

Mapping of Abandoned Mine Site Related Tailings Storage Facilities in Gauteng Province, South Africa

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Abstract—Abandoned Tailings Storage Facilities (TSFs) are hiding in plain sight across Gauteng, posing silent threats to both communities and the environment. The aim of the research is to quantify the number of abandoned TSFs in the province and assess their visible environmental impacts. The objectives of this study are to; firstly, identify and verify abandoned TSFs in Gauteng; and secondly, to analyse their physical and spatial characteristics. QGIS and Google Earth Pro were used to visually inspect the TSFs, relying on physical characteristics and verifying locations of the data obtained from the Department of Mineral and Petroleum Resources (DMPR). Using the abandoned mine sites data from the DMPR, a total of 144 sites were mapped and 29 were classified as abandoned TSFs, 50 rehabilitated sites, and the remaining 65 are buildings as well as residential areas. TSFs were classified as abandoned using characteristics such as erosion features, lack of vegetation, and close proximity of 500m to residential areas. These findings not only highlight critical non-compliance with environmental regulations but also emphasise risk to public health and ecosystem resilience. The study recommends that mining regulatory bodies such as the DMPR initiate immediate environmental risk assessments and prioritise the rehabilitation of TSFs near vulnerable communities.

Keywords—mining, environment, communities, TSFs, abandoned.

I. INTRODUCTION

Gauteng province, the economic hub of South Africa, has a long and rich history of gold mining. The famous city of Johannesburg was built at the back of gold discovery in 1886. Over the centuries mining activities have produced enormous volumes of tailings fine-grained residues left after the extraction of gold from ore. The total estimated volume of tailings storage facility (TSF) material managed by Ergo Mining Operations, a subsidiary of DRDGOLD Limited, is approximately 596.27 million tonnes. This figure represents the exclusive mineral resource estimate for all the company's TSFs as of 30 June 2022, excluding material already classified as reserves. All these TSFs including the Crown Complex, City Deep, Knights, Brakpan, Springs, and Nigel operations are situated within the central and eastern parts of Gauteng Province, forming part of the historical Witwatersrand goldfield (DRDGOLD Limited, 2022).

However, this tonnage reflects only the DRDGOLD-owned operations and therefore does not represent the full extent of TSF material in Gauteng. When other operators, legacy and ownerless TSFs, municipal dumps, and informal deposits are

considered, the provincial total is substantially higher. Studies using the Department of Mineral Resources and Energy (DMRE) database and remote sensing have identified more than 300 TSFs in Gauteng, indicating that the overall volume of stored tailings across the province is likely in the hundreds of millions to billions of tonnes (Mpanza et al., 2024).

These tailings are stored in purpose-built Tailings Storage Facilities (TSFs) to prevent environmental contamination and ensure operational safety. An abandoned tailings storage facility (TSF) is a mine dump where the waste from mining (called tailings) was once stored, but the site is no longer used, managed or looked after by anyone. Because it has been left without care or rehabilitation, it often becomes unsafe and harmful to the environment (Responsible Mining Foundation, 2021; South Africa Today, 2025). These TSFs can pose serious environmental risks, including soil and water contamination, dust generation, erosion, and physical hazards to nearby communities (Mpanza, 2024; SAHRC, 2016). Abandoned TSFs are particularly concerning because they are often located near human settlements or sensitive ecosystems. In addition, the lack of vegetation and the physical instability of these sites increase the likelihood of erosion, dust storms, and structural collapse, further endangering local communities and biodiversity (SAHRC, 2016). In Gauteng, several abandoned Tailings Storage Facilities (TSFs) such as the Princess TSF in Roodepoort and the Slovoville TSF near Soweto remain largely unrehabilitated, with barren surfaces and visible gully erosion. These conditions have led to the generation of dust affecting nearby communities, instability of slopes, and sediment runoff into stormwater systems. The Luipaardsvlei TSF in Krugersdorp shows advanced erosion, further illustrating how long-standing neglect results in land degradation and health risks.

The Council for Geoscience (CGS), Mintek, and the Department of Mineral and Petroleum Resources (DMPR) are the main organisations responsible for rehabilitating abandoned mining sites in South Africa. Their work typically includes slope stabilisation to prevent structural collapse, covering dumps with soil, and establishing vegetation to reduce dust and erosion (Mpanza, 2024; Oosthuizen, Ehrlich & White, 2019). In addition, Mintek has piloted the reprocessing of old tailings in order to recover residual gold and uranium while simultaneously reducing the footprint of abandoned dumps (Simate & Ndlovu, 2021). The CGS has also contributed through mapping, environmental risk assessments, and the development of cost-effective rehabilitation strategies

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(Mpanza, Adam & Moolla, 2020). Despite these initiatives, only a small proportion of abandoned TSFs have been successfully rehabilitated, and the majority remain unmanaged, particularly those situated close to residential areas. This situation continues to expose communities to serious risks, including dust inhalation, contaminated soil and water, and potential structural instability (SAHRC, 2016).

The aim of this study is to quantify the number of abandoned TSFs in Gauteng Province and to assess their visible environmental impacts. This aim is achieved through two main objectives: firstly, to identify and verify abandoned TSFs using spatial analysis tools and field verification where possible; and secondly, to analyse the physical and spatial characteristics of these TSFs, including evidence of erosion features, lack of vegetation, proximity to residential areas, and other signs of environmental degradation. By achieving these objectives, the study intends to provide crucial information to assist local authorities, regulatory bodies, and the mining sector in prioritising rehabilitation projects and improving environmental management practices.

The study is timely because South Africa continues to grapple with the legacy of historical mining. While some TSFs have undergone rehabilitation, many remain unmonitored, hidden in plain sight across urban and peri-urban landscapes (Mpanza et al., 2020). The Department of Mineral and Petroleum Resources (DMPR) has made efforts to establish a database of abandoned mine sites, yet inconsistencies in data quality and coverage limit its practical use (DMRE, n.d.). By using Geographic Information Systems (GIS) software such as QGIS and remote sensing tools like Google Earth Pro, this study seeks to bridge that gap, providing an updated, spatially accurate map of abandoned TSFs and highlighting those posing the highest environmental and social risks.

The significance of this study lies in its potential contribution to environmental governance, public safety, and sustainable urban planning. Quantifying and classifying abandoned TSFs will allow for more informed decision-making and resource allocation by municipal authorities and mining regulators. Furthermore, the study's findings may support ongoing initiatives to rehabilitate abandoned mining infrastructure and enhance community awareness about the risks associated with living near tailings facilities (Mpanza, 2024; SAHRC, 2016). In the long term, this research may serve as a foundation for integrating TSF management into broader environmental monitoring and risk reduction strategies, aligning with South Africa's commitment to sustainable mining practices, the Sustainable Development Goals (SDGs) and environmental stewardship.

II. METHODOLOGY

A. Study Site

The study area considered the entire Gauteng Province since there are known and visible TSFs left abandoned in the area. Gauteng has an average rainfall that ranges from 600 to 700mm per year. The rain mostly occurs in the summer season between

October to November. In the world, this Province has been recognised as a gold field with its enormous gold production since the 1880s (Phillips, 2011). Gauteng Province has historically been the heart of South Africa's gold mining industry, with gold production beginning in the late 1880s in the Witwatersrand Basin. Since then, it is estimated that the province has produced around 50 200 tonnes of gold up to 2019, with most of this coming from Gauteng itself (Handley, 2023). Despite this long history, gold mining is still ongoing, particularly in areas such as the West Rand and East Rand, where active mines continue to operate. In recent years, national gold production has declined significantly, with South Africa producing approximately 100 tonnes of gold in 2024, compared to the historical peak of over 1 000 tonnes per year in the 1970s (CEIC, 2024). The gold extraction is still an ongoing activity in this region, particularly in the West Rand East areas, and is dominated by active mine operations.

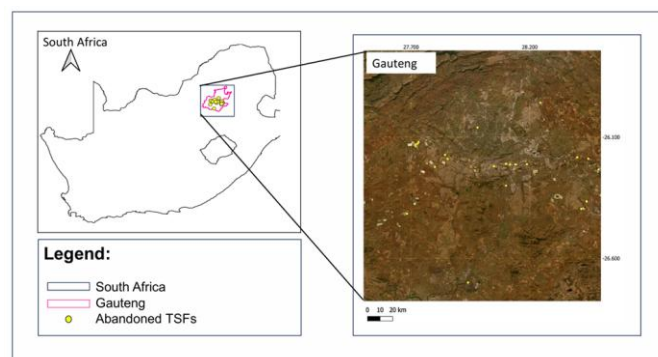


Fig 1: Abandoned Tailings Storage Facilities.

The figure shows the spatial distribution of tailings storage facilities (TSFs) across Gauteng Province. The yellow dots represent abandoned TSFs, highlighting areas where mining activities have ceased but tailings remain on the surface. As seen in the figure, most abandoned TSFs are concentrated in the West Rand and East Rand areas, reflecting the historical gold mining activity in these regions. This spatial pattern emphasises the large number of legacy mining sites and the potential environmental risks associated with abandoned tailings.

B. Research Design

This study used a spatially based descriptive quantitative research design that employed remote sensing and geographic information system (GIS) tools. The choice of a descriptive design was deliberate, as the aim of the research was to describe and quantify the spatial characteristics of abandoned Tailings Storage Facilities (TSFs) in Gauteng Province. Such a design is well suited for environmental research where the focus is on mapping, measurement and interpretation of physical features, rather than on experimental manipulation (Mpanza, 2024; Simate & Ndlovu, 2021).

C. Data Sources

The data for this study came from both primary and secondary sources. The secondary data consisted of the

database of abandoned mines provided by the Department of Mineral and Petroleum Resources (DMPR). This database acted as a reference for identifying potential Tailings Storage Facilities (TSFs), but because it contains inconsistencies, further verification was required (Mpanza, 2024). The dataset provided by the Department of Mineral and Petroleum Resources (DMPR) contained 144 mine-related sites across Gauteng. Each site was visually inspected using Google Earth Pro to confirm its status. Of these, 29 sites were classified as abandoned TSFs, 50 were identified as rehabilitated land, and the remaining 65 sites were found to be buildings or residential developments rather than tailings facilities. For the purposes of this study, the abandoned TSFs were further assessed and ranked in terms of rehabilitation urgency. Sites located within 200 metres of human settlements or showing severe erosion and no vegetation cover were classified as high priority. TSFs located between 200 and 500 metres from settlements, or showing moderate erosion and sparse vegetation, were classified as medium priority, while those further than 500 metres away or already showing partial natural rehabilitation were categorised as low priority.

In this study, the use of 500 metres as a threshold distance for assessing the rehabilitation priority of abandoned tailings storage facilities (TSFs) is justified based on both environmental and human health considerations. The 500 m buffer is frequently used in South African environmental planning and dust dispersion studies as a protective distance between pollution sources and residential areas. Research on abandoned gold mine TSFs in Gauteng found that communities located within 500 m of the sites experienced significantly higher dust exposure, posing serious health risks (Nkosi et al., 2023). Similarly, the Gauteng Pollution Buffer Zones Guideline, issued under the National Environmental Management Act (NEMA), recommends a minimum separation distance of approximately 500 m around high-risk facilities such as landfills and slimes dams to reduce direct human exposure (Department of Forestry, Fisheries and the Environment [DFFE], 2017). This classification provides a clearer framework for identifying which sites present the greatest immediate risk to surrounding communities and should therefore be prioritised for rehabilitation (Mpanza, 2024; SAHRC, 2016).

D. Data Analysis

Primary data was generated through spatial inspection and measurement using Google Earth Pro. The ruler tool was used to measure the distance between TSFs and nearby residential areas, while visual assessment of satellite imagery was carried out to identify signs of erosion and to evaluate the extent of vegetation cover. These observations formed an important dataset that had not been previously explored.

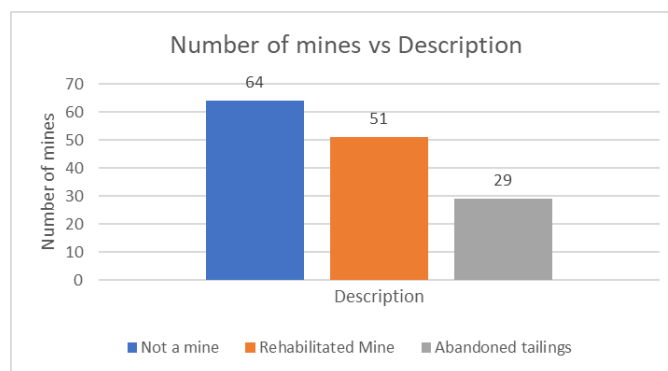
In addition, QGIS was used to augment the observations and for cartographic purposes. After the locations of the TSFs were verified in Google Earth Pro, their coordinates were imported into QGIS, where a map was drawn to show their distribution across Gauteng. The use of QGIS was therefore limited to

mapping rather than advanced spatial analysis, but the resulting visualization was important for communicating the findings clearly.

III. RESULTS

A. Site Selection

Graph 1 shows the number of sites in Gauteng Province categorised by their status. The figure illustrates that there are 64 sites that are not active mines, 51 rehabilitated mines, and 29 abandoned tailings. This distribution highlights that while a significant number of mining areas have been rehabilitated or remain inactive, there are still numerous abandoned tailings that may pose environmental and safety concerns.



Graph 1: The graph of the mine descriptions and the number of mines.

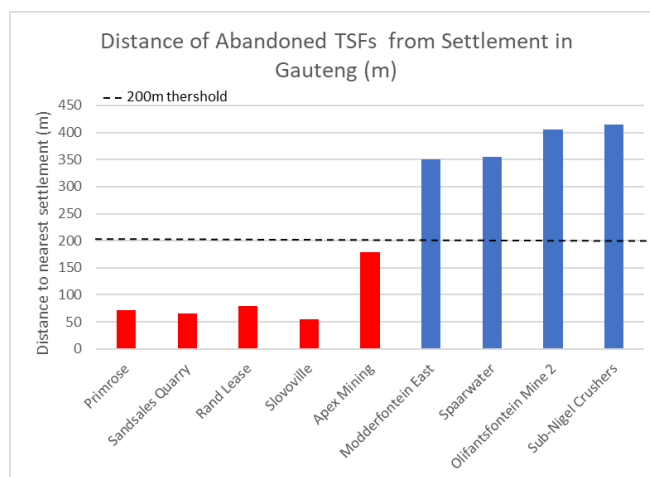
Using the DMPR dataset as a baseline, 144 mine-related sites in Gauteng were examined. Each site was systematically checked on Google Earth Pro to confirm whether it was a TSF. Sites were classified as TSFs if they showed the typical characteristics of mine tailings, such as exposed fine-grained residues, eroded slopes, or flat-topped storage mounds. Of the 144 sites, 29 were confirmed as abandoned TSFs. Sites identified as rehabilitated land, buildings, or other infrastructure were excluded from the final analysis. These sites were excluded from the final analysis because they no longer represent active or abandoned tailings storage facilities (TSFs) that pose environmental or safety risks. Once a TSF has been successfully rehabilitated, it typically undergoes processes such as surface stabilisation, vegetation establishment, and land repurposing, which significantly reduce the potential for dust generation, erosion, and contamination of nearby water sources (Department of Mineral Resources and Energy [DMRE], 2021). Tailings Storage Facilities (TSFs) can generally be classified into (Mpanza, 2024). Active TSFs are facilities that are currently in use for the deposition of mine tailings and are usually subject to monitoring and regulatory compliance. Tailings storage facilities (TSFs) can be divided into three main categories: active, dormant, and abandoned. Active TSFs are still receiving tailings from mining operations, and they are regularly monitored and maintained to make sure that they remain safe

and do not cause environmental problems. Dormant TSFs, on the other hand, are no longer receiving new tailings, but they are still managed or maintained in some way. This management helps prevent issues such as erosion, dust, or water contamination while the site waits to be fully rehabilitated or reused. Abandoned TSFs are sites that are no longer in use and receive no ongoing maintenance or monitoring. Because of this, they are much more vulnerable to erosion, dust, and pollution, which can negatively affect the surrounding environment and nearby communities (Mpanza, 2024; DFFE, 2022). In contrast, abandoned TSFs are those that have been left unmanaged after mining activities ceased, with no evidence of rehabilitation or ongoing maintenance. This distinction is important because abandoned TSFs typically pose the highest environmental and social risks due to erosion, dust emissions, and their proximity to human settlements.

After verification, the 29 TSFs were imported into QGIS, where they were mapped as individual points. This mapping process allowed the spatial distribution of abandoned TSFs to be visualised across the province, highlighting areas of high concentration of abandoned facilities. While the West Rand showed notable clustering due to its historic gold mining activity, the Central Rand also presented several abandoned TSFs, particularly around older mining towns such as Germiston, Boksburg, and Roodepoort. These concentrations are important because they point to regions where environmental and social risks are greatest. The use of QGIS therefore added an important dimension to the methodology by enabling the findings to be communicated clearly in map form.

B. Measurement of Distances

The results showed significant variation, with some TSFs located extremely close to specific residential areas while others were further away. For example, the Primrose TSF is only 71.4 m from houses in Primrose (Germiston), while the Sandsales Quarry TSF lies 66 m from homes in Edenvale. The Rand Lease TSF is situated 79.82 m from the settlement of Roodepoort, Slovoville TSF is 55.18 m from Slovoville, and the Apex Mining TSF is 179 m from residences in Benoni. By contrast, TSFs such as Modderfontein East (350.46 m from Modderfontein), Spaarwater (354.60 m from Springs), Olifantsfontein Mine 2 (404.88 m from Olifantsfontein) and Sub-Nigel Crushers (414.13 m from Nigel) were found to be located further from residential areas. These findings revealed not only the widespread presence of abandoned TSFs across Gauteng but also their alarming closeness to established human settlements in certain regions.



Graph 2: The bar graph showing the distances of abandoned TSFs from human settlements in Gauteng:

- Red bars = TSFs classified as Close (<200 m).
- Blue bars = TSFs classified as Far (>200 m).
- The dashed black line marks the 200 m threshold



Fig 2: a) Primrose TSF

b) Apex mining TSF

C. Assessment of Erosion

Erosion was assessed through visual inspection and interpretation of Google Earth Pro imagery. The pictures show that different types of erosion are taking place. At the Angelo Dump, the main form is sheet erosion, where thin layers of soil are washed away, leaving bare patches of red ground. In some areas, small rills are also beginning to form as water concentrates in narrow flow paths. The erosion here is spread across the slope but not very deep yet. It is mainly caused by the lack of vegetation cover, the steep gradient of the dump, and the fine-textured soils that are easily eroded by rainwater (Lal, 2019; Morgan, 2005).

At the Leeuwkuil Quarry, erosion is more severe. There are signs of gully erosion, where water has cut deep channels, as well as bank erosion, where parts of the quarry walls are collapsing. This is an indication of the age of the dump and means this dump has been long standing in the area, these signs point to slope instability. The erosion is concentrated in areas where stormwater runoff is strongest. The causes include uncontrolled surface water, clearing of vegetation during mining, and sandy or silty soils that erode quickly once disturbed (Stocking and Murnaghan, 2001; Boardman, 2022). The Luipaardsvlei site shows the most advanced stage, with

large and branching gullies. These gullies are deep and wide and are spreading upslope through headward erosion. The damage is extensive, and large portions of land are no longer usable. The main causes are uncontrolled stormwater from nearby mine dumps, absence of vegetation, and soils that break down rapidly once exposed, most likely clay-rich soils (Nyamadzawo et al., 2013; Morgan, 2005).



Fig 3: a) Leeuwkuil Quarry TS b) Luipaardsvlei gullies TSF

D. Assessment of Vegetation

Vegetation cover was also evaluated through Google Earth Pro. Sites with no visible vegetation were classified as barren, which indicated unstable and unrehabilitated conditions. Sites with small patches of grass or shrubs but large exposed areas were classified as sparsely vegetated, while those with widespread vegetation cover were categorised as moderately to densely vegetated. Historical imagery was consulted to observe whether vegetation cover had changed over time, which helped to distinguish between natural regrowth and long-term absence of cover. Vegetation cover is a crucial measure because it reduces dust generation, stabilises the surface of TSFs, and limits erosion. Its absence, therefore, signals heightened environmental and health risks (Oosthuizen, Ehrlich & White, 2019).



Fig 4: Princess TSF from 2017 to 2025

The Princess TSF, located in Roodepoort on the western mining belt of Johannesburg, is classified in this study as an abandoned facility, since there is no evidence of active management or rehabilitation. The dump lies in close proximity to residential areas, falling well within the 200-metre threshold adopted in this study, and is therefore considered a high-priority site for rehabilitation. Visual inspection through Google Earth Pro imagery shows that the Princess TSF remains largely barren, with only limited patches of natural regrowth. Based on the vegetation classification applied in this study, it falls within the sparsely vegetated to barren category, which reflects instability and elevated dust risk. Change detection over the past five years confirms that there has been little meaningful improvement in vegetation cover, pointing to the absence of formal rehabilitation efforts. Its location near densely populated areas, combined with poor surface stability, means that the Princess TSF continues to pose significant environmental and social risks, including dust pollution, erosion, and possible contamination of surrounding land and water resources.



Fig 5: Slovoville from 2017 to 2025

Similarly, the Slovoville TSF near Soweto is also classified as an abandoned facility. It is located immediately adjacent to the settlement of Slovoville, with residential houses extending to the foot of the dump, placing it firmly in the high-priority category. Satellite imagery shows that the Slovoville TSF is in a degraded condition, with large, exposed surfaces and evidence of erosion. Sparse patches of vegetation are present, but they do not provide meaningful surface stability. Historical imagery further confirms that the TSF has remained largely unrehabilitated for at least the past five years. Like the Princess TSF, its location is close to communities combined with its barren condition, it exposes residents to risks of dust inhalation, surface instability and possible contamination of soils and water sources.

IV. DISCUSSIONS

The analysis in this study focused on combining quantitative measurements with qualitative visual observations. Distances between Tailings Storage Facilities (TSFs) and residential areas were measured in Google Earth Pro and compared across sites to highlight cases where facilities were located extremely close to communities. In addition, the satellite imagery was visually inspected for evidence of erosion, such as gullies, collapsed slopes, as well as lack of vegetation cover. The availability or absence of vegetation was used as a basic indicator of whether a TSF was stabilised or remained exposed. QGIS was then used to draw a map showing the verified TSFs across Gauteng. The purpose of this mapping was not to conduct advanced spatial analysis but to illustrate the overall distribution of TSFs in relation to the urban landscape. The map provided a clear visual representation of how widespread the facilities are and helped to emphasise that many of them are located near residential areas.

V. LIMITATIONS

One of the main limitations of this study is that it relied mostly on satellite imagery rather than direct field surveys. While tools such as Google Earth Pro and QGIS provide useful and accessible spatial data, they cannot fully capture on-the-ground conditions, including the depth of erosion, the stability of slopes, or the actual quality of vegetation cover. These factors are important when assessing the environmental risks posed by abandoned tailings storage facilities (TSFs). The DMPR dataset was a valuable starting point, it contained some errors and inconsistencies that had to be corrected through visual verification.

Despite these limitations, the use of Google Earth Pro and QGIS allowed for systematic mapping and spatial analysis of TSFs across Gauteng Province. Mapping the 29 verified TSFs as individual points enabled the identification of areas with high concentrations, particularly within historic mining belts like the West Rand and Central Rand. This method also made it possible to rank sites according to rehabilitation urgency, based on factors such as distance from human settlements, vegetation cover, and erosion severity. Although on-site surveys would have provided more detailed and accurate information, satellite-based methods made it possible to cover a large area efficiently, which would have been difficult and costly with direct fieldwork. By allowing for cross-checking and mapping. Overall, while the study is limited by the absence of field verification, the methods used still provide valuable insights into the spatial distribution, condition, and rehabilitation priority of abandoned TSFs in Gauteng, offering a solid foundation for further research and policy interventions.

VI. CONCLUSION AND RECOMMENDATIONS

The findings of this study have shown that abandoned Tailings Storage Facilities (TSFs) in Gauteng continue to pose significant environmental risks. Measurements taken using Google Earth Pro revealed that several TSFs, such as Primrose

at 71.4 metres, Rand Lease at 79.82 metres and Sandsales Quarry at only 66.10 metres from residential areas, are located alarmingly close to people's homes. Such proximity places communities at increased risk of exposure to dust, contaminated soils and potential structural failure. In addition to these distance concerns, the visual assessment of erosion demonstrated that many TSFs show clear signs of physical degradation, with gullies and collapsed slopes reflecting long-term instability. The absence or scarcity of vegetation at several sites further emphasises the lack of rehabilitation, as barren surfaces continue to release dust and are more prone to erosion. Together, these findings illustrate the extent to which abandoned TSFs threaten both human health and environmental sustainability in South Africa's economic heartland.

The evidence presented in this study highlights the urgent need for stronger government intervention. While the Department of Mineral and Petroleum Resources (DMPR) has developed a database of abandoned mines, inconsistencies in the dataset and the slow pace of rehabilitation mean that many risks remain unaddressed (Mpanza, 2024). The South African Human Rights Commission (2016) has already warned that the continued presence of abandoned TSFs undermines environmental rights, yet progress towards remediation has been limited.

The government should prioritise three areas of intervention. Firstly, there is a need to update and verify the national inventory of abandoned TSFs using modern spatial tools such as QGIS and Google Earth Pro, ensuring that data is accurate and accessible for planning purposes. Secondly, a risk-based rehabilitation programme should be developed, with priority given to TSFs located within 500 metres of housing or those showing severe erosion and no vegetation cover. Rehabilitation should focus on stabilising slopes, controlling erosion, and establishing sustainable vegetation cover to reduce dust emissions. Thirdly, regulatory enforcement must be strengthened. Mining companies that left behind unrehabilitated TSFs should be held accountable where possible, and new policies should be introduced to ensure that similar legacies do not continue in the future.

In the longer term, abandoned tailings storage facilities (TSFs) in Gauteng can be monitored more effectively by combining artificial intelligence (AI) and machine learning (ML) techniques with traditional methods such as satellite verification and QGIS mapping. For example, satellite imagery provides a broad view of TSFs, showing erosion patterns, slope stability, and vegetation cover over time, while drone (UAV) imagery can capture high-resolution images of individual dams, revealing small cracks or localised erosion that may not be visible from space (Zhang, Li & Chen, 2022). Aerial photographs can supplement these images by providing context for wider historic mining belts, such as the West Rand and Central Rand. Using Convolutional Neural Networks (CNNs), these images can be automatically analysed to detect signs of deterioration. CNNs examine images in small sections, recognising patterns from simple edges to complex structures

like tailings dams, which allows problem areas to be flagged quickly without having to check every site manually (LeCun, Bengio & Hinton, 2015).

Additionally, predictive machine learning models, such as random forests or gradient boosting machines, can process historical and current TSF data—including slope angles, rainfall, and soil composition—to forecast which sites are most at risk of failure (Bui, Nguyen & Hoang, 2021). Unsupervised learning methods, like k-means clustering, can also highlight unusual changes in vegetation or surface conditions, which may indicate instability. Combining these image analyses with real-time sensor data—for example, moisture levels, seepage, or slope movements—enables early warning systems that can alert authorities and nearby communities before serious environmental impacts occur. Applying these AI and ML techniques to abandoned TSFs in Gauteng would strengthen the monitoring process, allowing for proactive management, prioritisation of rehabilitation efforts, and better protection of communities living near legacy mining sites (Zhang, Li & Chen, 2022; Bui, Nguyen & Hoang, 2021). Applying these AI and ML techniques to abandoned TSFs in Gauteng would strengthen the monitoring process, allowing for proactive management, prioritisation of rehabilitation efforts, and better protection of communities living near legacy mining sites.

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