, and team members should be clearly defined at the outset. The levels of maturity and capability elucidate the requirements for effective change management. Resource allocation for change management expertise directly correlates with these maturity, readiness and capability levels. Furthermore, the risks and potentials associated with the current operational state can be effectively balanced to ensure both survival and growth.

Realistically considering the life of mine, and the geographical context of operations, it becomes evident that such factors will influence the prioritisation of technology adoption. Fragmented adoption tends to arise when the diffusion occurs within an environment where the intended purpose of the technology lacks relevance in relation to time and location.

There is a serious need to consider the cultural ramifications of technology beyond immediate requirements and expand its influence on domains outside of the conventional scope. Substantial evidence suggests that adopting technology can facilitate skills enhancement, with each technological advancement regarded as a fundamental component of the skills development roadmap.

Assessing readiness levels for the specific technology, grounded in the technology roadmap, infrastructure, policies, procedures, and support systems, instils confidence in the adoption process. The greater the technology's readiness level, the less demanding it is to persuade individuals. Essentially, the technology promotes itself.

The people-centric approach reflects human nature in that we resist change on one hand, yet we are inquisitive and seek opportunities on the other.

Sustainable adoption necessitates leaders who exhibit disciplined thought and actions in the pursuit of modernisation. The flywheel (exponential change) is contingent upon intentional and adaptive change leadership.

Understanding and applying the recommended factors and processes is anticipated to support the sustainable adoption of technologies in the South African mining industry, the value drivers, and the ESG imperatives.

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RERERENCES

Andersson, U., Dasí, Á., Mudambi, R. and Pedersen, T. (2016). Technology, innovation and knowledge: The importance of ideas and international connectivity. *Journal of World Business*, *51*(1), pp.153-162.

Ayentimi, D. T. and Burgess, J. (2019). Is the fourth industrial revolution relevant to sub-Sahara Africa? *Technology Analysis and Strategic Management,* 31**,** 641-652.

Bandura, A. (2000). Exercise of human agency through collective efficacy. *Current Directions in Psychological Science,* 9**,** 75-78.

Baxter, R. (2023) Keynote address "Explring ten insights into value creation 4IR, Digital and ESG - An introduction to the 2023 study". Minerals Council South Africa, Johannesburg.

Bechtsis, D., Tsolakis, N., Vlachos, D. and Iankovou, E. (2017). Sustainable supply chain management in the digitalisation era: The impact of Automated Guided Vehicles. *Journal of Cleaner Production,* 142**,** 3970-3984. governance. *Futures,* 146**,** 103101.

Bezuidenhout, A. and Schultz, C. (2013). Transformational leadership and employee engagement in the mining industry. *Journal of Contemporary Management,* 10**,** 279-297.

Bezuidenhout, C., Wocke, A., Plint, N. and Mthombeni, M. (2021). The impact of job automation on shifts in levels of work.

Boikhutsi, T.M. (2013). Change Management: The impact on systems implementation – A business application solution centre case study. Master's Thesis, UNISA, South Africa.

Boloko, M.W. (2018). An assessment of leadership competencies for effective change management in a chemical organisation. MBA Mini-Dissertation. North-West University (South Africa), Potchefstroom Campus.

Botha, W.P., de Kock, N., Müller, R. and Ramparsad, S. (2023). Change Management Blueprint for the adoption of modern mining technologies. *Digital Transformation in Mining 2023.* The Southern African Institute of Mining and Metallurgy, pp. 23-24.

Botha, W.P., Mahadeo, V., Pelders, J., Müller, R. and de Kock, N. (2024). Change Management Blueprint (SATCAP 2022) Verified for Adoption of New Technologies; and Inter-Linked to a Change Impact Evaluation Dashboard. SATCAP WP 2.3. Milestone 3 – Final Report. Mandela Mining Precinct.

Boukenhooghe, D., Devos, G. and Van Den Broeck, H. (2009). Organizational change questionnaire–climate of change, processes, and readiness: Development of a new instrument. *The Journal of Psychology,* 143**,** 559-599.

Carreno, A. M. (2024). An Analytical Review of John Kotter's Change Leadership Framework: A Modern Approach to Sustainable Organizational Transformation. *Available at SSRN 5044428*.

Carroll, L.S.L. (2017). A comprehensive definition of technology from an ethological perspective. *Social Sciences*, *6*(4), p.126.

Choi, M. (2011). Employees' attitudes toward organizational change: A literature review. *Human Resource Management,* 50**,** 479-500.

Choi, M. and Ruona, W. E. (2011). Individual readiness for organizational change and its implications for human resource and organization development. *Human Resource Development Review,* 10**,** 46-73.

Collins, J. (2024). Good to great. *Personal Finance Magazine*, *2024*(525), pp.8-13.

Cresswell, J. (2013). Qualitative inquiry and research design: Choosing among five approaches.

Dou, S., Xu, D., Zhu, Y. and Keenan, R. (2023). Critical mineral sustainable supply: Challenges and governance. *Futures*, *146*, p.103101.

Edmonson, A. C. (2002). Managing the risk of learning: Psychological safety in work teams. Citeseer.

Ernst & Young (2015). Business risks facing mining and metals 2014–2015. [online] Business. Available at: <ey.com/miningmetals>

Finett, P. (2019). Navigating the geography of change. https://su.org/resources/ebook/navigating-the-geography-of-change-thirteen-steps-to-master/. [Accessed: 2 February 2025]

Ghazizadeh, M., Lee, J.D. and Boyle, L.N. (2012). Extending the technology acceptance model to assess automation. *Cognition, Technology and Work*, *14*, pp.39-49.

Ghorbani, M. (2023), September. Green Knowledge Management and Innovation for Sustainable Development: A Comprehensive Framework. In *ECKM 2023 24th European Conference on Knowledge Managemen Vol 1*. Academic Conferences and Publishing Limited.

Graetz, F. (2000). Strategic change leadership. *Management Decision,* 38**,** 550-564.

Hermanus, M., Coulson, N. and Pillay, N. (2015). Mine Occupational Safety and Health Leading Practice Adoption System (MOSH) examined-the promise and pitfalls of this employer-led initiative to improve health and safety in South African Mines. *Journal of the Southern African Institute of Mining and Metallurgy*, *115*(8), pp.717-727.

Hiatt, J. and Creasey, T. (2012). Change management. *The people side of change*, *2*.

Iacovou, C.L., Benbasat, I. and Dexter, A.S. (1995). Electronic data interchange and small organizations: Adoption and impact of technology. *MIS Quarterly,* pp.465-485.

Ismail, S. (2014). Exponential Organizations: Why new organizations are ten times better, faster, and cheaper than yours (and what to do about it). Diversion Books.

ISO 9241-210 (2010). Ergonomics of Human-System Interaction – Part 210: Human-Centred Design for Interactive Systems. International Standard. First edition. 2010-03-15.

ISO 9241-210 (2019). Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems. International Standard, ISO 9241-210:2019(E).

Jacobs, J. and Webber-Youngman, R.C.W. (2017). A technology map to facilitate the process of mine modernization throughout the mining cycle. *Journal of the Southern African Institute of Mining and Metallurgy*, *117*(7), pp.636-648.

Kahneman, D. (2011). Thinking, fast and slow (Kindle Edition): Penguin Books.

Kirrane, M., Lennon, M., O'Connor, C. and Fu, N. (2016). Linking perceived management support with employees' readiness for change: the mediating role of psychological capital. *Journal of Change Management,* 17**,** 47-66.

Kotter, J. P. (2012). Accelerate. *Harvard Business Review,* 90**,** 43-58.

Kotter, J. and Von Ameln, F. (2019). Agility, hierarchy and lessons for the future. John Kotter on the legacy and future of Change Management. *Gruppe. Interaktion. Organisation. Zeitschrift für Angewandte Organisationspsychologie (GIO),* 50**,** 111-114.

Lane, G.R. and Wylie, B. (2014). Case study: a value driver tree as a means of integrating value drivers across disciplines and activities. In *Proceedings of the 6th International Platinum Conference,'Platinum–Metal for the Future', The Southern African Institute of Mining and Metallurgy* (pp. 143-152).

Le Roux, J. (2021). Modernisation in mining-A people-centric approach. *CSIR Science Scope,* 18**,** 60-61.

Lourens, A. (2024). Minerals Council *https://www.mineralscouncil.org.za* [Online]. Available: https://www.mineralscouncil.org.za/all-categories?task=download.send&id=2293:mining-input-cost-inflation-may-2024&catid=121. [Accessed July 04].

Lozano, R. (2022). Towards Sustainable Organization – A holistic perspective on implementation efforts. Springer Nature. Gävle, Sweden.

Lumadi, V.W. and Nyasha, S. (2024). Technology and growth in the South African mining industry: An assessment of critical success factors and challenges. *Journal of the Southern African Institute of Mining and Metallurgy*, *124*(4), pp. 163-171.

Macnamara, S. (2023). 360° Digitalisation to unlock R213-billion in SA by 2026. *African Mining*.

Mahadeo, V.J., Botha, P.W., Govindasamy, K., Swettenham, T. and Ramparsad, S., (2022). Digital Leadership Competency Assessment Tool for SA Mining Operations. *The South African Institute of Mining and Metallurgy*.

Majerova, J. and Das, S. (2023). Sustainable Development and Digitalization in the Supply Chain for Environmental Protection: Changes and Trends. *New Normal in Digital Enterprises: Strategies for Sustainable Development.* Springer.

Malatji, S. and Stewart, J.M. (n.d.) *The MOSH Leading Practice Adoption System: A Leading Practice in its Own Right.* The Chamber of Mines of South Africa. URL: https://www.mosh.co.za/ [Last Accessed 29 Jan. 2024].

Marwala, T., Hurwitz, E. (2017). Supply and demand. *Artificial Intelligence and Economic Theory: Skynet in the Market*, 15-25.

Minerals Council South Africa (2021). Modernisation towards the mine of tomorrow. Fact Sheet, pp. 1–7.

Minerals Council South Africa. (2023). Facts and Figures Pocketbook. pp. 1–78.

Minerals Council South Africa (2023). Facts and Figures Pocketbook 2022. https://www.mineralscouncil.org.za/downloads/send/18-facts-and-figures/1996-facts- and-figures-2022-pocketbook

MMP (2019). Factsheet. *In:* Mandela Mining Precinct

Moran, J.W. and Brightman, B.K. (2000). Leading organizational change. *Journal of Workplace Learning*, *12*(2), pp.66-74.

Müller, R., Mshodi, A., Tsililo, D., Steenkamp, M., Ferreira, F. and Van Der Schyff, S. (2019). MOSH Review and Modification. Successful Application of Technology Centred Around People (SATCAP). Work Package 2.1. Mandela Mining Precinct. Unpublished report.

Müller, W.E. and van Dyk, L. (2024). Industry 5.0 concepts and components. SAIIE34 Proceedings. Van der Bijlpark.

Nguyen Ngoc, H., Lasa, G. and Iriarte, I. (2022). Human-centred design in industry 4.0: case study review and opportunities for future research. *Journal of Intelligent Manufacturing,* 33(1), pp.35-76.

Norman, G., Mason, T., Dumville, J., Bower, P., Wilson, P. and Cullum, N. (2022). Rapid Evaluations of Innovations: A Scoping Review.

Ntsoelengoe, J. S. (2019). Factors necessary for effective adoption of modernisation in the South African mining industry. Master's Thesis, University of Pretoria, South Africa.

Ntsoelengoe, B. (2021). Mining 4.0-Modernisation of mining in the four th industrial revolution. *CSIR Science Scope,* 17, 24-24.

Parasuraman, A. and Colby, C.L. (2015). An updated and streamlined technology readiness index: TRI 2.0. *Journal of Service Research,* 18(1):1-16. DOI: 10.1177/1094670514539730

Parasuraman, A. (2000). Technology Readiness Index (TRI) a multiple-item scale to measure readiness to embrace new technologies. *Journal of Service Research*, *2*(4), pp.307-320.

Pelders, J. and Schutte, S. (2021). Worker inclusion in equipment development processes in the modernizing minerals sector in South Africa. *Journal of the Southern African Institute of Mining and Metallurgy,* 121, 63-69.

Price Waterhouse Cooper (PWC, 2021). The state of digital transformation in the South African mining industry: Ten insights into 4IR.. Johannesburg: Minerals Council South Africa.

Rogers, E. M. (2010). *Diffusion of innovations*, Simon and Schuster.

Sancak, I. E. (2023). Change management in sustainability transformation: A model for business organizations. *Journal of Environmental Management,* 330, 117165.

Saunders, M.N.K. and Lewis, P. (2018). Doing research in business and management: An essential guide to planning your project. Pearson.

Schwab, K. (2016). The Fourth Industrial Revolution. Available at: https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab/

Singh, N. (2017). Weathering the 'perfect storm' facing the mining sector. *Journal of the Southern African Institute of Mining and Metallurgy,* 117, 223-229.

Soiferman, L.K. (2010). Inductive and Deductive Research Approaches. *University of Manitoba*, [online] (April), pp.1–23. Available at: <https://eric.ed.gov/?id=ED542066>. Stanway, Graeme; Mahoney, Paul; Griebel, C., 2017. Innovation: State of Play. *Mining Survey 2017 report*, pp.1–72.

Stanz, K., Botha, W., Pelders, J. Michalowski, G. and Nortjé, J. (2020). Change Processes. SATCAP WP 2.1. Mandela Mining Precinct.

Trawick, S., and Carraher, T. (2023). Contextualising Kotter's 8-step model to a sustainable digital transformation: A qualitative study from the perspective of organisational change. Master's Thesis, Malmö University, Sweden.

Uys, J. and Webber-Youngman, R. (2019). A 4.0 D leadership model postulation for the Fourth Industrial Revolution relating to the South African mining industry. *Journal of the Southern African Institute of Mining and Metallurgy,* 119**,** 793-800.

Venkatesh, V., Morris, M.G., Davis, G.B. and Davis, F.D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, pp. 425-478.

Weiner, B. J. (2009). A theory of organizational readiness for change. *Implementation Science,* 4**,** 67.

World Economic Forum. (2017). Digital Transformation Initiative, Mining and Metals Industry. Available from: http://reports.weforum.org/digitaltransformation/wp-content/blogs.dir/94/mp/files/pages/files/wef-dti-miningand-metals-white-paper.pdf [Accessed 13 January 2025]

Zulu, M. S., Pretorius, M. W., and Van der Lingen, E. (2021). Strategic competitiveness of the South African mining industry in the age of the Fourth Industrial Revolution. *South African Journal of Industrial Engineering,* 32(3), 185-200.

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Rina has conducted applied research within the field of change management and the mining industry's quest for upskilling and reskilling. She has a keen interest in turning research into reality through unlocking the potential of people. Rina works with her team of curriculum designers, content writers, facilitators and project leaders developing change and learning journeys within a co-created and people-centric environment. Her quest in the mining industry since 1994 is to integrate technical and behavioural approaches. Within the last 5 years, the work expanded into Africa to construct skills development journeys and move artisanal mining companies into a professionalised, modernised and mechanised world of work. Rina has served the industry in AngloGold, Gold Fields, Barplats and her consulting journey commenced in 2011. Rina is proudly a wife, mother, mother-in-law and a grandmother and resides in Potchefstroom.

Sibongile Ntsoelengoe

Executive cluster manager, mining
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Sibongile (Bongi) brings over 15 years of experience in the mining industry, with a focus on iron ore and base metal commodities. She has held several leadership positions, leading multidisciplinary teams in the development, deployment, and adoption of innovative solutions across mining operations. In her previous role as Manager: Technology at Kumba Iron Ore, Anglo American, Bongi gained extensive experience in formulating and implementing integrated innovation strategy roadmaps across the mining value chain. She currently serves as the Executive Cluster Manager for Future Production: Mining at the Council for Scientific and Industrial Research (CSIR), where she plays a key role in advancing research and innovation in support of the mining sector. Bongi remains committed to the industry through various leadership roles, including her appointment as a Non-Executive Director at Fraser Alexander and as a Council Member of the South African Institute of Mining and Metallurgy (SAIMM). She continues to provide thought leadership in developing digital capabilities and bespoke, cutting-edge solutions that enable a safer, modernised, and sustainable mining industry. Among her recent achievements is the delivery of a comprehensive research and innovation strategy roadmap at the CSIR aimed at revitalising the South African mining sector and rebuilding the mining Research, Development, and Innovation (RDI) ecosystem.

Karel Nicolaas de Kock (Nico)

CEO
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Nico is the CEO of Louis Allen Southern Africa as well as the COO Grow to N. He has been involved in Management Leadership Development and Organisational Development for over 24 years. He has impacted multiple organisation's leaders in various countries covering a wide range of industries including Mining, Manufacturing, IT, Services, Insurance and Banking. His passion lies in formulating customised Management Leadership Development solutions to address complex challenges in organisations. For an analytical person such as Nico, the Louis Allen systematic approach towards management leadership development was an ideal match. As the business has grown through the years, Nico and his business partner Neo, have added also the internationally recognised Zenger Folkman leadership development as well as the Kepner & Fourie problem-solving and decision-making offerings through the Grow to N business. Since 2014, Nico has been the country representative for The European House Ambrosetti, assisting the Italian consultancy with the coordination and hosting of various CEO forums, bilateral meetings and summits within Southern Africa. Over the last 4 years, Nico has also been a research partner for SATCAP programmes, contributing to various deliverables for the benefit of the mining industry. This ranged from supervisory leadership development to change management interventions, developing a change management blueprint and impact dashboard.

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Wessel has conducted research for both private and government institutions within the following industries: Mining, Construction, Renewable Energy, Motor Industry, Manufacturing and Production (various), Water Services, Services (Management, Delivery, Financial) and Forestry. He has taken a personal interest in investigating and understanding technology's impact on people and identifying future skills requirements. He has also operated within the educational and regulatory structures by developing Sector Skills Plans for various SETAs, developing 5-year strategies and conducting large scale skills audits. His core skill is described as developing models from academic research and applying this to real-world solutions.