The legacy and prospects of the Gauteng City-Region's mining landscapes

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Abstract

Mine Residue Areas (MRAs) describe general mine waste associated mainly with gold-mining. In a recent study compiled by the Gauteng Department of Agricultural and Rural Development (GDARD), 374 Mine Residue Areas were identified in the Gauteng City-Region (GCR) of South Africa (SA). Of these, only 25km^2 of the total 321km^2 covered by MRAs can be rehabilitated at a low cost. Insufficient mine closure plans have created a mining landscape legacy that is scattered across the GCR, serving as a constant reminder of how concepts of sustainability were not part of past mining responsibilities and still appear to slip through the cracks of SA's environmental and mining legislation. MRAs affect air and water quality, present geo-technical safety concerns for communities and create physical barriers to the movement of people, presenting challenges for spatial redevelopment and integration programmes. It is predicted that these challenges will only be exacerbated as a result of climate change, which predicts increased variability in weather extremes. This paper provides an overview government mining policy around MRAs and the environment and evaluates how these policies align with strategies to mitigate and adapt to climate change to create a more sustainable region. This paper identifies potential risks of exposing MRAs to changing climatic variables, informing the management of MRAs within the GCR. These findings will assist with clarifying appropriate mitigation and adaption strategies to ensure infrastructure and communities, infrastructure and the environment are not further affected.
Keywords: mine residue areas, mining, Gauteng City-Region, sustainability, climate change, settlement vulnerability.

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1 Introduction

Like Australia, India and Canada, South Africa (SA) has become burdened with a legacy of unplanned mine closures, hazardous mine sites and ownerless and derelict mining lands (Smith [1]). This has largely been a result of insufficient and inadequately applied legislation that has allowed mines to cease activity without implementing appropriate mine closure plans.

SA's early gold mining economy was purely an extraction industry with very little consideration of the long term (Adler *et al.* [2]). Prior to 1991, mining companies used irresponsible mining methods with little consideration of their impact on the environment. Social and environmental costs were deflected by mines in order to keep profits high, diverting adverse socio-economic and environmental effects onto third parties (Adler *et al.* [2]). Unprofitable mines were left un-rehabilitated before liquidation, in some cases with mine owners simply abandoning their responsibilities and leaving the country (Swart [3]). The many ownerless and derelict mines in SA are a consequence of government not enforcing their regulatory role, allowing the mines to self-regulate (Adler *et al.* [2]). A current estimate of cleaning up SA's some 6000 ownerless and derelict mines, including mine dumps (DMR [4]), is R30 billion (WWF [5]).

This paper focuses on the Gauteng City-Region (GCR), where a cluster of cities, towns and urban nodes – including the primary cities of Johannesburg and Pretoria – together make up the economic heartland of SA. At the core of the city-region is Gauteng, which is the most densely populated province of SA supporting an estimated 12,272,263 individuals.

Gauteng's total land surface area is estimated to be 18,178.30km^2. Some 130 years of mining in this region has led to 374 mine residue areas (MRAs) with a total surface area of 321km^2 (GDARD [6]). This accounts for 1.8% of Gauteng's land surface area. Mine waste in the form of MRAs include tailings disposal facilities (either hydraulically or mechanically placed), waste rock dumps, open cast excavations, quarries, water storage facilities, return water dams, footprints left after the re-mining of tailings disposal facilities and a mixture of other building material, mine waste and industrial waste within the boundaries of current or former mines (GDARD [6]).

The region's MRAs stretch across the mid-section of Gauteng, dividing the urban core into two parts located to the north and south of the mining belt (fig. 1). Unlike other mining contexts in other parts of SA and abroad, where mining activities have been at the periphery of cities and towns, the urban areas of Gauteng have developed around the mines. This has put communities at a greater risk to the impacts of active mines and mine waste. The local municipalities of Merafong City, Westonaria, Randfontein, Johannesburg and Ekurhuleni are most affected by MRAs (fig. 1).

Most of the MRAs in Gauteng are associated with gold mining and are radioactive as a result of the high proportion of uranium contained within the mined ores (GDARD [6]). This is because uranium was not extracted as a by-product of gold mining prior to the 1950s (GDARD [6]). Because of both radioactive and non-radioactive elements, MRAs pollute and affect air quality,

water quality, contribute to acid mine drainage and present geotechnical safety concerns.

Mine residue areas not only pose a series of environmental and social risks in Gauteng, but also create barriers to the movement of individuals. This creates challenges for post-apartheid spatial redevelopment and integration programmes.

In order to mitigate and adapt to climate change to create a more sustainable region for the future, it is important to qualify the historical and current mining contexts in the GCR. This includes understanding and addressing the mining landscape legacy inherited by the region and to reconcile present obstacles in applying SA's mining legislation. In order to investigate these dynamics, this paper aims: 1) To provide a brief overview of current mining policy around MRAs and the environment; 2) To identify the potential risks of exposing MRAs to changing climatic variables; 3) To assist with the development of appropriate mitigation and adaptation strategies to ensure communities, infrastructure and the environment are not further affected.

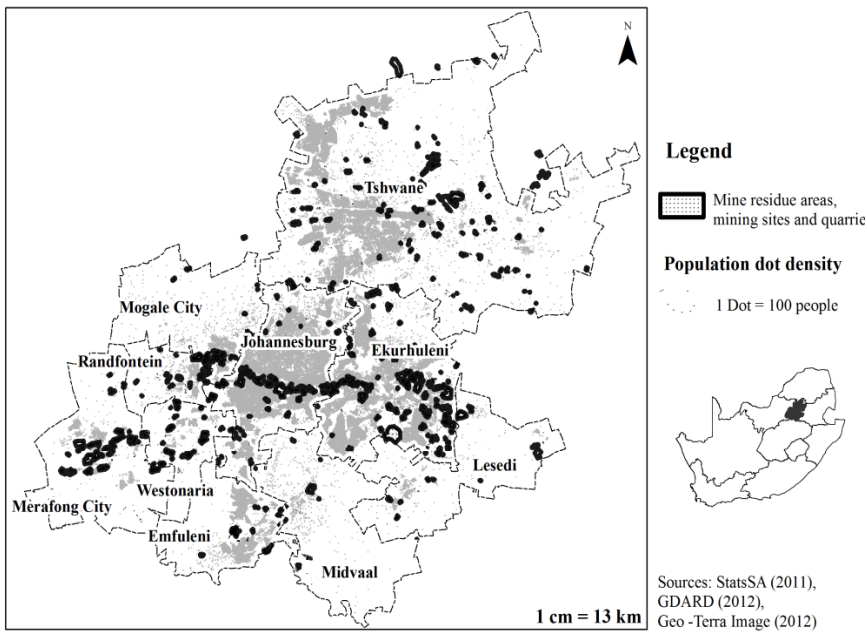

Figure 1: Mines and MRAs have developed along the gold bearing reef that runs along the mid-section of Gauteng.

2 Varied settlement vulnerability in the GCR

Historical strategies to control the distribution of the SA population along racial lines have created a highly distorted settlement geography in the Gauteng City-Region (Bremner [7]). The result is a spatially fragmented and dis-continuous

city where natural or open land has been used to segregate the population according to land use zoning, income groups and race (Bremner [7]). Historically, MRAs were used as a buffer to divide race groups in Gauteng. In places like Soweto, individuals were purposely placed beyond the mining belt to separate the white northern parts of Johannesburg from the predominately black south. The spatial separations inherited from apartheid have not been systematically addressed in the democratic era (Bremner [7]), and mines and mine waste still dissect the province, acting as dividing lines for an unequal society divided in space.

Most common household income per small area layer (SAL) in GP, which has been derived by merging the enumerator area boundaries, can be used an indicator of financial vulnerability and the ability of households to financially mitigate and/or adapt to climate change. At present, areas of high and low annual household incomes typically fall above and below the gold reef in Johannesburg (fig. 2(a)). More specifically, maps (fig. 2(b)–(d)) indicate where mines and mine waste present challenges for spatial redevelopment and integration programmes. Mines and mine waste created along the reef preceded the development of road networks, and has created barriers to the flow of traffic (fig. 2(b)). Mines on the East Rand have created a fragmented settlement and road network across the areas that are in close proximity to the mines (fig. 2(b)). Mines, quarries and MRAs in the south of Gauteng are fragmented across different SALs and present challenges for spatial development programmes (fig. 2(c)). To the north of Gauteng, mines are located in peripheral areas where SALs are shown to have a lower common income per household versus more urban locations (fig. 2(d)).

It is for these reasons that the location of MRAs still serve as a constant reminder of SA's history of placing individuals on land that was not suitable for human occupation or development. Further, the current expansion of low income housing and the growth of informal settlements in the GCR still follow similar developmental patterns prescribed under the apartheid regime, situating individuals on dangerous ground or in areas that cannot support large influxes of people. New social housing projects continue to be developed on land adjacent to mine dumps, despite the effects on human and environmental health. This has exacerbated spatial inequalities where settlement vulnerability can be related to the poor location of settlements together with low annual incomes per household. Low annual incomes per household marks settlements more susceptible to environmental hazards and the risks associated with climate change (fig. 2(a)–(d)). This is a result of the reduced ability of households to financially mitigate and adapt to hazards over the long term, forcing them to rely on state or organisation funded interventions.

The patchwork of variable settlement vulnerability presents a key challenge for SA in light of predicted climate change in the region. Often these settlements are not only located around current or past mining activities; they are also located in low lying areas subject to flooding and on dolomitic land, which means these communities are 'doubly' or 'triply' burdened by risks and vulnerabilities.

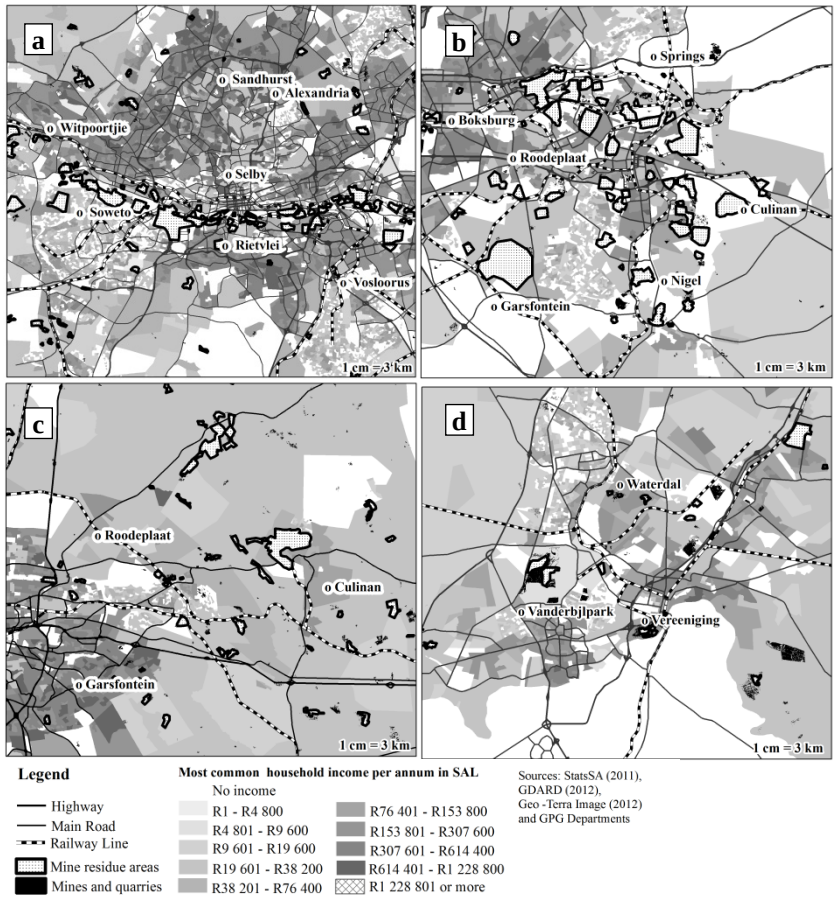

Figure 2: Mines, quarries and mining waste create obstacles for spatial redevelopment programmes and transport routes. (a) The gold reef dissects Johannesburg into north and south portions and pre-dates the development of roads. (b) Mines on the East Rand have created a fragmented settlement and road network. (c) Mines, quarries and MRAs present challenges for spatial development programmes. (d) Mines located in peripheral areas have a lower common income per household versus more urban locations.

3 Predicted changes

According to current Global Circulation Models (GCMs), it is predicted that variations in temperature and rainfall will become more extreme across the year with high intra- and inter-seasonal variability (DST [8]). Under this scenario, the existing 374 MRAs in the GCR presents a key challenge of increased risk to society and the environment. Predicted weather extremes can create heightened

risks and increased settlement vulnerability as a result of its diverse impact on MRAs. On the one hand increased rainfall can contribute to the siltation and flooding of pits and dams (Loechel [9]), creating knock-on pollution impacts for downstream water users (DEA [10]). In the context of acid mine drainage (AMD), already a pressing challenge facing the region, increased rainfall will lead to increased pumping and treatment requirements as a result of greater water ingress into the mine voids. On the other hand a decrease in rainfall and increase in temperature can lead to droughts (EWT [11]), contributing to the increased transport of air-borne pollutants especially radioactive dust, a key concern in relation to MRAs.

4 Responsibility and governance of the mines

Given this historical context, and a future likely to be shaped by climate change, the governance of mines and mine residue areas in the GCR is extremely challenging, and becoming ever more so.

At present, all spheres of government are responsible for the administration of legislation and regulations around MRAs in the GCR. This includes over 13 national and 9 provincial departments and institutions (GDARD [6]). The local sphere of government is the one that is directly impacted by MRA issues and often is not equipped with the necessary skills, capacity and knowledge to deal with them.

SA's transition to democracy in 1994 presented an opportunity to transition its historic mining philosophy into one that is more sustainable. The adoption of SA's new Constitution and Mineral and Petroleum Resources Development Act, 2002, signified the agreement of natural resources as the people's collective property with government as the central custodian (Adler *et al.* [2]). The current SA mine legislative framework, under which mine closure and MRAs are situated, is currently bounded by eight separate common laws and acts (Table 1). The current SA legislation seeks to create a balanced legislative framework that ensures that human rights are upheld in respect of development and the hazards associated with active mining, mining waste and pollution.

Core concepts of sustainability are incorporated in the framework through the inclusion of the Environmental Management Act, 1998, National Water Act, 1998 and the Mineral and Petroleum Resources Development Act, 2002, that together seek to incorporate integrated environmental management considerations and economic, social and environmental costs associated with the whole life cycle of a mine (Table 1). While this framework attempts to encourage a more sustainable approach to mining, mine closure and mine waste, these concepts do not often run full circle in regulating and managing mining practices. This is due to the fragmented governance of mines, in particular because legislation was not rigorously and consistently enforced. Enforcement tends to be sporadic and episodic, frequently driven by public outcries over the worst symptoms of regulatory failure leading to environmental damage, or by the media campaigns of non-governmental organisations.

Table 1: Summary of South African Mining Legislation Framework (Swart [3]).

	Legislation	Summary
1.	Constitution of South Africa, 1996 and common law	– Mines to conduct operations and closure in consideration of the rights of others. – A person suffering as a result of mining activity can claim damages from a mine/or directors in terms of a company law. – Common law claims based on pollution emanating from a closed mine can be issued within 3 years of the incident.
2.	Environmental management Act, 1998 (act no. 107 of 1998)	– Provides principles of sustainable development and sets norms for integrated environmental management. – Government and organs of state need to consult and support each another. – Includes a 'polluter pays' principle where any person that causes, may cause and has caused environmental damage is responsible for its remediation.
3.	Minerals Act, 1991 (Act No. 50 of 1991)	– Provides statutory requirements to enforce environmental protection, management of environmental impacts and rehabilitation of the environment. – Requires that rehabilitation of the surface land concerned in any prospecting or active mining. To be carried out by the holder of the prospecting rights or mining authorisation and to be in accordance with an Environmental Management Programme (EMP). A mine closure certificate will not be issued if these objectives are not met.
4.	Mine Health and Safety Act, 1996 (Act No. 29 of 1996)	– Employers to ensure and maintain a safe and healthy environment for the entire mining lifecycle (commissioning, operation, decommissioning and closure). This must include adequate health and safety equipment, training and medical surveillance.
5.	National Water Act, 1998 (Act No.356 of 1998)	– Maintains the integrity of water resources through pollution prevention, water re-use, reclamation, water treatment and discharge. – Both the mining sector management strategy and the policy on groundwater quality management seek to employ controls and enforce remediation.
6.	Atmospheric Pollution Prevention act, 1965	– To prevent and control dust pollution through the prohibition of the disposal of assets by mines, prompting mines to follow a proper mine closure programme
7.	Nuclear Energy Act, 1996	– As mining waste contains radio-active elements as uranium, radiological requirements need to be met before mine closure is granted.
8.	Mineral and Petroleum Resources Development Act, 2002	– Provides a 'cradle to grave' approach to prospecting and active mining considering economic, social and environmental costs to achieve the sustainable development of mineral resources. – Requires that an environmental impact assessment be undertaken together with an EMP to identify areas of focus, mitigate and manage environmental impacts associated with mines. – Makes provisions for the management of mining residue waste and to adopt principles from the Integrated Pollution and Waste Management Policy and the precautionary approach as specified by the National Water Act. – Requires a mine closure certificate to be issued and the transfer of liabilities to a competent person.

Interventions around MRAs at a provincial level have been initiated by the Gauteng Premier and implemented through the Gauteng Department of Agriculture and Rural Development (GDARD). This intervention has focused on the reclamation of mine residue areas for development purposes, as MRAs were identified as a provincial priority for the reclamation of land. While phase 1 of this project – which aimed to quantify mine residues through a technical review – was achieved, the larger five-year programme has not been followed up neither at the level of national nor provincial government. Attempts by provincial government to create an AMD/MRA action committee have also fallen flat as a result of lack of interest by national government and no budget.

5 Disjuncture between mining legislation and practice

Systemic barriers have resulted in the episodic and sporadic enforcement of SA's current mining legislative framework. Systematic barriers have manifested partly as a result of staff capacity issues and budgetary constraints, with staff vacancy rates estimated to be at 30% (GDARD [6]).

For example, Department of Environmental Affairs (DEA) is largely responsible national government departments in coordinating the responsibilities of the DMR, National Nuclear Regulator (NNR) and Department of Water Affairs (DWA) around mining oversight and legislative enforcement GDARD [6]). Capacity issues in the DEA, prevent the effective enforcement of responsibility where onus is placed on other local or provincial departments or directorates for enforcement (GDARD [6]).

Tracing these systemic barriers from national to provincial government, the weak capacity and legal standing of provincial government also limits prospects for a co-ordinated response (Taviv [12]). In terms of the Municipal Systems Act, provincial government may lead processes to introduce draft standard local by-laws for all municipalities in a province to adopt. GDARD did attempt to implement a local by-law to prevent houses being built within a 500m buffer of MRAs, but poor legal representation, and objections stifled this attempt at managing settlement vulnerabilities and spatial development.

Current mine closure certificates, issued by DMR, do not incorporate all the aspects as laid out by the mining legislative framework, complying only with minimum criteria defined by the Department of Mineral Resources (DMR) and not those of DEA and DWA. This creates problems for local government, where land has not been sufficiently reclaimed and rehabilitated for further use (Taviv [12]). The liabilities of mining are thus passed on to other spheres of government that do not have the budgets or capacity to deal with the risks associated with mining and MRAs.

Local municipalities, at the face of issues related to MRAs, deal with the immediate effects of MRAs on communities and the environment. These departments or agencies typically have further limited capacity, small budgets and divided roles between internal departments.

In the case of the City of Johannesburg municipality (CoJ), one MRA in particular has presented a key challenge to the municipality and provides a case example of the difficulties of dealing with mine waste (Lekotso [13]).

The Princess dump, located to the west of central Johannesburg, has created social and environmental issues for the surrounding community who were forced to lodge a formal complaint through a legal group to have their voices heard and to engage with the relevant departments. In 2006, a court order was lodged against CoJ, a mining company and the DMR to rehabilitate the dump, but in 2013, the dump has still not been reclaimed. This is result of a complicated web of actor interests and agendas in applying and enforcing SA's mining legislative framework. While DMR is responsible for rehabilitating the mine dump, it has issued and renewed mining prospecting rights and prevented reclamation from taking place as this waste may create revenues in the future.

One common strand that weaves through various stakeholder interviews is that the DMR sees itself as the official custodian of the country's mineral wealth. There is therefore a self-regulating aspect to the management of mineral extraction activities in South Africa as DMR controls the issuing of prospecting and mining rights and also regulates the sector as a whole. The common viewpoint is that DMR cannot both promote and regulate the mining industry in SA. The division of roles in this regard is skewed, resulting in environment and human rights likely to take second place to mineral wealth development and extraction.

As mine waste is seen as a resource by the DMR, with potential reclamation projects generating profits for an already constrained industry, this presents a divided interest from the very beginnings of mining regulation and enforcement. This management conflict provides little incentive to either rehabilitate MRAs for the benefit of the communities surrounding them or to mitigate any local or regional environmental impacts.

6 Discussion

This paper has provided an overview of SA's current mining legislative framework around MRAs and the environment. It also investigated the potential risks of exposing MRAs to changing climatic variables, informing the management of MRAs within the GCR. These findings will assist with clarifying appropriate mitigation and adaption strategies to ensure infrastructure and communities are not further affected.

The perspective of this paper is how insufficient and unsustainable mine closure strategies of the past have created the mining landscape legacy inherited by the GCR. This, together with the poor enforcement of current mining legislation, presents a series of challenges for the planning and management of many settlements in the region.

Weather extremes predicted as a result of climate change will interact with MRAs over the long term and make these challenges even more complex. In this regard, it is important for mines to follow a 'cradle to the grave' approach as

outlined by the Mineral and Petroleum Resources Development Act, 2002 (Table 1) (Swart [3]). This act aims to consider the whole life of a mine incorporating economic, social and environmental costs to achieve the sustainable development of mineral resources over time. This kind of approach is required to ensure that present mining sites do not become the derelict and waste sites of the future (Swart [3]).

While MRAs have not been included in SA's National Climate Change Green Response paper (DEA [10]), it is important to begin to consider the effects of climate change on mine waste and to acknowledge its likely effects on already vulnerable settlements. The harsh reality is that Gauteng already has faces a series of challenges and complexities associated with a legacy of mining that has not been resolved by the necessary stakeholders. The current mining legislation has been loosely applied to regulate the mining industry with mining waste still not being adequately addressed.

The actors that guide mine regulation are currently spread between the various spheres of government, non-governmental organisations, stakeholders and the public. These actors are guided by a framework of legislation in the form of acts and/or common laws that can allow for the interlacing of mining regulation with concepts of development and the rights of society and the environment. Although this framework incorporates concepts of sustainability and holistic mine management over the long term, in practice, it has allowed for the episodic and sporadic governance and regulation of the mines that is likely to remain for the foreseeable future.

Considering the transition that is required in the current mining philosophy of SA, the added pressures presented by climate change may only complicate the current disjuncture between the roles and responsibilities of government, amplifying current systemic pressures. Before climate change can begin to be addressed by SA mining legislation, the mining landscape legacy needs to be considered to create a more sustainable legacy for the future.

In order for the mining legacies and prospects of the GCR's mining landscapes to be addressed, the development of appropriate mitigation and adaption strategies around mine waste, mine closure and sustainable mining need to be levered across responsible stakeholders that have clearly defined roles, adequate budgets and trained staff. Enforcement at all levels of SA's current mining framework is necessary to create a fair and integrated regulatory system.

Advances may include alternative futures for the region that may evolve in the form of mining waste opportunities. Work on alternative mining futures is currently being executed by academics and researchers alike who have begun to showcase alternative solutions for the future through the media. While these technologies can provide the answers to reconciling past and present challenges associated with mine waste, these ideas are subject to government and stakeholder interest.

7 Conclusion

While the South African mining legislative framework incorporates concepts of sustainability, these are not necessarily put into practice by the various stakeholders and departments. The GCR has inherited a legacy of mining residues that impact communities and the environment in the present day and will continue to do so in light of predicted climate change. The GCR therefore faces a double conundrum in dealing with mine waste of the past and addressing current mining practise to create a more sustainable solution over the long term. If this double conundrum is not addressed, the legacy of mine residues will continue to influence its spatial form and will impact on the future management of its spatial redevelopment and integration programmes. In turn, the vulnerability of many low income communities will continue to deepen, with climate change risks further reducing their ability to mitigate and adapt to the many hazards associated with mine residues.

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