

# Research article

## Perceptions of external costs of dust fallout from gold mine tailings: West Wits Basin

Mbalenhle Mpanza<sup>1</sup>, Elhadi Adam<sup>2</sup> and Raeesa Moolla<sup>3</sup>

<sup>1</sup>55 Beit St, Doornfontein, Johannesburg, 2028, Gauteng, South Africa, mmpanza@uj.ac.za

<sup>1</sup>University of Johannesburg, Post Office Box 17011, Johannesburg, 2018, and School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand,

<sup>2</sup>Private Bag X3, School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Braamfontein, 2050, Elhadi.Adam@wits.ac.za

<sup>3</sup>Private Bag X3, School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Braamfontein, 2050, Raeesa.Moolla@wits.ac.za

Received: 30 October 2019 - Reviewed: 27 February 2020 - Accepted: 2 June 2020

<https://doi.org/10.17159/caj/2020/30/1.7566>

### Abstract

Mining is essential for the South African economy, just like in many developing African nations. In 2017, mining was reported to contribute 6.8 % to the South African GDP and provided more than 460 000 jobs. Though the sector adds an enormous amount of value to the country, its activities have significant impacts on the environment and the socio-economic factors of society. The environmental impact of mining operations includes air pollution from dust and the well-documented impact on water resources in the form of Acid Mine Drainage (AMD), creation of sinkholes and pollution of agricultural soils. Dust remains a persistent problem in South African urban areas due to the climatic conditions, extensive surface quarrying, unrehabilitated tailings storage facilities and mineral processing. However, very little is reported on the social and economic costs that accrue due to poor ecological management. Some scholars assert that despite the Mine Health and Safety Act, deposition monitoring guidelines and national dust regulations, South Africa still experiences persistent dust problems, especially in coal and gold mining districts. This paper investigates the perceptions of society on the effect of gold production dust pollution in and around a gold mining village (hereinafter referred to as the “gold mining village”) in South Africa. A mixed method was used, where a questionnaire and interviews were conducted to examine the gold mining village perceptions on dust pollution and their socio-economic environment. This paper further examines perceptions on how poor and premature mine closure through liquidation results in unrehabilitated mine tailings and how this has significant impacts on the quality of life of individuals and surrounding businesses. The community being investigated in this study perceives the dust fallout impact to be a threat on their living conditions. The paper finds that the community believes it incurs medical and financial expenses due to treating respiratory-related diseases triggered by dust fallout.

### Keywords

Mine liquidation, mine closure, environment, dust, socio-economic costs, perceptions

### Introduction

Recently the profitability of gold mining operations in South Africa has been reduced through increases in labour and operational costs, and stagnant productivity (Minerals Council of South Africa 2018). This has resulted in some gold mining shafts being closed or placed under care and maintenance. South Africa is known to have a significant legacy of inadequately rehabilitated and closed mine sites, attracting an estimated 70 000 illegal miners (Digby 2016).

The processes of liquidation and business rescue have allowed mining companies to evade costly closure obligations (Humby 2014). Liquidation involves an insolvent company, placed

under the custodianship of a liquidator, who manages the fair and equitable allocation of the company's assets to its various creditors while the remaining assets go to partners or shareholders. This has led to premature or sudden mine closure, and poor rehabilitation of tailings storage facilities (TSFs), which is believed to affect surrounding communities. Mines that are disused or abandoned by their owners and have not undergone appropriate decommissioning and rehabilitation have a large number of negative impacts on the surrounding community. The adverse impacts include: job losses from the mining activity, security issues relating to illegal mining activities in disused shafts, and ongoing pollution of soil, water and air (Digby 2016).

There are various drivers of premature closure which lead to a degraded environment and affected communities. These drivers include:

- liability shifting amongst companies,
- unclear regulatory leadership on care and maintenance,
- challenges with the enforcement of the integrated closure plan, and generic company regulation relating to transactions,
- poor mine planning, lack of business rescue programmes, as well as an ineffective liquidation process.

Environmental and human rights activists view care and maintenance as a 'faux legal term', referring to indefinitely warehousing mines instead of spending money on rehabilitation (FSE 2018).

Laurence (2006) notes that only a small percentage of mines are closed according to the mine closure plan, with the majority closing prematurely for various reasons. Milaras and McKay (2014) contend that numerous mines do not have contingencies or make specific plans for sudden or emergency closure. Milaras and McKay (2014) argue that there is a lack of institutional capacity in mine closure decision-making, compliance monitoring and enforcement as well as the support of long-term studies on mine closure impacts, costs and remediation.

Thus, the focus of this paper is to investigate the community perceptions on the socio-economic costs of dust fallout in a gold mining village situated in the West Witwatersrand Basin.

The perceptions of the community are assessed to articulate how sudden mine closure can be linked to dust fallout and the effects on society's well-being.

## The mining situation in South Africa

### Mine liquidation

Liquidation is regulated under many Acts in South Africa. The purpose of liquidation is to dissolve the company in an orderly manner and not to rescue it. The company's existence ceases through the formal process of dissolution (Humby 2014). Post final liquidation a brand-new company can sometimes be constructed.

An early example of a mining company that experienced liquidation, was the Aurora Empowerment System (AES) which took over Pamodzi Gold Ltd in April 2009. The process of taking over was finalised in October 2009. Since 2008, this company had been operating a mine in Orkney, one of the most productive gold mining areas in South Africa (Stuit 2009; Van der Walt, 2009). However, some issues that arose included that post-liquidation, employees did not receive their salaries.

Sudden mine closure is common in South Africa with catastrophic repercussions for the environment and surrounding communities. The gold mining company, for example, had no closure certificate and was liquidated in 2013. The liquidator

and activists failed to gain access to the gold mining company's financial provision. According to Olalde (2017), the Promotion of Access to Information Act (PAIA) documents show the fund sits at about R35 million, a level admitted by the gold mining company to be vastly inadequate to clean up the mine.

Another example of a liquidated mining company is Mintails Mining South Africa; which holds three mining rights, which cover an area of 1751 hectares near Krugersdorp. It is stated that Mintails requires approximately R259 million to complete rehabilitation on those rights, a figure that is far too low, according to the environmental management programme report (FSE 2018). The PAIA documents reveal that the company and related entities hold less than R17 million in funds for rehabilitation (FSE 2018).

During the process of liquidation of a mining company, the financial provision for rehabilitation seems not to be recognised as a special claim against the company's assets to be set aside before satisfying creditors. This forms part of the reason why some mining-affected communities like the gold mining village are faced with environmental impacts from unrehabilitated tailings storage facilities.

### Mine closure in South Africa

Mine closure planning is part of the mine life cycle, which includes exploration, pre-feasibility, development through operations to closure and rehabilitation. The closure planning is multi-dimensional and is mutually dependent on the surrounding communities (ICMM 2010). In South Africa, mine closure is regulated under the Minerals and Petroleum Resources Development Act (MPDRA) and National Environmental Management Act (NEMA) under the Department of Mineral Resources (now called the Department of Mineral Resources and Energy, DMRE) and the Department of Environment, Forestry and Fisheries, (DEFF) regulatory authorities.

The best practice of mine closure planning is to consider closure at the exploration phase, when the feasibility of the mine, design and mining permits are established (Stacey et al. 2010). Mines typically close at the end of their life cycle, when the mineral resources and reserves are depleted. However, recently a number of mines are closing prematurely for reasons including diminishing economic feasibility resulting from changes to the mineral resource, geological complexities that were not anticipated in the planning stages and a changing political, legislative and labour regulatory environment (Laurence 2006).

Fourie and Brent (2008) point out that South Africa has adequate policies and legislature on mine closure, especially when considering social and community development. The promulgation of the MPRDA aims to ensure that mining companies take responsibility for community growth and development. The MPRDA Section 43 (3) states that a holder of a mining right must apply for a closure certificate upon cessation of mining operations or relinquishment of any portion of land to which the right relates.

Until mid-2014, mine closure planning was regulated by the MPRDA. Since then, it has been regulated under the National Environmental Management Act (NEMA) as a sustainable development construct. Although mine closure is regulated under NEMA the enforcing department is not DEFF but DMRE. Some of the elements of mine closure, such as relinquishment are still regulated by the MPRDA. Section 2 of NEMA provides specific guidance on the closure of mining operations, mandating that a mining right holder must:

1. Rehabilitate the environment as far as reasonably practicable to its natural state or to a land-use which conforms with the generally accepted principle of sustainable development;
2. Set aside a financial provision, which only the state can access, to ensure such rehabilitation occurs; and
3. Retain liability for environmental damage even after closure of the operation.

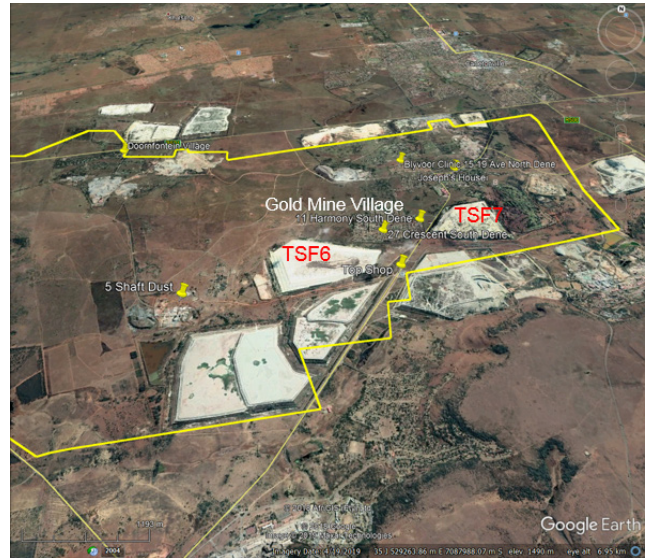
Most attention has focused on the financial provision, the duration of liability and the gaps which allow companies to contract out of their mine closure obligation (WWF 2012; Humby 2013). The issue with this provision is that it only applies if the new order mining right has been issued for a particular mining company. In the case of the gold mining company, this new order mining right had not been issued prior to the liquidation, thus neither the DMRE nor the liquidator could step in to take care of the community and avoid environmental degradation.

**Air pollution by dust challenges**

The pollution of air, soil and water caused by mining activities has detrimental impacts on the health and well-being of surrounding mining communities. The South African Human Rights Commission (2016) study on mining-affected communities in the Gauteng Province reports that most mining-affected communities complain about increased levels of dust, deteriorating health and threatened food security. Communities have drawn attention to poor environmental remediation and overall management (SAHRC 2016). Statistics show that South Africa produced an estimated 468 million tonnes of mineral waste per annum between 1997 and 2001 (DWA 2001). Of this quantity, gold mining waste accounts for 221 million tonnes – equivalent to 47% of all mineral waste in South Africa.

NEMA acknowledges that the state’s environmental obligation is linked to the responsibility to respect, protect and fulfil socio-economic rights. Environmental degradation due to a failure to rehabilitate tailings storage facilities by mining companies infringes human and socio-economic rights. Environmental rights go hand-in-hand with rights to sufficient food, water, health, land and dignity. Anglo Gold Ashanti (2004) reports that more than 270 tailings dams exist in the Witwatersrand Basin, which covers 400 km<sup>2</sup> of land.

Air pollution due to unrehabilitated tailings dumps is known to trigger respiratory diseases in surrounding communities. Nkosi, Wichmann and Voyi (2015) found that people residing near mine dumps are exposed to dust from these dumps, which pose an



**Figure 1:** Tailings storage facility number 6 in relation to the community location.

increased risk for respiratory disease. Illnesses such as asthma, chronic bronchitis, chronic cough, emphysema, pneumonia and wheeze are associated with communities residing near mine dumps at a distance of less than 5 km (Benchmarks Foundation 2017). The respiratory illness is triggered by the fact that tailings material is usually fine-grained and can be inhaled; the material also contains toxic heavy metals.

Air quality monitoring and management are regulated under the National Environmental Management: Air Quality Act, 39 of 2004 (NEMAQA). In 2013 DEFF released the National Dust Control Regulations, founded on the need to prevent pollution and ecological degradation and ensure the protection of the right to an environment that is not harmful to health and well-being. Moreover, Section 33 of NEMAQA requires mining companies to notify the minister in writing if mining operations are likely to cease within five years. Despite all these regulations and standards in place, non-compliance is still prevalent in the mining industry.

In Soweto, for example, the communities residing near tailings dumps have ongoing respiratory illnesses (BMF 2017). Harvard Law School International Human Rights Clinic (HLSIHR) points to the chemical toxicity of the Witwatersrand tailings dumps (HLSIHR 2016). These tailings dumps contain significant levels of arsenic, cadmium, cobalt, uranium, lead and zinc (Coetzee et al. 2006; Heyl 2007 in van Eeden et al. 2009). Uranium is of the most significant concern because it is radioactive. When inhaled or ingested, can cause brain damage and lung cancer in the long term (Van Eeden, Liefferink and Durand 2009). Other scientific research has shown that when water containing uranium is rubbed against animal skin, it causes skin irritation and damage.

## Study area

The gold mining village is found in the West Witwatersrand Basin, located 6 km south of Carletonville, in the Gauteng Province of South Africa (Golder Associates 2016). The gold mining village is situated within the jurisdiction of the Merafong City Local Municipality. The gold mining company first commenced in the 1930s and continued up until August 2013, when it was placed under liquidation. The mine is believed to have been liquidated 14 years ahead of schedule due to a slumping market and internal labour disputes. The mine generated about £2.5 million of gold, silver, uranium and other minerals, but it is now a volatile wasteland (DRDGOLD 2007). Before the sudden closure of the mine, there were ten tailings (slimes) dams on the mine property, of which only two were active. Of the two active slimes dams on the property the Number 6 Slimes Dam (TSF6) was the main waste disposal area while Number 1 Slimes Dam was reserved for use under emergency conditions. Figure 1 shows TSF 6 located near (60 m) from the community of the gold mine village.

## Challenges

In 2016, when the residents of the gold mine village were interviewed by Lawyers for Human Rights, they mentioned that the air was not clean (Lawyers for Human Rights 2017). Residents said that tailings caused health problems including amongst others cancer, asthma, skin rashes, eye irritation and eczema. However, a lack of local epidemiological studies has made it nearly impossible for communities near mine dumps to pursue litigation against mining companies. Residents also mentioned that there were several deaths in the area due to illnesses such as tuberculosis (TB), which they believe, are exacerbated by the dust (Lawyers for Human Rights 2017). The community complaints about the fallout dust problem were mostly during the windy season, from July to October 2014. There was non-compliance with the residential area limit in the months mentioned previously. In September and October of 2014, there was non-compliance with the non-residential area limit, which is concerning for environmental pollution. Since two consecutive months were non-compliant, there was overall non-compliance in 2014 in the area. Unfortunately, no mitigation measures were undertaken since the gold mining company was liquidated.

## Methodological approach

This research utilises a mixed method approach to investigate the socio-economic costs of dust at the gold mine village. Semi-structured questionnaires and interviews were designed and conducted with the following groups; residents of the mine village, businesses in the mine village and personnel from the Centre of Environmental Rights, Lawyers for Human Rights and various liquidators.

In order to understand the socio-economic status of the gold mining village, a household survey was conducted. This data was augmented by census data, Integrated Development

Plans, Service Delivery and Budget Implementation Plans. The Department of Mineral Resources and Energy (DMRE) could not contribute to this paper, which is unfortunate since their views and comments would have added significant value to the overall research as they are part of the key stakeholders in regulating mineral resources. It was expected that the DMRE could explain whether they have any plans in place to curb the environmental and socio-economic impacts by holding liquidated mining companies liable during the mine liquidation period.

## Sampling

The key stakeholders were identified as informants of this research regarding the socio-economic costs of dust in the gold mine village. A simple random sampling technique was used when administering the questionnaires.

A total of 300 households were visited by five enumerators. The households were first selected at Ward 5, close to the community clinic. The second set of questionnaires were conducted in New Village, located 200 m away from the small local supermarket and about 60 m away from Tailings Storage Facility 6 (TSF6).

## Data collection and instrument

The first questionnaire that was designed for surveying the residents of the gold mine village was adapted from the World Health Organisation (WHO) House Health Survey questionnaire to elicit specific, quantifiable information about household demographics, common illnesses linked to dust and health services (WHO 2002).

The second questionnaire (open-ended interview questions) was directed at the businesses of the gold mine village and other stakeholders, which included Lawyers for Human Rights, liquidators and the Centre for Environmental Rights.

## Data analysis

The responses were analysed through the Statistical Package for Social Sciences (SPSS) Descriptive statistical analysis supported in understanding the community perceptions regarding dust, socio-economic impacts and the premature mine closure.

The interview responses were interrogated through conceptual analysis, the number of concepts to code, distinguishing the concepts, coding the text and analysing the results.

## Data reliability

The questionnaire directed at residents was first administered to 20 households from Ward 5 and another 20 households in New Village. The responses were analysed, and some questions were amended, with ambiguous questions being rephrased or removed. The questionnaire was re-administered again to the same 40 individuals; the same responses were observed, thereby giving us confidence in the robustness of the questionnaires and the stability of the responses. Validity was tested by comparing the two wards, and how the households responded was found to be similar.



### Ethical considerations

The study methods and research instrument (questionnaire) was scrutinised and approved by UJ’s Faculty of Engineering and Built Environments’ ethics committee. The questions were designed such that a respondent could be objective when answering. Confidentiality of the respondents was assured through the anonymity of individuals. It was also explained that respondents have an option to withdraw from the study at any time. The respondents were told how the information would be used, and why it was collected. The respondents were also assured of their safety and security.

## Results and discussion

### The socio-economic characteristics of the households

The gold mine village is a typical mining town which consists of a mixture of individuals from different language backgrounds, including Afrikaans, Xhosa, Sotho, Tswana and Zulu speaking people. The village consists of about 6000 residents, and approximately 700 households (LHR 2017). A significant number (72 %) of the residents have lived in this town for more than 10 years and originally came to the gold mine village for work purposes. Approximately 52% of individuals in the 25-64 age group in the mining village are unemployed. The youth age 30-39 was mostly found in the village (Figure 2).

There was almost an even split in the gender of the respondents with females being slightly more prevalent at 54%. Some women explained that their husbands had returned back to their homes after the mine was liquidated, and for others, their spouses have part-time employment.

In each house, there were about 4 to 7 individuals residing. This is attributed to the fact that a household is made up of family members and tenants renting rooms inside the house as well as outside cottages. Homeowners are taking on tenants as a means of supplementing income through rentals. It is anticipated that households are larger in size in mining villages like this one due to the surrounding mining activities which promise employment and thus increase migration.

Figure 3 indicates that since the liquidation of the gold mining company in 2013, most residents are unemployed (51 %). This number is higher than the national unemployment rate of 26.7% in 2017 (StatsSA 2018). The residents of the gold mine village explained that they struggled to find employment anywhere around the Carletonville area. Most respondents indicated that the only skills and work experience they had been in gold mining. In a study conducted by the Lawyers for Human Rights in this same mine village, 62% of the people employed by the mine had worked in the gold mine for 10 years and 38% worked for 20 years (Lawyers for Human Rights 2017). When this study was undertaken, the individuals who had some form of employment were involved in economic activities such as mining, agriculture, livestock farming, piece jobs and subsistence business activities.

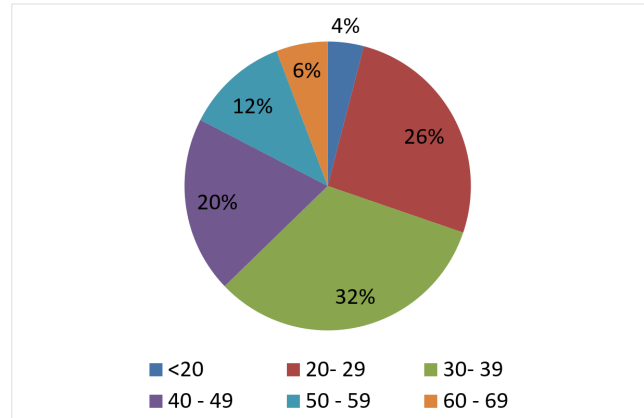


Figure 2: Age distribution of the respondents

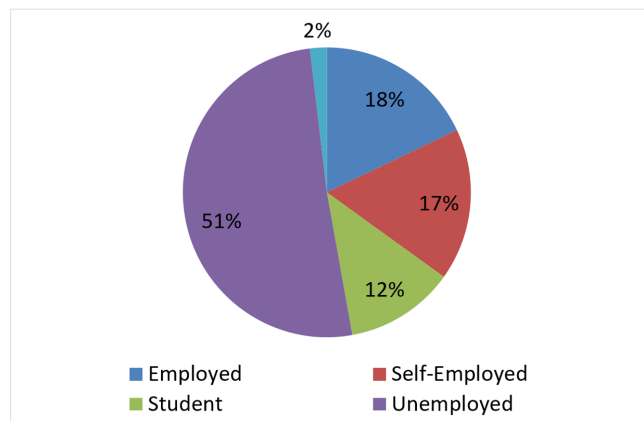


Figure 3: Employment status of the respondents

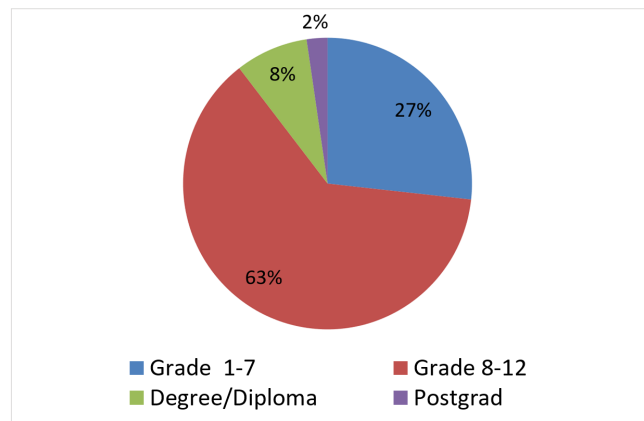


Figure 4: Level of education of the respondents

63 % of the residents had completed matric, whereas 27% had not completed their schooling (Figure 4). The national South African household survey reported higher education level as a protective factor for respiratory diseases (Ehrlich White, Norman, Laubscher, Steyn and Lombard, 2004). According to the Census (2011), only 28.4% of South Africans over the age of 20 had completed the twelfth grade, 33.8% had reached high school, and 12.1% had a tertiary qualification, which is reflected in this community.

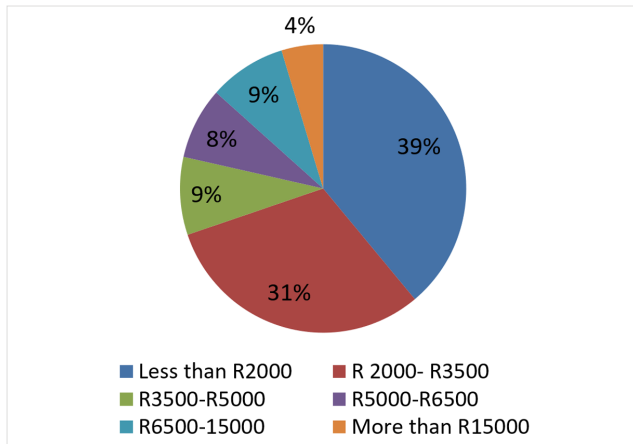


Figure 5: Monthly income of the respondents

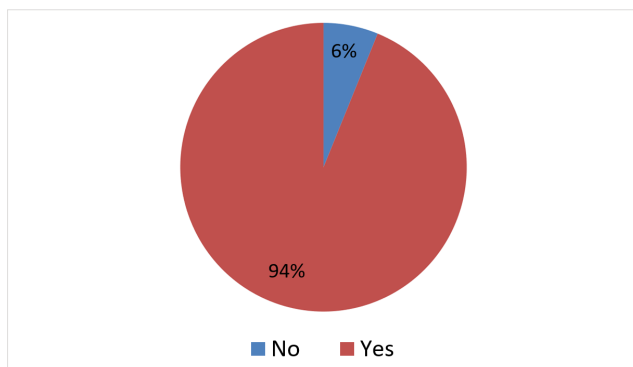


Figure 6: Fallout dust a problem

The average monthly income for residents ranged from less than R2 000 (39%) to R3 000 (31%) (Figure 5). This amount is below the minimum wage of South Africa (National Minimum Wage Act 2019). In Gauteng the monthly average income is reported as approximately R13 000 (Census 2011).

Significant factors for chronic respiratory symptoms and diseases are due to residing close to mine dumps, smoking habits, and the use of paraffin for cooking and heating as well as low levels of education (Nkosi et al. 2015). Furthermore, low levels of literacy are associated with low socio-economic status and have been identified as a risk factor for respiratory illnesses and symptoms (Karnevisto et al. 2011). What is observed in the present study accords with the findings of Karnevisto et al. (2011) as the community complained of respiratory illnesses and seemed not to have reached a higher education level.

Only 4% of the respondents indicated that they earned more than R15 000 per month. These individuals are possibly the residents who indicated they have permanent employment. Before the sudden mine closure, 70% of the respondents in this Gold Mining Village reported earning over R4 000 per month. This is of great concern, as some respondents stated that they rely on government social grants for income. Furthermore, some of the respondents mentioned not being able to pay school fees for their children due to a lack of income and unemployment. Table 1 summarises the socio-economic characteristics of the Gold Mine Village community.

Table 1: Characteristics of the Gold Mining Village households

Variable	Descriptive Statistics
Age	12% is below 20, 26% is between 20-29, 32% 30-39, 20%: 40-49 4% 50-59, 6% 60-69
Gender	Female 54%, Males 46%
Employment	Unemployment 51%, Contract work 18%, Self-employed 17%, Formally employed 2%, Students 12%
Education	Below matric 27%, Matric 63%, Degrees 10%
Income	70% earns between R2000-R3000, 4% earns >R15 000
Smoking	78% non-smokers, 14% smokers, 8% ex-smokers
Years lived in the Gold Mining Village	20% (< five years) 41% (5-9 years), 31% (10-20 years) and 8% lifelong resident

The occurrence of smoking in the community was also assessed. Of the respondents, 78% said that they did not smoke, 14% responded in the affirmative while 8% said they were ex-smokers see Table 1. This question was investigated to show that the respiratory illnesses that occurred in this mining village were not necessarily as a result of smoking but could be related to dust fallout. The ex-smokers mentioned that doctors advised them to stop as they had been diagnosed with chronic respiratory symptoms.

### Dust challenges in the gold mine village

The residents of the gold mine village were asked whether they considered that dust is a problem to the community. The majority (94%) of the residents responded in the affirmative.

The overwhelming majority of respondents consider dust to be a significant problem. 27% of the respondents stated that dust pollution was a critical problem. 32% stated that they considered pollution by dust to be a very serious problem and 36% stated that it was a serious problem. Only 5% believed that dust was not an important problem, with 4% saying it was less serious and 1% saying it was not a problem at all (Figure 7).

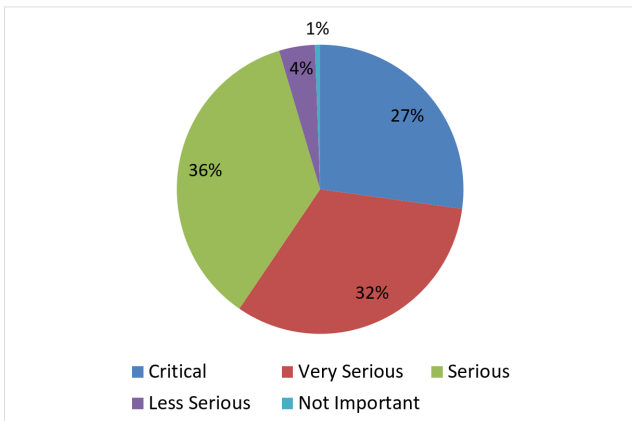


Figure 7: Level of importance placed on air pollution by dust

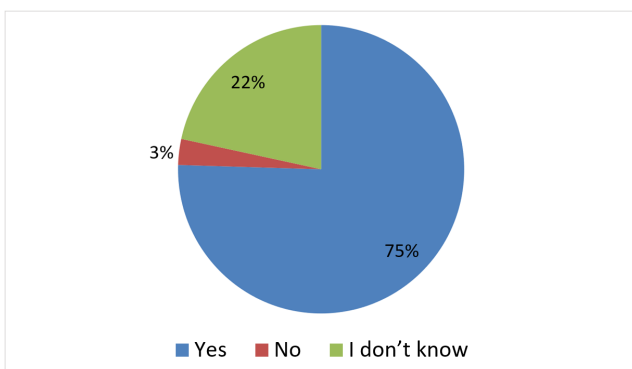


Figure 8: Dust effects on economic status

It is evident that the residents of this mine village consider fallout dust to be a significant problem such that they obtained legal assistance from the Lawyers for Human Rights to hold the gold mining company directors accountable for the pollution.

The majority of respondents (63%) answered that they were interested in environmental well-being. Most of the residents (94%) admitted that there is a problem of dust pollution, and specifically emanating from TSF6. The Sotho and Tswana speaking respondents euphemistically called TSF6 ‘motoro’ which means mud. The Xhosa and Zulu speaking people called it ‘iindunduma’ which means hills. All respondents (100%) agreed that TSF6 was the source of dust causing air pollution.

This poses health threats to the surrounding community, which believes it inhales the toxic dust from the tailings. A similar observation was made by Kitula (2006) in Tanzania’s Geita District. There, the Geita Gold Mine Company (GGMC) was closed and the community suffered respiratory illnesses due to dust from poorly rehabilitated tailings dumps. Nkosi et al. (2015) suggest that there is a link between the respiratory problems among the elderly living in or near mining communities in Gauteng and mine waste facilities. They note that exposed communities have a higher prevalence of chronic respiratory symptoms and diseases such as asthma, chronic bronchitis, chronic cough, emphysema, pneumonia and wheeze, compared to unexposed communities.

Similarly, to other residents in mining communities of the West Rand, the gold mine village residents are not amiss in associating their respiratory problems with dust from the surrounding mine dumps and mining operations (Wright et al. 2014). From the responses, 97% of the residents answered in the affirmative when asked whether they think dust fallout triggers any respiratory-related diseases. When the respondents were asked which respiratory diseases do, they suffer from during the windy season, 83% of the respondents stated severe cough, 9% of the respondents said sinusitis, 6% of the respondents said TB and 2% of the respondents mentioned asthma. This affirms findings by the Benchmarks Foundation (2017) in their Soweto household survey, that residents near tailings storage facilities suffered respiratory-related illnesses such as cough, asthma, sinus and TB. This study could not validate the above as a toxicological and epidemiological study would need to be undertaken to prove such claims.

It was also asked whether there were any indoor sources of air pollution (i.e. heating and cooking methods). This was investigated due to the knowledge that people spend more time indoors than outdoors, and indoor pollutant levels are worse than outdoor pollutant levels (Ao et al. 2003). Furthermore, according to a comparative risk study of WHO, 28% of all deaths are caused by indoor air pollution in developing countries (Massey et al. 2009). It was noted that electrical heaters and stoves were used for indoor power generation; as electricity is subsidised by the Merafong Municipality, during the period of mine liquidation. This, therefore, reduced the potential of indoor pollution being a significant threat to the households.

The respondents mentioned that dust was most prevalent in winter (51 %) and early spring (31 %). This concurs with the study by Sithole et al. (2000) which found that nuisance dust fallout is most evident during the windy, dry early spring season, which is late July to early November. The respondents were asked whether they were aware of national dust standards. 90% of the respondents answered in the negative, indicating they were not aware. A follow-up question was posed to find out what individuals wanted to be improved in the standards. The respondents explained that there was nothing wrong with the standards themselves; they did mention, however, that the enforcement of compliance was a problem. The respondents also expressed the hope that the government would strengthen the enforcement, management, monitoring and compliance with standards.

### The perceived socio-economic costs of dust

The respondents were asked whether dust affected their economic status in any way (Figure 8); 75% responded in the affirmative.

Other respondents went on to explain that this was something they had never actually thought about, therefore they did not know (22%). According to Article 12 of the International Covenant on Civil and Political Rights (1998), there is a direct

link between a healthy environment and quality of life, including the fulfilment of human rights. Similarly, the Committee on Economic Social and Cultural Rights (2002) recognises that the enjoyment of economic, social and cultural rights depends on a healthy environment. From the responses gathered, the community feels that these rights are infringed upon due to the poor air quality.

When asked if dust affect their socio-economic status, the respondents who answered in the affirmative, mentioned medical (97%) and cleaning costs (3%) as the significant external costs of dust. The respondents mentioned that they purchase cleaning detergents and they clean the house more than once. This affirms findings by the Benchmarks Foundation, where the residents of Riverlea found it necessary to clean their homes two to three times per day during the high dust periods (Benchmarks Foundation 2017).

The residents maintained that they perceive the dust to have brought about respiratory illnesses. During the high dust periods, the community mentions that they spend copious money on medicine for coughing, nasal sprays or go to the clinic (R25, four times per month) or doctors (R350-R500, three to four times per month). This confirms work in other areas, that estimate health costs to contribute 75% of the total externalities associated with air pollution (Cropper and Oates 2002; Matus et al. 2011).

The loss of human health creates external costs which invariably lead to overall loss to social welfare. The health effects from air pollution incurs direct and indirect costs to society. Freeman (2003) divides the health effects associated cost into four categories: medical cost, labour cost, averting cost and welfare loss (discomfort, suffering). This study clearly reveals that the community perceives dust impacts to be medical and welfare costs.

Approximately 96% of the respondents perceive dust management to have not improved in the area due to the lack of rehabilitation on TSF6.

The respondents (92%) also mentioned that they get discouraged from going to the shops during windy days because of impaired visibility on the road. This corresponds with what business owners are saying that during windy days when there is dust, there are fewer customers than when there is no dust. Other respondents (8%) mentioned that they go to the shops regardless of the dust. 100% of the respondents go inside the house, close all doors, and windows, and this costs them nothing to prevent nuisance dust from entering the house. However, dust still enters the houses through the ambient air, thereby remaining a case for concern. Other members of the households mentioned that they put wet towels around the windows and they try to sweep the dust out.

The respondents do not realise the indirect cost associated with dusty days. For example, when people go inside the house, close

doors, and windows, start opening the heater or utilising water that they would have otherwise not used if there was no dust. Kyung-Min Nam et al. (2010) and Mayeres and Van Regemorter (2008) reveal in their studies that labour and leisure loss are significant economic impacts of air pollution and can affect market equilibrium.

About 71% of the respondents mentioned that they had vegetable gardens. Only 30% of the respondents with gardens said they did not eat the produce from their gardens due dust and bought vegetables from shops. About 88% of the respondents explained that they produced fewer vegetables during the windy season and more during the non-windy season. The concern is that plants absorb radioactive substances from the soil, deposited by dust and are then consumed as food. The continuous consumption of vegetables that are exposed to dust on a daily basis means that there is constant accumulation of radioactive substances in the bodies of the consumers. This becomes a threat to their health in the long run. Therefore, the 70% respondents that agreed to eating vegetables from their gardens are at risk of ingesting toxic vegetables.

Businesses in the small shopping centre located approximately 60m opposite TSF6 listed the following as costs due to dust from the tailings dump:

- Damage to electronic equipment (printer, photocopier and scanner);
- Purchasing dust masks for employees (petrol attendants);
- Absenteeism of employees due to illness; and
- Cooked food products accumulating dust from the tailings dump having to be thrown away.

The economic valuation of health effects can be evaluated based on two approaches: willingness to pay (WTP) or willingness to accept (WTA) and the cost of illness approach (COI). COI is the sum of lost productivity and medical expenses (Quah and Boon 2003). The WTP method measures what individuals would be willing to pay in exchange for improved health. This method was considered in this study.

The community of the gold mine village was asked whether they would be willing to pay to offset the dust fallout impact. Some residents (55%) of mine village indicated that they were not willing to pay to rehabilitate TSF6. However, the remainder mentioned that they were willing to pay, but had no employment and would therefore not be able to contribute to a rehabilitation fund see Figure 9. Income is observed to be a significant factor which influences WTP and education, on the other hand, is known to have a negative influence on WTP.

As can be seen in Figure 10, the bulk of the respondents (56 %) were not willing to pay any money for something that they believed was not their fault. Other respondents expressed willingness to pay a sum of R150 (38%) and others a sum of R200 (6%).



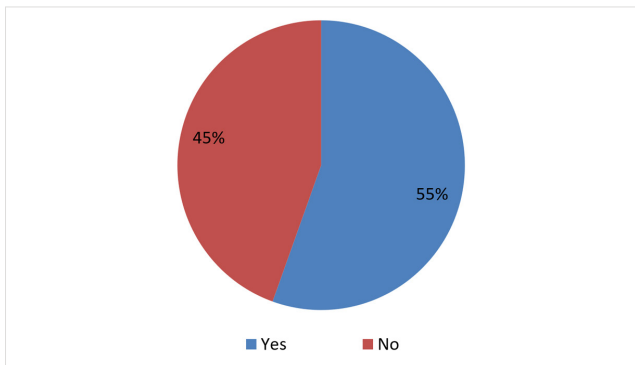


Figure 9: Households' willingness to pay for rehabilitation of the tailings facility

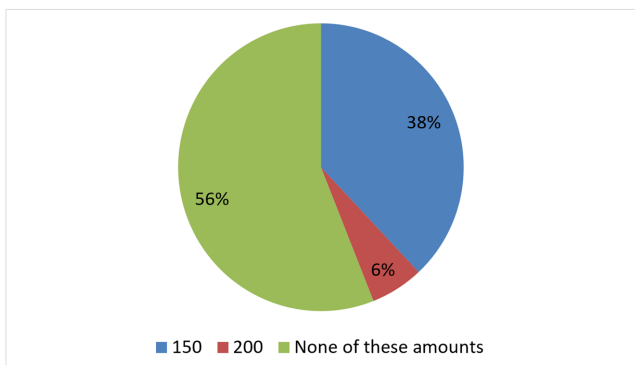


Figure 10: Households' amounts they are willing to contribute for rehabilitation of the tailings facility

The challenge is exacerbated when a mine closes unexpectedly, and diminished growth and development are experienced. Numerous scholars have raised concerns about local communities, with regards to mine closure. The concerns focus on adverse environmental effects such as disintegrated infrastructure, river contamination, and dust generation (Andrews-Speed et al. 2005; Murray et al. 2005). Other scholars focused on social impacts such as crime increase, drop in the quality of life, people exiting mining towns and food insecurity (Botha et al. 2014; Marais 2013; McDonald et al. 2012; Rawashdeh et al. 2016; Rixen and Blangy 2016; Block and Owusu 2012; Ennis et al. 2014; Mengwe 2010; Ntema et al. 2017). It is evident that communities become vulnerable after sudden mine closure.

## Summary

Despite the size of the mining industry, the direct and indirect environmental and socio-economic impacts are not clearly understood. Most research has focused on environmental impacts with a limited focus on the quality of life. Golder Associates (2003) note that possibly, the only accurate measure of sustainable development is quality of life, which is affected by many factors derived from Maslow's Hierarchy of Needs (Maslow 1954).

The hierarchy of needs of the gold mine village community appears to have been severely impacted by the liquidation of the gold mine. The results of the study indicate that the community

feels that the biophysical environment is degraded through air pollution by dust and this poses health threats. The community perceives that environmental degradation occurs as a result of unrehabilitated TSF 6. The community also perceives the dispersed dust as a threat to their health and economic status. Furthermore, the community feels that their economic status is affected by medical expenditure to treat respiratory illnesses.

It is estimated that R890 million is the rehabilitation liability for the Gold Mining Company. Instead, only R34 million is available to address this problem (Golder Associates 2003). The community of the Gold Mine Village is not willing to pay for the rehabilitation of TSF6 and income is mentioned as their major barrier. Though the community in the mining village complains about the dust from TSF 6, it is likely that they will stay with the problem for some time is the mining company does not commit itself to solving the problem. This is because they are unable to pay for a rehabilitation fund for the tailings dump.

Anger, depression and anxiety were observed amongst the gold mine village community because of TSF6, and the sudden mine closure. TSF No.6 has been a major environmental problem for the Gold Mine Village ever since the mine liquidation occurred. People in communities such as this are exposed to nuisance dust as well as airborne dust through inhalation as well as ingestion. Particulate Matter has two inhalable fractions called PM<sub>10</sub> and PM<sub>2.5</sub>. These dust fractions are of interest since it can enter the lungs by way of inhalation, with the finer dust fraction (PM<sub>2.5</sub>) able to penetrate deeper into the lungs. The biggest threat with the dust from TSF6 is that it is a receptor for toxic heavy metals which are part of the mining waste and is a nuisance for the community

## Conclusion

The community perceives that conditions resulting from the unrehabilitated tailing dumps do affect their health, well-being and economic status. The gold mine village community has been unable, since 2013, to avoid breathing and ingesting the pervasive dust from TSF6. Although the South African mining regulatory frameworks and dust standards seem robust, compliance, management and mitigation strategies seem to be offset by conflicting regulations such as the NEMA, MPRDA with the Companies Act, 1973 and the Companies Act, 2008. The effects of these conflicts result in uncontrolled dust pollution from unrehabilitated tailings storage facilities, which poses threats to communities' health, well-being and economic status. In policymaking and development, all stakeholders need to meaningfully contribute, including governments, citizens, civil society and companies. This paper shows that socio-economic impacts will be different for each stage of a mining project, and not all impacts will occur at each stage. For example, in the case of the gold mine village community, the perception is that major environmental impact continues to affect the socio-economic status of the community, which is dust post sudden mine closure.

## Acknowledgements

Mr C Molebasti and all the enumerators are acknowledged for their assistance during the data collection at the gold mine village.

## Author contributions

The contribution of Dr R Moolla is acknowledged and appreciated for the conceptualisation and supervision of the entire research. Dr E Adam is thanked for his technical contribution, final production of this research article and project management

## References

- AngloGold Ashanti 2004, 'AngloGold Ashanti Environmental Report, Woodlands Project Good Progress being made with Phytoremediation Project'. [https://www.academia.edu/5257660/The\\_Mine\\_Woodlands\\_Project\\_in\\_the\\_Witwatersrand\\_Basin\\_gold\\_fields\\_of\\_South\\_Africa\\_strategy\\_and\\_progress](https://www.academia.edu/5257660/The_Mine_Woodlands_Project_in_the_Witwatersrand_Basin_gold_fields_of_South_Africa_strategy_and_progress) [accessed 2 February 2020]
- Ao, C.H., Lee, S.C., & Yu, J.C. 2003, 'Photo catalyst TiO<sub>2</sub> supported on glass fibre for indoor air purification: Effect of NO on the photo degradation of CO and NO<sub>2</sub>' [J]. *Journal of Photochemistry and Photobiology A: Chemistry*, 156(1-3): 171-177
- Benchmarks Foundation 2017, 'Soweto Report: Waiting to inhale: A survey of household health in four mines Soweto Report: Waiting to inhale: A survey of household health in four mine-affected communities'. Policy Gap 12.-affected communities. Policy Gap 12, Benchmarks Foundation website, <http://www.benchmarks.org.za/> [accessed 3 September 2018]
- Census 2011, 'Census 2011 Statistical release – P0301.4' / Statistics South Africa. <https://www.statssa.gov.za/publications/P03014/P030142011.pdf>. [Accessed 16 February 2018]
- Coetzee H., Winde F. & Wade P.W. 2006, 'An assessment of sources, pathways, mechanisms and risks of current and potential future pollution of water and sediments in gold-mining areas of the Wonderfontein spruit catchment'. *Water Research Commission*, Report No. 1214/06.
- South Africa 2008, Companies Act 71 of 2008. [http://www.cipc.co.za/files/2413/9452/7679/CompaniesAct71\\_2008.pdf](http://www.cipc.co.za/files/2413/9452/7679/CompaniesAct71_2008.pdf) [Accessed on: 3 February 2020].
- South Africa 1973, Companies Act 61 of 1973. <<https://www.wylie.co.za/wp-content/uploads/COMPANIES-ACT-NO.-61-OF-1973.pdf>> [Accessed on: 3 February 2020]. Companies Act No. 61 of 1973 - see South Africa.
- Cowherd C., Muleski, G. E. & Kinsey, J. S. 1988, 'Control of Open Fugitive Dust Sources', *United States Environmental Protection Agency. Office of Air Quality Planning and Standards Research Triangle Park NC 27711*. EPA450/3-88-008.
- Cropper M.L. & Oates L. 2002, 'Measuring the benefits from reduced morbidity.' *The American Economic reviews* 71:(2), Environmental Economics: A survey resources for the future, Washington D.C.
- Digby C. 2016, 'Mine Closure & Rehabilitation: From Dereliction to Accountability?' Presentation; *Centre for Sustainability in Mining and Industry*, University of the Witwatersrand.
- DWAF. 2001, Department of Water Affairs and Forestry- see South Africa.
- Department of Environmental Affairs (DEA), National Environmental Management Act (NEMA), No.107 of 1998. Pretoria: Government Printer.
- Department of Mineral Resources (DMR) 2009, The Mineral and Petroleum Resources Development Act, No, 28 of 2002. Pretoria Government Printer.
- DRDGOLD 2007, Annual Report 2007. Available at: [https://www.drdgold.com/assets/files/annual/ar\\_2007/files/DRDGOLD\\_AR2007.pdf](https://www.drdgold.com/assets/files/annual/ar_2007/files/DRDGOLD_AR2007.pdf). [accessed: 31 January 2020].
- Ehrlich R. I., White N., Norman R., Laubscher, R., Steyn, K. & Lombard C. 2004, 'Predictors of chronic bronchitis in South African Adults', *International Journal of Tuberculosis and Lung Disease*, 8:369-376.
- Fourie A. & Brent A.C. 2008, 'Project-based Mine Closure Model for Sustainable Asset Life Cycle Management', *Journal of Cleaner Production*, 16:2-13.
- Freeman A.M. 2003, 'The measurement of environmental and resource values: theory and methods'. 2nd ed. Washington, D.C. Resources for the future'. [https://www.researchgate.net/publication/258261294\\_The\\_Measurement\\_of\\_Environmental\\_and\\_Resource\\_Values\\_Theory\\_and\\_Methods\\_related](https://www.researchgate.net/publication/258261294_The_Measurement_of_Environmental_and_Resource_Values_Theory_and_Methods_related): [accessed 3 February 2020].
- FSE 2018, Federation for a Sustainable Development presentation on 'The Efficacy of South Africa's Environmental Impact Assessment (EIA) Regime: A call for Responses to Government's Legislative and Policy Framework to Strengthen Environmental Governance and the Sustainability of our Developmental Growth Path'. <https://www.fse.org.za/>: [accessed 3 February 2020].
- Golder Associates 2003, 'Environmental Impact Assessment (EIA) for the Blyvooruitzicht Gold Mine'.
- Golder Associates 2016, 'Environmental Impact Assessment and Environmental Management Programme', *Submitted in Support Mining Right Conversion Application (2012)* 94, 104, 109, 131.
- Golder Associates 2016, 'Update for Tailings Reclamation & Underground Mining at Blyvooruitzicht Gold Mine', available at

- [http://www.golder.com/af/en/modules.php?name=Pages&sp\\_id=1850](http://www.golder.com/af/en/modules.php?name=Pages&sp_id=1850) [accessed on 1 December 2016].
- Harvard Law School International Human Rights Clinic HLSIHR 2016, 'The Cost of Gold. Environmental, Health and Human Rights Consequences of Gold Mining in South Africa's West and Central Rand'. Available at: <https://hrp.law.harvard.edu/wp-content/uploads/2016/11/The-Cost-of-Gold-Full-Report-Final.pdf>. [Accessed on: 3 February 2020].
- Heyl A.J. 2007, 'Effect of mining effluent on the distribution of freshwater invertebrates in the Tweelopiespruit, Gauteng'. Unpublished BSc Honours research report, Department of Zoology, University of Johannesburg, 24.
- Humby T.L. 2013, 'The spectre of perpetuity liability for treating acid water on South Africa's Goldfields', *Decision in Harmony II. Journal of energy and natural resources law* 453.
- Humby T.L. 2014, 'Facilitating dereliction? How South African legal regulatory framework enables mining companies to circumvent closure duties'. [https://www.academia.edu/8621292/Facilitating\\_dereliction\\_How\\_the\\_South\\_African\\_regulatory\\_framework\\_enables\\_mining\\_companies\\_to\\_circumvent\\_closure\\_duties](https://www.academia.edu/8621292/Facilitating_dereliction_How_the_South_African_regulatory_framework_enables_mining_companies_to_circumvent_closure_duties). [accessed 3 February 2020]
- ICMM (International Council on Mining and Metals) 2010. Projects. [http://www.icmm.org/ourwork/projects/mine\\_closure](http://www.icmm.org/ourwork/projects/mine_closure). [accessed 22 August 2018].
- Karnervisto M., Vasankari, T., Laitinen, T., Helivaara, M., Jousilahti, P. & Saarelainen, S. 2011, 'Low socioeconomic status is associated with chronic obstructive airway diseases', *Respir Med.* 105 (8) 1140-6
- Kitula A. G. N. 2006, 'The environmental and socio-economic impacts of mining on local livelihoods in Tanzania: A case study of Geita District', *Journal of Cleaner Production*, 14, 405-414.
- Kyung-Min N., Noelle E. Selin J. M. Reilly M. & Sergey P. 2010, 'Measuring welfare loss caused by air pollution in Europe': A CGE analysis. *Energy policy*, 38:5059-5071.
- Laurence D. 2006, 'Optimisation of the mine closure process', *Journal of Cleaner Production* 14 (3-4) 285-298 [http://www.sciencedirect.com/science?\\_ob=MiImageURL&\\_cid=271750&\\_user=745831&\\_pii=S0959652605000399&\\_check=y&\\_origin=article&\\_zone=toolbar&\\_coverDate=31Dec2006&view=c&originContentFamily=serial&wchp=dGLzVltzSkzk&md5=ee5f2c2c1f8a5a32214b95eedee018af/1-s2.0-S0959652605000399-main.pdf](http://www.sciencedirect.com/science?_ob=MiImageURL&_cid=271750&_user=745831&_pii=S0959652605000399&_check=y&_origin=article&_zone=toolbar&_coverDate=31Dec2006&view=c&originContentFamily=serial&wchp=dGLzVltzSkzk&md5=ee5f2c2c1f8a5a32214b95eedee018af/1-s2.0-S0959652605000399-main.pdf) :[accessed: 10 February 2019].
- Lawyers for Human Rights 2017, 'Blyvooruitzicht Mine Village: The human toll of state and corporate abdication of responsibility in South Africa'. <https://www.lhr.org.za/publications/blyvooruitzicht-mine-village-human-toll-state-and-corporate-abdication-responsibility-s>: [accessed 3 February 2020].
- Limpitlaw D. 2004, Mine closure as a framework for sustainable development, paper presented at a Sustainable Development Practices on Mine Sites Conference, *University of the Witwatersrand, Johannesburg 8-10 March*.
- Massey D., Masih, J. & Kulshrestha A. 2009, 'Indoor and the outdoor relationship of fine particles less than 2.5µm (PM<sub>2.5</sub>) in residential homes locations in the central Indian region'. [J]. *Building and Environment*, 44:2037-2045.
- Mayeres I. & Van Regemorter, D. 2008, 'Modelling the health benefits of environmental policies and their feedback effects': a CGE analysis for the EU countries with GEM-E3. *Energy J*, 29:135-50
- Mine Health and Safety Act 1996. <https://www.mhsc.org.za/sites/default/files/public/publications/Mine%20Health%20and%20Safety%20Act%2029%20of%201996%20and%20Regulations%20Final%20Booklet.pdf>. [accessed 3 February 2020]
- Michael Bauer Research 2018, 'South African household characteristics', *MB Research* <http://www.english.mb-research.de/>[accessed 18 November 2018]
- Milaras M. & McKay J.M. 2017, 'Public lies, private looting and the forced closure of Grootvlei Gold Mine', *South Africa Journal for Transdisciplinary Research in Southern Africa*, 13: 1-12.
- Minerals Council of South Africa 2018, 'Facts and Figures. Overview of the South African mining industry', *Minerals Council of South Africa*. <https://www.mineralscouncil.org.za/>[accessed 02 February 2020].
- National Minimum Wage Act, 2019 – see South Africa
- Nkosi V., Wichmann J. & Voyi K. 2015, 'Chronic respiratory disease among the elderly in South Africa: Any association with mine dumps', *Environmental Health* 14:33
- Oelofse S.H.H., Hobbs P., Rascher J. & Cobbing J. 2010, 'The pollution reality of Gold Mining Waste on the Witwatersrand', *ReSources*, 12:51-55.
- Olalde 2016, 'SA's failed system of mine closure' <https://www.iol.co.za/news/opinion/sas-failed-system-of-mine-closure-7117963> [accessed 05 February 2018].
- South African National Standards (SANS) 2005, 'Ambient air quality: Limits for common pollutants', *SANS 1929:2004. Standards South Africa*.
- One Environmental System 2017, 'Environmental Assurance' (Pty) Ltd ([www.envass.co.za](http://www.envass.co.za)). Corrie Retief ([corrie@envass.co.za](mailto:corrie@envass.co.za)). [Accessed: 16 September 2017].
- South African Human Rights Commission 2017, 'National Hearing on the Underlying Socio-economic Challenges of Mining-

affected Communities in South Africa', South African Human Rights Commission. <https://www.sahrc.org.za/home/21/files/SAHRC%20Mining%20communities%20report%20FINAL.pdf> [accessed 04 July 2018].

Siyongwana P.Q & Shabalala A. 2019, 'The socio-economic impacts of mine closure on local communities: evidence from Mpumalanga Province in South Africa', *GeoJournal*, 84:367-380

Stacey J., Naude A., Hermanus M. & Frankel P. 2010, 'The socio economic aspects of mine closure and sustainable development. Literature overview of lessons for the socio-economic aspects of closure', *Project 73835 of the Coaltech Research Association, Report 1 of 2 (2). CSMI: WITS. p. 1-32*. <http://www.wrc.org.za/wp-content/uploads/mdocs/SP%2071%20The%20Socio%20Economic%20Aspects%20of%20Mine%20Closure%20and%20Sustainable%20Development%20Vol%201%20-%202010.pdf>. [accessed 04 February 2020]

StatsSA 2018, 'Annual Report'. *Statistics South Africa*. [http://www.statssa.gov.za/publications/AnnualReport/AR201819\\_Book\\_1.pdf](http://www.statssa.gov.za/publications/AnnualReport/AR201819_Book_1.pdf) [accessed 02 February 2020]

Stuit A. 2009, '400 000 South Africans face famine by black gold mine closure', *Digital journal*. <http://www.digitaljournal.com/article/270798> [accessed: 1 December 2018].

Van der Walt N. 2009, 'Myners huis toe, geen geld. Planne vir noodfondse, skoolhulp aan die gang'. *Noordwes Beeld*, 1.

Van Eeden E.S., Liefferink M., & Durand J.F 2009, 'Legal Issues concerning mine closure and Social responsibility on the West Rand', *The Journal for Transdisciplinary Research in Southern Africa*, 9: 51-71.

World Bank and International Finance Corporation 2002, 'Mining and Development', *Global Mining*.

World Gold Council 2015, 'The social and economic impacts of gold mining', *Maxwell Stamp PLC*.

World Health Organisation (WHO) 2002, 'World Health Survey: Guide to Administration and Question by Specifications'. *WHO, Geneva, Switzerland*.

World Health Organisation 2013, 'Mental health'. [http://www.who.int/topics/mental\\_health/en/](http://www.who.int/topics/mental_health/en/) [accessed: 16 Jul. 2018]

Wright C. Y., Matoane, M., Oosthuizen M. A. & Phala N. 2014, 'Risk perceptions of dust and its impacts among communities living in a mining area of the Witwatersrand, South Africa', *Clean Air Journal*. Available from: <https://www.arcgis.com/home/item.html?id=582208eeca2424ab6e387d9cdcf01e3>. [Accessed: 18 October 2018].

World Wide Fund- South Africa WWFSA 2011, 'Coal and Water Futures: a case study of the Enkangala grasslands', *World Wide Fund- South Africa*.