Analysis of Application and Impact of Technology Innovations in the Mining Industry in Tanzania

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Abstract: Developments in technology have significantly altered the quality and quantity of data that mining companies in Tanzania can access. These developments, in turn, support the utilization of automation in various activities carried out by mining companies. This study explores the application of various general technology innovations applied in the mining industry in Tanzania. Even though in most cases, the application of these technologies is influenced by the potential to increase the companies' production efficiency and competitiveness, they also facilitate the reduction of pollution and other impacts of mining activities on the surrounding environment. Moreover, technological innovations can go further to support other economic sectors that are linked to the mining industry in Tanzania. Areas addressed in this study include computerization, remote control, remote sensing, automation, and geographic information system (GIS), concerning economic developments and environmental and safety benefits. Moreover, the study also discusses productivity and safety gains from technology and highlights on highlights on what the government and community should keep in mind while adopting these technologies. to the government and community.

1 INTRODUCTION

Tanzania, which is located on the eastern side of Africa, is rich in varieties of minerals and other natural resources. In Africa, the country is in the top five countries with a diversity and richness of mineral resources (gemstones, industrial minerals, and metal deposits). According to the Tanzanian ministry of energy and resources, minerals are categorized into five: metallic minerals (gold, iron ore, copper, cobalt, and silver), gemstones (diamonds, tanzanite, rubies, garnets, tourmaline, sapphires, topaz, and emeralds); industrial minerals (Clays, glass, sand, kaolin, and limestone), energy minerals (low- sulphur coal and uranium) and dimension stones (granite) (Poncian, 2019). Despite having these rich resources for many decades, the country's wealth from minerals started growing at length in the late 1990s following the privatization and liberalization of the economy, which also lead to an increase in mineral exportation and expansion of the mining industry as a whole (Maliganya & Bengesi, 2018; Malyamkono & Mason, 2006).

The fundamental purpose of mining is removing or extracting materials such as minerals and metals from the ground and extracting the desired products from waste materials. Thousand years ago, miners used to apply basic knowledge of digging the ground to find any possible minerals or metals (example in Figure 1).

Figure 1: Picture showing mining activities using handwork.

However, due to changes in economic eras, the scale of mining sites as well as the applied technology

have significantly changed. Likewise, advanced technologies can now predict the type of minerals or metals in demand and further in which part of the world, which in turn help to put the industry into proper perspectives, not only in Tanzania but also in other countries in the world following the third industrial revolution which started in the late 1950s. Although new technologies increase productivity and mining contribution to the country's economy, they also help in managing pollution from mining activities, improve safety measures at the mining sites as well as protect the environment as a whole from any possible hazards associated with the mining activities. Thus, understanding these new technologies and their impacts on the country is significantly important.

Recently, an increased inspection of environmental and social issues has led mining companies to adopt sustainability plans. The adoption and implementation of new technologies were also emphasized by Mr. Seif Gulam, the Committee Deputy Chairman of the Tanzanian Parliamentary Committee for Energy and Minerals, at the fourth exhibition on technology and investment held in Sept-2021, with the call on miners to learn and adopt various technologies to increase efficiency in the mining industry (https://www.ice.it/it/news/notizie-dal-mondo/190367).

The history and technologies applied in mines usually intend to maximize the production outputs of the mined material while minimizing the production and processing costs. These processes lead to the growth of the economy and easy accessibility of the required raw materials. On the other hand, the processes are associated with environmental pollution and the destruction of the normal function of the ecosystems. For example, the open pits mines of diamond (in Mwadui-Shinyanga), gold (in Geita and Bulyanhulu), Ruby (in Umba), Phosphate (in Minjingu), and limestone (in Mbozi and Dar es Salaam) and others, which are susceptible to disposing of water toxic into the ecosystems, as well as underground mines also which have several impacts on the environment. Considering that environmental impacts from mining operations from many years ago are still detectable today the industry must continue to pay much attention and emphasis on environmental issues by exploring varieties of technology.

The following section highlights some of the general applications and impacts of technological innovations in the Tanzanian mining industry.

2 GENERAL APPLICATIONS AND IMPACTS OF TECHNOLOGY INNOVATIONS IN THE TANZANIAN MINING INDUSTRY

The mining activities depend on reliability and predictability, both for production efficiency and for ensuring the safety of workers while keeping the surrounding environment safe from any possible hazards. Moreover, mining companies and investors are demanded to provide better environmental performance and transparency to earn the operational social license (Maliganya & Bengesi, 2018). Increasingly, they aim to position the mining industry as an advanced and forward-looking part of the transition to a more significant and sustainable economy. Some of these technologies are highlighted in this section Examples are shown in Figure 2.
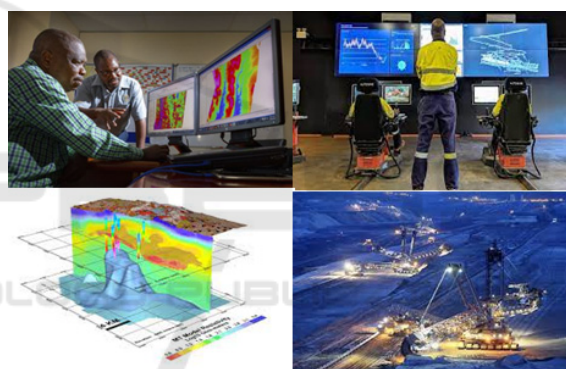

Figure 2: Technology in mining operations.

i. Automation of Mining Activities: This is one of the most important innovation trends in the mining industry. The driving factors for this innovation are not primarily environmental but rather productivity, health, and safety. This industry is widely known to be a dirty business that is also susceptible to various dangerous activities and usually dangerous business. The application of automated mining trucks and outfits prevents a large number of workers from direct exposure to the minerals and associated chemicals. Simultaneously, automation enables mines to function at the appointed time while maximizing their use of inputs (NRCan, 2016). Mining activities are automated in different forms with significant benefits that increase productivity as well as reduce environmental impacts:

ii. Site monitoring: automation and remote sensing technologies can significantly benefit environmental performance by facilitating a fast track of issues before they occur or cause damage (Wang, Yang, & He, 2018).

iii. Ventilation systems at underground mining sites: this causes major costs in underground mines. The systems are important to regulate temperature, clear smoke, gases, and fuel fumes, and ensure safe operations in mines. Automated ventilation systems use network sensors to move air to the required areas at any time, which saves more than 30% of energy consumption.

■ **Visualization of Mine Spatial Data:** 3D-Modelling creates a viewable and easy presentation of spatial data which makes it easy to understand even those complex interrelated issues. This also helps the mining companies to gain insights into the mine systems at a lower cost and reduced impact on the environment.

■ **GPS and GIS (Geographic Information Systems (GIS)):** As surveying is an important aspect of the mining industry, GPS and GIS are integral tools that provide a deeper look at how geographic relationships affect our environment, facilitate surveying and mapping huge areas in the mining sites, which also saves a lot of time. GIS enables the miners to go about and solve daily real-life issues which have location and accessibility problems. GIS also facilitates easy exploration of minerals, insights into the geochemical and hydrology data, documentation of mining activities, facility and tailings management, as well as insights into regulatory compliance.

■ **Artificial Intelligence (AI):** in recent years, AI has taken lead in decision-making at insight-driven companies. They apply machine learning and smart data to improve the companies' operational efficiency, safety, and mine production workflow. AI is applied in the exploration and processing of minerals, autonomous vehicles, and drillers.

■ **Data Collection and Analytics Software Systems:** recent applications of computer systems help to improve mining operations by collecting and analyzing data that shows daily mine operations as well as can predict required machine maintenance at the right time. This is done through sensors placed in different locations to collect data such as quality of air; consumption of fuels, temperature ranges, etc. which gather data. All of these help in reducing time consumption and reduce operational costs.

■ **Asset Management Systems:** mobile computers for tracking assets and production control software are an essential part of asset management systems in the mining industry. Secure, fast processing, built-in data capture equipment, easy data entry options, and connectivity capabilities facilitate reliable assets and resource tracking and management.

■ **Remote Sensing:** Nowadays, drones have started to take lead across the mining industry in Tanzania. They now produce similar outputs as a helicopter but at a lower cost. When set to perform operational tasks at mining sites, drones provide these advantages: safety in hazardous areas, management of assets, maintenance and inspection of infrastructure as well as site mapping. Also, the technology helps in (i) Mine exploration and (ii) Site operation and management through network sensors, machinery, and devices, along with imagery data from satellites. It ensures that mine management is better aware of what is going on at the site (Cosbey et al., 2016).

3 DISCUSSION AND CONCLUSIONS

Rapid growth in technological innovation, including the few that have been discussed above and many other, are having a fundamental impact on the mining industry in Tanzania. Technology offers several impacts on mining daily operations, such as safety and productivity, protection of the environment, and providing a safe environment for both men and women to work at the mining sites.

Compared to previous years, current innovations employed in this industry have improved environmental conservation through improved waste management efforts, and efficient processing of tailings. With improved technology, the industry has increased its contribution to the economy of the country. It has also helped to reduce the belief of this industry is too dangerous for women, as more jobs are operated at a distance from the rock face. And now, thanks to technology, the number of women working in the industry is increasing by the day.

However, despite all those benefits and more, there are some critical issues that the Tanzanian community and government as a whole need to consider to benefit more from this industry. It is a fact that most of the mining companies especially the large-scale mines are foreign companies (foreign investment); which come with more advanced technology for their daily conduct and to increase

their productivity. This is a call for the community and government to stay updated on the latest innovations and changes brought in to ensure that increased targeted productivity comes with balanced economic and social benefits for all the time that the company will be operating in the country.

On the positive side, the government can ensure high environmental standards within mining operations by incentivizing certain technological innovations, setting up targeted tax incentives for the mining companies, creating research and education opportunities for their local workforce on the technology, and facilitating the achievement of local scholars. The companies should be encouraged to collaborate with different local sectors universities and other research institutions to bring new and valuable technology insights into the industry while also managing risks.

Moreover, the government needs to ensure that these new technologies do not undermine shared value efforts, including employment and investment opportunities in local communities or dividing the sector into low-paying, low-skilled jobs and high-paying jobs for individuals who can take advantage of the shift to new technologies.

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