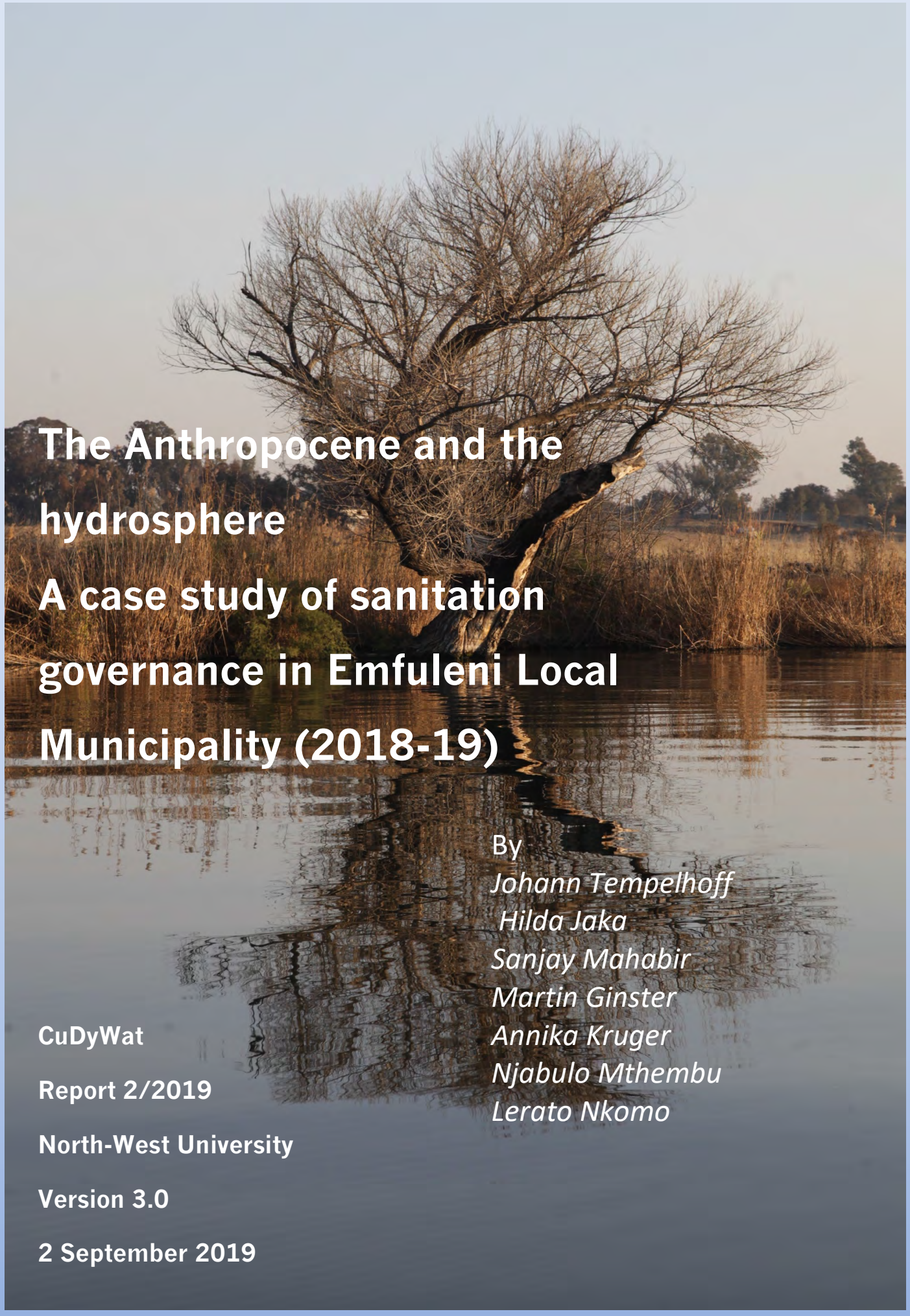

The Anthropocene and the hydrosphere
A case study of sanitation governance in Emfuleni Local Municipality (2018-19)

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Summary

In June 2018, at the end of a countrywide drought (2014-18) Emfuleni Local Municipality in South Africa's Gauteng Province came in for considerable public criticism. The municipal wastewater treatment system collapsed and raw sewage flowed into the Vaal River on the municipality's southern border. Thousands of fish were killed in a rapid onset pollution disaster event that affected riverfront urban communities, farming operations and tourist resorts over a distance of almost 200 km downstream of the Vaal River Barrage.

The event had a marked impact on the national Department of Water and Sanitation's management of the Integrated Vaal River system (IVRS). The Vaal River is one of the hardest working rivers in the country and it is key to providing water to consumers in the most populous parts of South Africa. The deteriorating health of the Vaal River system had a highly negative impact on strategic industrial sectors as well as downstream tourism and farming operations that rely on the river system for consistent quality supplies of water.

In this study it is argued that climate change (the Anthropocene) has a marked effect on the regional hydrosphere of the Vaal River. The Anthropocene is a strategy for understanding climate change from the perspective of the role humans play in changing the environment. That role, in itself, is subject to human-induced climate conditions. By what appears to have been the end of the drought, the wastewater spillage event literally sparked off contingent processes of collapse with disastrous consequences for the strategic management of the Integrated Vaal River System.

To make matters worse, the underperforming and increasingly cash-strapped Emfuleni Local Municipality, was unable to prevent events of sewage spills into the Vaal River. By 2018, the situation peaked with Emfuleni being placed under financial administration by the Gauteng Provincial Government. Things went from bad to worse. The necessary funds were not available to deliver proper services. This created a governance crisis.

A number of innovative, but futile attempts followed in an effort to address the mounting problems experienced in restoring dysfunctional wastewater infrastructure and the operational status of Emfuleni's wastewater treatment plants.

Politically, the South African government was in a transitional phase. The national political climate was toxic. A new president, Cyril Ramaphosa, started a campaign to halt rampant corruption and blatant attempts at state capture by unscrupulous business operators who had hijacked the former president, Jacob Zuma (2009-2018). Countrywide, society had become highly suspicious of politicians and government officials, who were almost all seen to be tarnished by corruption and fraud. At the same time the country was preparing for national elections in 2019. Under these circumstances the under-performing Emfuleni Local Municipality became the butt of public suspicion of corruption and incompetent leadership dating back to the early 2010s.

Between September 2018 and mid-2019, a number of unique interventions were made by the central and provincial authorities in an attempt to address the problems and sooth public sentiment. However, by August 2019, it became clear that the crisis had not yet been addressed satisfactorily. In the research process a number of micro case studies were identified and described under the rubrics of labelled case descriptors. These were interpreted and, in some cases, analysed.

In the report there is also an interpretation of diverse views of governance and governance-related issues that emerged from interviews and focus group discussions with stakeholders.

In the final section there is a set of Word Cloud assessments of members of the research group. Other contributors of include i) a group of identified wastewater stakeholder leaders in civil society; ii) local private sector stakeholders; iii) municipal councillors and officials of Emfuleni; and iv) the national Department of Human Settlements Water and Sanitation.

The final analysis presents a scenario of potential future developments related to Emfuleni's wastewater conundrum.

Lessons for practitioners

There is a need for transparent municipal governance, proper communication with residents and with all stakeholders.

Efficient participatory governance measures should be maintained.

There is a distinct need for sound, effective and systematic planning in the wastewater treatment sector of local government.

All practitioners are urged to look at the bigger picture and start addressing the primary crises which are:

a) Anthropocene conditions
b) IVRS needs to manage a clean Vaal River Barrage

Practitioners must aspire to maintaining proper governance and management procedures in the municipal sector.

It is essential to work towards consistency in maintaining sound operations in key service delivery areas such as water, wastewater, refuse removal and electricity.

Adequate multi-stakeholder disaster management operations must be in place to deal with potential crises on the Vaal River Barrage. Disaster management must be a cooperative endeavour in conjunction with all the potential stakeholders who can render service.

The Department of Human Settlements Water and Sanitation should consider establishing a water catchment management agency (CMA) for the (Upper) Vaal River to coordinate and improve the management of the system.

There must be consistent communication with stakeholders on the prevailing state of affairs. Prevention is better than cure.

Officials need to be provided with sufficient skills in specialised areas of responsibility.

Special attention should be given to training in how to operate strategic and technical infrastructure systems of local government.

A concerted effort should be made to secure the services of dedicated officials who are better qualified.

Improve planning and management strategies for infrastructure maintenance and upgrades. These strategies must be subject to council and national department approval.

There is a need to create a greater public awareness of using water responsibly in this time of climate change.

Special measures have to be taken to alert the public on the proper use of sanitation facilities in the domestic environment.

It is important to develop the political will to realise aspirational ideals of effective local government in collaboration with residents.

Give attention to developing a sense of pride in the urban areas in which communities reside and live out their daily lives.

Maintain proper and transparent municipal financial systems at all times.

Communicate extensively with the public.

There are many misunderstandings about sound cooperative governance. Try to address this by effective communication with all stakeholders, especially those at grassroots.

Greater attention needs to be given to proper engagement between government departments and the public at large.

Nurture a culture of service delivery that is driven by a passion to act in the service of the people.

Keywords

Wastewater, infrastructure, sewage, municipal governance, Emfuleni Local Municipality, Vaal River Barrage, Integrated Vaal River System, Vanderbijlpark, Vereeniging, Sebokeng, Sharpeville, WordCloud, interpretation, analysis, corruption, Anthropocene, resilience, WEF nexus, private sector.

Introduction

The 1 300 km-long Vaal River with its origins north of Ermelo, Mpumalanga, is at the heart of an important river catchment that is linked to Gauteng, the most populous province in the country. Since the 1930s the government's water department has managed what is today described as the Integrated Vaal River System (IVRS). Apart from providing Gauteng, with water supplies, the eastern section of the IVRS serves the province of Mpumalanga where most of South Africa's electricity is generated by Eskom, the national service provider. Also in the Eastern sub-system of the IVRS, Sasol's, petroleum-from-coal process plants at Secunda, Mpumalanga and at Sasolburg, located in the Free State's Metsimaholo Local Municipality, provide extensive strategic fuel and chemical supplies to an energy-hungry country.

The Vaal River is a prime provider of water supplies to Rand Water, the country's largest regional water utility that provides water to about 14 million people. Municipal authorities in the provinces of Gauteng and parts of the provinces of Mpumalanga, North West Free State and Limpopo, rely on potable water supplies for urban residents, local industries and businesses. In addition, extensive urban settlements, farming and mining operations located as far as 700km downstream of the Vaal River Barrage rely on the IVRS for their water supplies.

Since the 1980s a sophisticated planning and modelling strategy has been in place for monitoring the IVRS. But in recent years, exemplified by the recent drought (2014-2018) unpredictable conditions have rendered the system less able to predict anticipated conditions of drought and/or flood disaster. There appears to be a shortfall of climate hydrological knowledge in the current management model. The unpredictable weather conditions resemble typical symptoms of what scientists are beginning to describe as the Anthropocene.

In this study it is argued that the drought which began in 2014 in the northern parts of South Africa placed the over-used and under-maintained water infrastructure of the country's local authorities under severe stress. Municipal

wastewater infrastructure appears to be especially vulnerable. A recent report points out that many of the country's 824 wastewater treatment works in 152 municipalities are dysfunctional. At least 248 plants were over-worked, outdated and seriously in need of upgrades (Toxopeüs, 2019). Emfuleni Local Municipality's wastewater system falls into this category. Given the strategic location of Emfuleni, situated on the northern banks of the Vaal River Barrage, it is of vital strategic importance for the municipality's system to be brought up to the best compliance standards possible.

In June 2018 the Gauteng Provincial Government placed Emfuleni Local Municipality under administration. The local authority was unable to manage its finances or render proper service delivery to the municipality's 670 000 residents (Mahlase, 2018). The municipality owed Rand Water, the regional water supply utility, arrears to the tune of R441 million. Emfuleni's bill to Eskom, had meanwhile reached a staggering R679 million (Emfuleni Local Municipality, 2018). Again, Emfuleni was not the only culprit. An audit report published in mid-2018 pointed out that 45% of Gauteng's municipalities, financially speaking, were in a bad state (Mailovich, 2018). Furthermore, Emfuleni was by no means the only local authority spilling sewage into the Vaal River system (Kings, 2017).

What tarnished the reputation of Emfuleni was the fact that the municipality was in the unenviable position of having a reputation of inconsistency in maintaining its wastewater infrastructure properly. Since the late-1990s the municipality faced High Court cases because its water services authority, Metsi a Lekoa, was unable to manage and operate the over-used and ageing wastewater infrastructure in an acceptable manner. Geographically, large parts of Emfuleni are situated in the lower parts of the upper Vaal River catchment. Streams, wetlands and rivers frequently carry large loads of wastewater from southern Gauteng into the Vaal River Barrage – a 64km stretch of the Vaal River between the Vaal Dam and a barrage-type weir (Tempelhoff, 2009a). Pollution in the Barrage catchment is not confined to the dysfunctionality of local infrastructure. The water quality is affected by diverse sources of water in wetlands, flowing wastewater, and river tributaries into the river. The lowest elevation of the Vaal

Barrage catchment in the southern parts of Gauteng is in the Emfuleni stretch of the river.

The June 2018 sewage spill in the Barrage was a cut above the rest. In the aftermath of a stern February 2018 High Court warning, Emfuleni's officials and political leadership, supported by the DWS, made what proved to be futile plans to allay the concerns of angry residents and property owners downstream in the Vaal River (Tempelhoff, 2019a). Within days of being placed under financial administration, untreated sewage emanating from Emfuleni's wastewater treatment works started spilling into the Vaal River Barrage. Soon the spill became an environmental disaster of substantial proportions. Downstream urban settlements, tourist resorts and farming operations were affected over a distance of almost 200 km.

At the national level there was political turmoil. The ruling African National Congress (ANC) sidelined the head of state, President Jacob Zuma and replaced him with his former deputy, Cyril Ramaphosa. All this happened amid a growing countrywide awareness of gross corruption by political leaders, officials and private sector operators alike. The atmosphere in South Africa was tense. Government was seen to have fallen victim to unscrupulous business operators who literally pulled off a 'state capture' heist, leaving the country's economy in dire straits (Pauw, 2017). At the same time the country's national and provincial politicians had to prepare for countrywide elections in 2019.

In Emfuleni there were hard words from local residents and non-governmental organisations. They were mustering support for a concerted effort to take the local authority to task. The plight of Emfuleni's residents reached the ears of influential political role players. This debilitating situation could not go unchecked. With the unobtrusive support of the Ramaphosa presidency, government introduced a number of strategies seldom attempted before. South Africa's National Defence Force (SANDF) received instructions to take charge of Emfuleni's municipal wastewater infrastructure and start undertaking the necessary repairs (TPA TOA/20181108, 2018). They had been trained to understand a need for disciplined action. This was the first time since 1994 that

the SANDF's engineers and technicians, with extensive experience in UN-related operations in African states, stepped in to address a South African local authority's wastewater problems. Emfuleni's crisis had meanwhile attracted national media attention. Before long opposition parties in the Emfuleni Municipal Council called on the South African Human Rights Commission to launch an investigation. Between September 2018 and February 2019 extensive public hearings were held in both Emfuleni and Johannesburg (Tempelhoff, 2019a).

The reasons for the sudden interest in Emfuleni and the way the problem has been addressed are not isolated. A number of contingent factors can be singled out as playing an agency role in the collapse of reasonable wastewater and environment health conditions. Some are deep-laden systemic problems that can best be understood from a social-ecological perspective. For the purposes of providing deeper thought patterns, the research team has used theoretical and empirical conceptions of the Anthropocene (climate change), the Integrated Vaal River System (IVRS), the water-energy-food (WEF) nexus and resilience to gain deeper insight into Emfuleni's wastewater crisis.

Other factors are more direct and have a bearing on governance, the politics and economy of the day, as well as quirks of fate that frequently surface in the complex structures of local authorities – largely the result of a lack of reliable sources of revenue as well as the political will to make things work. Issues of inferior standards of infrastructure governance/management, and planning abound. There is a significant lack of proper communication between local authorities and their residents in all parts of Emfuleni. It is not confined to the wealthy, or indeed to the under-privileged. All residents of the Emfuleni area are affected. The situation is aggravated by an apparent lethargy among officials and political leaders to engage with the residents of urban nodes in all parts of South Africa, from the local to the regional and national level of government. By missing the focus on communities where people experience a sense of neglect and a lack of reciprocity in a benevolent democratic system of governance, both officials and the political leadership are responsible for causing societal well-being great harm. It affects the moral fibre of South African society in most parts of the country.

Theoretical and methodological considerations (not necessarily the exact wording of the section)

For the purposes of this study attention is given to the empirical contextualisation of theory related to the concepts of the Anthropocene, the Integrated Vaal River System (IVRS), Water-Energy-Food nexus and resilience.

Grassroots participation

The objective of members of the research team was to secure information from residents – from the proverbial horse's mouth. Interviews were conducted between 5 July and 13 August. Members of the research group focused in on residents at grassroots level.

Data was captured qualitatively at the time of the team's research fieldwork in the form of one-on-one (1-1) interviews, and also in focus group discussions (FGDs). The target population was Emfuleni residents at grassroots level. The emphasis was on the poorest of the poor who live in Sebokeng and Sharpeville, who, it appears, have thus far been neglected by both municipal officials and local political leaders. Attention was also given to residents of the formerly exclusive white residential areas, where service delivery, especially in Vereeniging, has fallen into disarray.

In addition, there was a focus on individual commercial and industrial stakeholders who have a role to play in the local economy. Owing to limited time it was not possible to harvest information from informal businesses. Key private sector role players, potentially representative of specific sectoral operations, were identified to garner information on entrepreneurial activities.

There were limited opportunities to engage directly with local officials and local council political leaders to gain insight into the problems they are experiencing. The research team's engagement was focused particularly on officials and political leaders who are not directly linked to executive leadership roles responsible for wastewater matters at local government level.

Wastewater leadership sector section

An advisor to the Mayor of Emfuleni provided guidance for establishing contact with key role players in Emfuleni. The office of the Emfuleni Municipal Council, facilitated communications with local political leaders and officials. These communications were primarily to gain key information and also to secure participation in a wastewater stakeholder leadership session.

On 15 August 2019 the research group facilitated a session with the Emfuleni wastewater stakeholder leadership. A total of 26 identified leaders of non-governmental organisations, civil society, Emfuleni's Metsi a Lekoa, and councillors, representative of either civil society, private sector and local and national government, attended the session. Respondents were asked to engage actively in the discussion and to share their views verbally. They were also requested to provide written responses to specific questions and data-forms.

At the time of the stakeholder leadership engagement the research team used the music of the American composer, John Adorney, to play in the background to create an enabling environment. The ambient music created a sense of calm in deliberations that tended to become heated from time to time. On a screen in the chamber 919 photographic images, displayed a mixture of scenic Vaal River Barrage waterscapes as well as explicit images of wastewater spills in Emfuleni where wastewater spills. In the first session (contemplating prospects for resolving the problem) the images were slightly off-colour and unclear. When the second session started (recommending plans for resolving the crisis) the images were clear. The ambient sound of Adorney's acclaimed calm music, used in combination with the varied images tended to have an effect on the manner in which stakeholders responded at time of open discussion.

The research group (comprising natural and social scientists) made use of transdisciplinary strategies to create an integrated system of knowledge based on what is known in the fields of natural science and social sciences – along with local knowledge of people at grassroots level. By incorporating the views of residents of Emfuleni, as well as two outlying areas (Deneysville/Refengkgotso and Parys) it was possible to form an impression of local actor views.

Interpretation

The research fieldwork engagements, and the stakeholder leadership session were used to garner information that was primarily subject to interpretation. By extracting qualitative information it was possible to fathom the mentality and the emotional aspects of how local residents and some key role players viewed Emfuleni's wastewater crisis. Respondents not only described the 'self', but also the 'other' in exchanging their views on local wastewater conditions and the way they engaged with the authorities and political leaders.

There were limited opportunities for the interpretation of quantitative data during the fieldwork process. A water quality assessment at various points in Emfuleni and the neighbouring Deneysville's wastewater that flows into the Vaal River Barrage, was interpreted in the context of insights gained whilst participating in the research team's fieldwork.

Figure 1: Members of the research group at work in preparation for writing and ordering their research fieldwork notes for uptake in the project's digital archive

Analysis

Members of the research group were also part of the first analysis of the views expressed at a focus group session at Loch Vaal with local residents. After the group interview the research team, still very much aware of what they had experienced in the field, shared information that provided data for a Word Cloud project aimed at identifying key terms and phenomena. Another session of data gathering, this time more refined and focused, took place two weeks later for assembling a more comprehensive view. By this time the research team had been able to process and interpret their research findings. WordArt is an on-line Word Cloud generator accessible at: https://wordart.com/my-word-art.

On 15 August participants in the wastewater stakeholder leadership sector were requested to fill in forms for capturing data for the Word Cloud analysis project. The data generated from the stakeholder leadership group was then integrated and synthesised with the views generated by members of the research team. However, in order that he could provide an independent analysis of the data provided by the respondents, a senior member of the research group stood aside from the heuristic and interpretive phases of the project. In addition, there was the aspiration, indeed a concerted effort, to create a sense of synthesis to eliminate potential bias on the side of all stakeholders and the research team. The information gathered appears in the section on the dominant themes identified by the stakeholder respondents and the members of the research team.

In the final section a scenario of potential developments in the future of Emfuleni is outlined. This prediction is based on data and conceptions garnered from all the respondents, that is, in the Word Cloud assessments. The perspectives include views of circumstances loosely grouped under the thematic headings: Me, myself and I; Forced equality; You 'pay' to stay; and Controlled 'crash landing'.

Digital archive

All the documents, beginning with oral interviews, personal notes and observations, as well as illustrations and documents received from stakeholders have been ordered/categorised into a digital archive. The information will be

stored in the South African Water History Archival Repository (SAWHAR) at North-West University.

The information will be closed to scrutiny; it will only be open to peers, until such time as a formal review article has been submitted for publications in an accredited academic journal, or as an academic book chapter.

Sharing knowledge with stakeholders

Knowledge dissemination related to the findings of the report is incorporated into the research report. The first version of the report, submitted to the EU project management, will be shared with the public at a meeting, and will also appear in a digital format. Once the project report is completed in the preliminary format, it will be distributed as broadly as possible to stakeholders. There will also be a public engagement opportunity where stakeholders can share their views publicly in an open forum.

Gatekeepers

As to the methodology, a select number of members of the research group, were identified as gatekeepers and knowledgeable people at the places where wastewater issues posed a major threat to local residents. The gatekeepers, comprising academics and activists, were asked for their views and also had the freedom to express their opinions if and where the research team may have erred. Two activists, respectively representing the Vaal Environmental Justice Association (VEJA) and the Organization Undoing Tax Abuse (OUTA) participated in all fieldwork activities and discussions in the research group. They guided the research team to affected local communities and facilitated the deliberations. In addition the research team had engagements with members of NGOs and non-profit organisation (NPOs) such as Save the Vaal Environment (SAVE), as well as the Emfuleni Ratepayers Association (ERPA), the Golden Triangle Chamber of Commerce (GTCoC), the Vaal Action Group (VAG), Proudly 3 River and the Federation for a Sustainable Environment (FSE) for important additional information required for the purposes of this report.

Interpreting case descriptions

Case descriptor: Anthropocene-type climate change

During South Africa's countrywide period of drought (2014-18) there was a growing awareness among scientists and operators in the water sector of climate change. In many parts of the country urban communities were unable to plan for mitigation of potential water-related crises. Cape Town was a prime example. One of the best managed metropolitan municipal authorities in the country faced an imminent 'Day Zero' in early 2018, because it had proved impossible to manage diminishing water resources effectively under circumstances of unexpected and extended drought conditions in the populous urban and farming areas of the Western Cape dating back to 2015 (Tempelhoff, 2019b, Nhamo and Agyepong, 2019). In the arid northern and north-western parts of the country, small towns ran out of water. Many crop and livestock farmers reported debilitating financial losses.

In Gauteng Province there was also cause for concern. Premier David Makhura commissioned a report on the implications of climate change on the province from a water security perspective. A national report on water security (Muller, 2009), less than a decade old appeared to be outdated and Mike Muller, a former director-general of DWAF, was commissioned to explore Gauteng's situation. Meanwhile, Makhura started up a 'water war room' to deal with contingent circumstances subject to peripheral agency factors that might cause disruptions in the provincial water sector (Anon., 2018). Muller's awareness of the crisis had him urging hydrologists to focus on bringing 'humans into the picture', to consider the Anthroposcene, when it comes to issues of climate change (Muller, 2019).

Emfuleni's wastewater disaster is a direct result of prevalent Anthropocene conditions. But what is the 'Anthropocene'? The term was first coined in 2000 by Nobel Prize-winning atmospheric chemist, Paul Crutzen (Crutzen and Stoermer, 2000, Crutzen et al., 2016). By the beginning of the new millennium he had become frustrated by the academic and public debates over global climate

change and a persistent public scepticism that it was people, 'humans' (*Anthropos* the Greek word for human) who were responsible for atmospheric pollution, especially carbon dioxide emissions, that pushed up global temperatures.

Crutzen and a growing group of like-minded scientists began their discourse on climate change as recently as the 1940s. It has now been shown that in a mere eight decades, humans have been responsible for changing the planet's climate conditions – a process that for the greater part of the past four billion years was determined by natural forces. According to Anthropocene proponents the scientific classification of the Holocene epoch, which began some 11 000 years ago , now (since the 1940s) appears to be outdated. We have in recent times made the transition to the Anthropocene epoch where humans have started playing a significant, and not always positive, role.

Humans, the Crutzen school argues, were responsible for the first release of nuclear debris into the atmosphere in the mid-1940s, when the Japanese cities of Nagasaki and Hiroshima were bombed with destructive nuclear weapons at the end of the Second World War (Syvitski, 2018, Otter et al., 2018). Moreover, the rapid increase in mass industrial production and the growth of transportation communications systems reliant on fossil fuels, contributed to the concomitant release of carbon into the atmosphere. What is more, the global population, as a result of advances in medical science, started growing ever more rapidly than before. Thanks to the Green Revolution (Evenson, 2003, Moore, 2017) there is now sufficient food available to feed more people, but the source of food is not infinite. In addition, industrialisation and the rapid growth of megacities in all parts of the globe, along with the excessive exploitation of water and energy resources have all contributed to the earth's changing climate with potentially fatal consequences in the future.

For example, plastics are at present the hallmark of the human presence on the planet (Rilov and Crooks, 2009, Bouwman et al., 2018, Fukuyama, 2018) Plastic, formerly considered to be indestructible, is now in various stages of decay, in some cases even laying down sedimentation on the planet's 300km deep crust – a process that was previously the exclusive domain of billions of tonnes of

weathering rock mutating into fine-grained layers of sand over thousands of years.

Figure 2: A typical roadside wastewater spill with plastic waste accumulating in one of Emfuleni's suburbs

Human-made plastics are now ever-present in the oceans of the world. Marine life is threatened and subterranean landscapes, still to be explored by humankind, have become littered with plastic waste. There are never-ending currents of water in the oceans because of the melting polar ice caps, so the earth's oceans now contain more water. Furthermore, there is a growing concern amongst scientists about microplastics in the Anthropocene (Kramm et al., 2018, Geyer et al., 2017). Recent research, reported on Sky News (August 2019) shows that micro-particles of plastic may even be present in bottled drinking water.

Figure 3: Plastic waste, in many cases as a result of non-collection by municipal waste workers, abound in areas where the local wastewater eventually flows in the direction of the Vaal River Barrage

A 16-year old Swedish school girl, Greta Thunberg, has inspired a renewed movement against climate change and this has wrought a marked impact on the awareness of climate change in the northern hemisphere (Stott et al., 2019, Shah, 2019). The younger generation (after all, it is going to be their world in 20 years' time) now speaks with renewed urgency and a growing impatience with petulant political leaders who are blind to climate change (Boykoff et al., 2019). In Europe and Asia there are indications that a hard core of green environmentalism (similar to the Deep Greens of the 1970s) is now mobilising to protest under the banner of Extinction Rebellion in major capitals of the Northern Hemisphere. There are also indications that climate change, specifically in the context of the Anthropocene speaks to what has been labelled as the Capitalocene and the need for the rearrangement of political and economic priorities in society (Moore, 2017). The political discourse in academia is growing amongst political scientists, economists, sociologists, as well as environmental scientists and natural science

practitioners who are now calling for more pronounced action against governments that are unwilling to embrace renewable energy.

Although the Anthropocene is still under intense scientific discussion (Ruddiman, 2019) the use of the term has become more widely used among scientists and the public at large. They are noting with concern how irresponsible we are as humans when engaging with the environment (Syvitski, 2018, Baskin, 2019, Chakrabarty, 2016, Emmett et al., 2016, Ogden et al., 2015). The water sector is not precluded from a growing corpus of advanced and highly respected research that is already in print (Gupta et al., 2013, Hannah et al., 2018, Savenije et al., 2014, Falkenmark et al., 2019, Meybeck, 2003).

There is currently an emergent mindframe, with scientists at the forefront, calling for a robust public campaign to create a greater awareness of the urgency of dealing with climate change. It is a problem that needs attention sooner rather than later in our energy-intensive societies. A sombre voice of historical reason calls for a far stronger public standpoint against developmentalism, blind economic growth and consumerism (Headrick, 2019). In this project the objective is to use the Anthropocene in a generic context. Climate change is instrumental in unwittingly changing human lives.

In the context of water, the Anthropocene can be linked to weather conditions that unravel what was considered 'normal' a few decades ago. The new normal is not the old system of weather patterns; or the way the water cycle ensures there is sufficient pristine water for all of humankind to drink and to maintain the ecological system. This is no longer a realistic assumption. Water resources have been mechanised to the extent that populous communities in urban settlements extract their water resources at great distances – often to the detriment of people where the water is sourced. More energy is required to distribute the water resources. Water purification, as well as the intensive treatment of wastewater, require much more energy and call increasingly for more refined technologies.

At the time of conducting fieldwork in July 2019 local residents, as well as industrial and business operators in Emfuleni confirmed that climate change is playing a significant role. However, in many cases, it appears that lay persons are

not fully aware of the areas climate scientists are now exploring to determine the impact of climate change. Research interviews revealed that many residents of Emfuleni have discussed aspects of changing climate. None of the respondents encountered in the fieldwork refuted the reality that Anthropocene-type climate change is a very real threat and this is particularly so in water-related crises.

Linking the Anthropocene with Emfuleni's wastewater crisis

The completion of the first phase of the Vaal Dam's construction in 1938, sparked major local industrial development (SAWHAR MCKC2b). By the 1940s the future Vaal Triangle emerged as a burgeoning industrial complex feeding into the wealthy Witwatersrand gold mining region to the east and west of Johannesburg. The Vereeniging-based utility called the Rand Water Board (currently known as Rand Water) supplied water to many parts of the Transvaal and Free State. The state-owned Iron and Steel Corporation (ISCOR) started up at Vanderbijlpark in 1943 and by 1950 SASOL's petrol-from-coal operations began at Sasolburg (Metsimaholo) on the Free State side of the Vaal River Barrage. The national electricity corporation, Eskom, increasingly produced more electricity at its local coal-fired (ever hungry) thermal power stations that fed into a national power grid by the 1970s. Industrial development in the Vaal Triangle attracted large numbers of migrants from the rural parts of the country. They settled there and become employed in the industrial towns of the Vaal Triangle that were soon bursting at the seams in a boisterous economic climate that lasted until the late 1980s. By that time the Vaal Triangle was the eighth most populous region of South Africa (Prinsloo, 1993, Meintjes, 1975, Conradie et al., 2000, Tempelhoff, 2003). The African townships of the region also formed part of the emergent pattern of successive segregation and apartheid policies in respect of urban locations; they compounded the problems of post-1994 urban South Africa profoundly (Butler, 2017, Tempelhoff, 2017).

Local social ecological conditions at the time were reminiscent of a typical industrial revolution where the resources of water and energy were prime nexus components. These conditions stimulated anthropogenic growth and

development, and provided a sense of socio-economic well-being (Prinsloo, 1992). There was more than enough water, energy and food production in the country. All three resource components of the WEF nexus were available locally in this burgeoning urbanisation process on the northern and southern banks of the Vaal River Barrage.

The Vaal Triangle also made its mark during the struggle era against the government's apartheid policy, when residents of Sharpeville participated in a mass action on 21 March 1960, showing their defiance against the law which demanded the carrying of pass books (Smith, 1993, Lodge, 2011). In the early years of the 20th century there were a number of sprawling urban townships including Top Location in Vereeniging; and Evaton near Meyerton. These were the only local urban settlements where African people could reside lawfully in close proximity to white, segregated urban areas. By the 1980s the more recent urban townships of Sharpeville, Sebokeng, Bophelong, Boiphatong, Evaton, and Zamdela at Sasolburg, along with a number of informal settlements, had become home to thousands of people. Most were in the employment of local industries which were running at peak capacity (van Zyl, 1993, Willemse, 1999, Jansen van Rensburg, 1992). It was well-known that the Vaal Triangle was one of the country's most air polluted areas, along with parts of Mpumalanga where coal mining operations served the production processes of Sasol, Iscor and Eskom. As will be pointed out below, the water quality of the Vaal River Barrage, also came under scrutiny in the era of industrial growth.

By the 1990s the Vaal Triangle entered a phase of post-industrial development. As local coal deposits became depleted, or were halted by activists, using legal measures, the energy sector resorted to alternative resources. Soon fossil gas was piped from neighbouring Mozambique to the Vaal Triangle to feed Sasol's production processes (Madamombe, 2007). In addition, South Africa's transition to a multiracial democracy in 1994 saw the Vaal Triangle moving into post-industrial mode. Iscor was privatised in an era when the local demand for steel had dropped. It became difficult to run at a profit. Little wonder that by the 1990s Iscor had dropped its employment quota from some 50 000 employees in the

1980s to less than 5 000 by the 2000s. South African steel producers were simply unable to compete with global markets where the price of steel dropped rapidly and the government privatised Iscor before the multinational corporation ArcelorMittal, acquired what used to be the country's largest steel producer (Hlatshwayo, 2017).

Meanwhile the urban face of South Africa changed constantly as more South Africans, formerly prevented to do so by influx control measures of the apartheid era, started migrating to urban areas (Harrison, 1992). Most metropolitan centres were able to contend with the swelling numbers. But the larger towns, (with many facing post-mining and post-industrial conditions) in the western, eastern and southern part of Gauteng) faced critical conditions of growth with local economies unable to bolster rapid population growth. It was a countrywide phenomenon at the beginning of the new millennium (Todes, 2001). The strained social circumstances in the urban areas of Gauteng Province are symptomatic of the Anthropocene phenomenon of the current burgeoning urban growth in sub-Saharan Africa.

South Africa's early 2000s' economic growth in the Mbeki presidential era, was only marginally bolstered by local economies, specifically in the case of the newly formed Emfuleni Local Municipality. By the time countrywide service delivery protests began in 2004, first in the rural areas of the Free State and Mpumalanga, before spreading to the country's metropolitan urban areas (Tempelhoff, 2009b, Gouws et al., 2011, Motloung, 2010), the consequences of rapid population increase and urban sprawl, along with over-hasty and under-planned urban development took its toll on the existing municipal infrastructure. At first, especially in the rural areas of South Africa, local authorities were unable to provide the growing domestic and industrial demand for water and energy. These two vital components were provided on the understanding that local authorities would be able to generate sufficient revenue to pay for the management of local public goods and services.

There were indications that the regional hydrosphere of the Vaal River Barrage catchment was in a state of deterioration. The Anthropocene was evident in

increasingly heavy loads of polluted municipal and uncontrolled industrial wastewater flowing from parts of southern Gauteng and the Northern Free State into the Vaal River Barrage. Wherever there were traces of worked-out mining operations, acidic mine drainage water (AMD) contributed to the build-up of a toxic cocktail of chemical pollutants (Naidoo, 2017). The AMD marginally neutralised biological pollutants from under-performing municipal wastewater systems. However, despite governmental interventions, only temporary measures have been put into place to deal with the legacy of mining in the form of AMD.

The current status quo on AMD is by no means final. In the water sector there have been calls for the formalisation of AMD treatment and processing in the western, central and eastern catchment basins of the former goldmining mecca of the Witwatersrand. Among the latest strategies to attract attention has been information on a membrane-free system for water electrolysis to generate hydrogen power at the same price as petroleum. The technology was announced by a South African company, Hydrox Holdings, at a meeting of the International Convention on Electrolysis in Norway in June 2019 (Creamer, 2019a). Meanwhile, at the stakeholder leadership session on wastewater the Federation for a Sustainable Environment (FSE) called for more urgent and permanent measures to be taken to address potential problems related to AMD (TPA 20190815, 2019).

While a plan has been formulated by the DWS to deal with AMD and even prepare the way for water re-use by 2021, the information has not yet been communicated satisfactorily with stakeholders at grassroots level. Over the short-term the current planning has implications of higher water tariffs in the Integrated Vaal River System, but there is little clarity of how the complex system will pan out at the local and regional levels of governance (Mlilo, 2019).

There are also bigger issues at stake. In Gauteng, municipal wastewater plants have had to contend with unpredictable and uncontrolled growth. Urban sprawl and concomitant random waste disposal in the most populous region of South Africa wreaked environmental havoc in the regional hydrosphere. The Anthropocene registered prominently in the living waters of rivers and streams in Gauteng. Local rivers, like the Klip, were symptomatic of the deterioration

(McCarthy and Venter, 2006). In 1992, when the future East Rand Wastewater Treatment Works (ERWAT) started up, there was a further increase in the wastewater load flowing into the Klip River, albeit in a treated form (Ballenger, 1997). The same river carried water from 18 wastewater treatment works in Western Gauteng – also in the direction of the Vaal River Barrage (Cameron, 1997).

The prevailing state of the social ecology of Emfuleni in the second decade of the 21st century is that the Anthropocene is deeply seated in its historical social-ecology. Ever since the 1940s the former Vaal Triangle region, as was the case in the era of the industrial revolutions in the United Kingdom and Western Europe in the 18th-19th century, was in an upward phase of rapid development and growth. But then there also followed the inevitable phases of de-industrialisation. The psycho-social symptoms of these circumstances on the human psyche is a mature and much-explored field of research.

Figure 4: Working class suburbs in Sebokeng have fallen victim to waste spills in open spaces

Figure 5: In Vereeniging's Peacehaven, residents have lined up their own systems to dispose of raw sewage flowing from their homes

Currently, Emfuleni's social-ecology is one of post-industrialisation. At the social level, local residents have become disorientated. A state of *anomie* prevails in most parts of Emfuleni. *Anomie*, first described by Durkheim in the late-19th century (Durkheim, 1964) implies that individuals and local communities start dismantling social norms that were formerly part of a cultural texture of close-knit communities. At the time of rapid development in an industrial setting, *anomie* takes root in the face of political and economic disruption in the living spaces where people find themselves. In former times, especially the early years of industrial development, an almost utopian-type of positive sentiment prevailed. Workers' unions were very influential. The good symptoms of sound industrial development at the grassroots level held much promise. This was epitomised by the typical working-class father returning home after a hard day's work in the factory. As local job opportunities started disappearing in an over-populated post-industrial environment, a dystopian cultural landscape formed – notable for a state of deep-seated psycho-social depression.

Figure 6: Raw wastewater spills abound in the proximity of the Sebokeng hostels

At present 37% of the economically active population in the African townships of Emfuleni are jobless (Tempelhoff, 2019a). Former industrial hostels have become informal homes of nuclear families living under abject conditions. There are pools of wastewater in open spaces in and around the long rows of semi-detached homes. There is leaking sewage flowing through some of these homes. The general state of social depression is not confined to former African townships. It has also had a profound impact on the central business districts of Emfuleni. Residential areas that formerly housed white residents have also fallen victim to the sewage wastewater spills.

The sewage wastewater problem is not the only cause of the psychological depression. At the end of 2018, Emfuleni's municipal waste removal service was halted, only to be restored in May 2019. Mature residential areas became part of a sombre landscape of deep psycho-social depression. It was reminiscent of a communal experience of 'things falling apart' (Petersen, 2018). There was a general loss of confidence and a growing sense of personal vulnerability. Residents were very aware of the presence of environmental health threats.

In circumstances of this nature, evidence of the Anthropocene manifests in the cultural responses of individuals and their communities, as will be dealt with in the empirical descriptive section below. Little wonder then that after a former minister of the DWS in 2015 promised residents of Sebokeng that 'thousands' would be employed at the Sebokeng regional wastewater treatment works (SANEWS, 2015), there were protests in 2018. Desperate residents demanded job opportunities even while the future mega-wastewater plant was still under construction. In 2019, large numbers of unemployed people, often resorting to protests and pilfering, waited outside the Sebokeng works, anxious to be employed – even if only on a temporary basis (TPA 20190711a, 2019). Apart from being blinded by poverty and the onset of decay, there was a devastating loss of meaning and purpose in their lives.

The stamp of the Anthropocene is most profound in the case of Emfuleni's wastewater infrastructure. The three primary municipal wastewater treatment works had their origin in rapid urban growth and development in the heyday of industrial progress in the Vaal Triangle. The wastewater treatment plants constructed at Zuurfontein (1943), Rietspruit (1952) and Leeuwkuil (1955) in the early years, were part of a comprehensive plan to provide for industrial, commercial and domestic development (Tempelhoff, 2019a). In the mid-1990s the Sebokeng works (c. 1996), followed as the future hub of a regional wastewater treatment works scheduled to service a more comprehensive region which included parts of Metropolitan Johannesburg, and the new neighbouring Midvaal Local Municipality.

Currently, a 2 800 km pipeline reticulation system with 44 pump stations, transfers water of the wastewater treatment works. Sebokeng with a capacity of 100ML/d, currently processing as much as 160ML/d is being upgraded to process 200ML/d of wastewater (TPA 20190711a, 2019). Rietspruit (36ML/d) and Leeuwkuil (36ML/d) currently operate well above their capacity (TPA 20190729, 2019). Urban sprawl, leaking municipal water pipelines, along with domestic toilet and tap leaks account for as much as 42% of Emfuleni's potable water being lost even before it reaches consumers. Most lost water becomes free-

flowing surface wastewater that flows into the Vaal River Barrage, providing it is not absorbed by the wastewater treatment system.

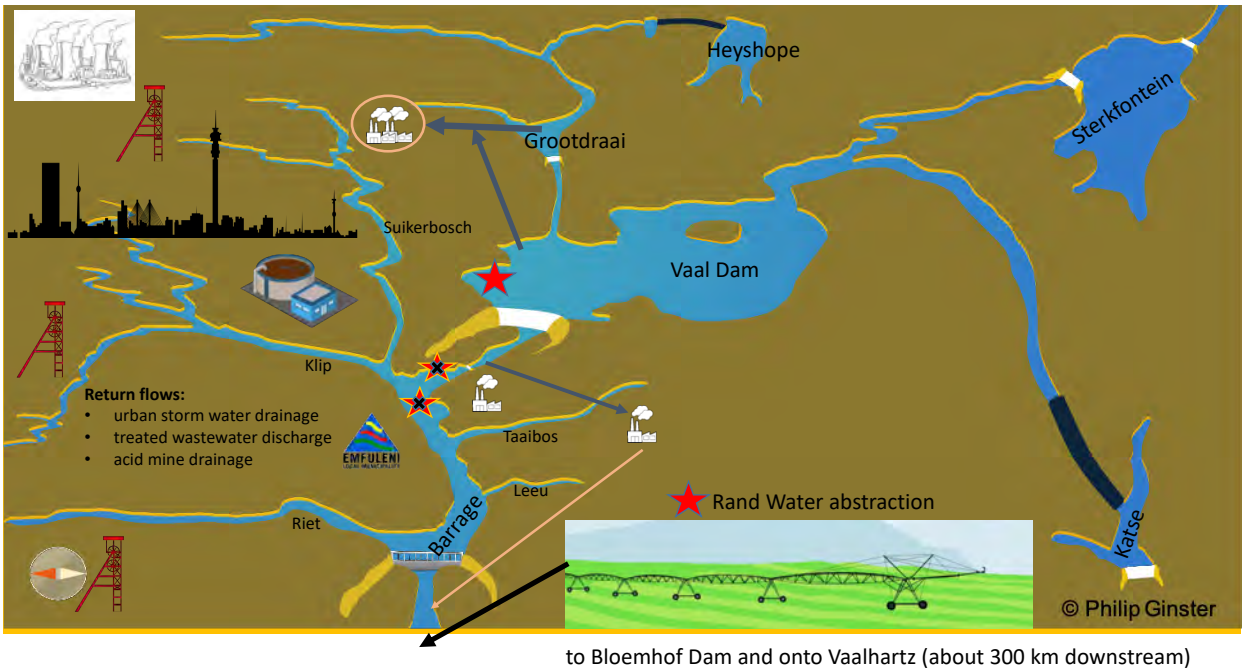
Emfuleni's long-standing problems with wastewater infrastructure has all but halted ambitious development plans. At the onset of the countrywide drought in 2014, the municipal authorities announced plans for developing a riverfront office and residential area in a rundown former industrial part of Vereeniging. The project was to form part of a collaboration strategy with the Development Bank of Southern Africa (Emfuleni Local Municipality, 2014). But Emfuleni's positive development plans fell victim to the hammer blow of a disastrous, countrywide drought. In the four years that followed there were signal events at upstream Deneysville and downstream Parys – local wastewater infrastructure systems were unable to maintain their resilience under the pressures of over-use and poor management in sensitive parts of the Integrated Vaal River System (JTPA 20190715a, 2019, Tempelhoff, 2019a). By 2018, Emfuleni's wastewater infrastructure was also unable to cope with the rapid onset of severe sewage spills into the Vaal River Barrage.

Case descriptor: The Barrage as pollution sink

The construction of the Barrage on the Vaal River in 1923 created the first significant surface storage impoundment on the river. It enabled the provisioning of a reliable and adequate supply of water to the residents of Johannesburg as well as to mining and industrial users (SAWHAR Laburn, 1974). But the Barrage also became an unintended pollution sink and this has led to significant water quality problems that are still prevalent today. Key to understanding the observed water pollution in the Barrage is recognising that the Vaal Barrage impoundment is located downstream of most of the urban settlements, mining and industrial areas served by the water sourced originally from the Barrage. In many respects the current state of the Vaal River Barrage is a product of the Anthropocene in the catchment of this prime South African river.

This phenomenon is illustrated in Map 1 (below) of the Integrated Vaal River System. It shows the Vaal Barrage located downstream of the Vaal Dam with five tributaries entering the Vaal River, namely the Klip, Suikerbosch and Riet rivers on the Gauteng side of the Vaal; and the Leeuspruit and Taaibosspruit rivers on the Free State side.

As urban demands increased, greater volumes of water were abstracted from the Vaal Barrage but there was a growing realisation that another impoundment was needed upstream of the Barrage. By 1938 the Vaal Dam had been commissioned with the dual purpose of supplying urban needs and irrigation water supplies to the Vaalharts irrigation scheme located almost 200 km downstream (Triebel & Van Niekerk, 1994). The wall of the Vaal Dam was subsequently extended and flood gates installed (Brooks, 1980). As far back as the 1950s it was recognised that the Vaal River, with its associated infrastructure (which at the time consisted of the Vaal Barrage and Vaal Dam) would not be able to supply the increasing demand and would have to be augmented with water from beyond the Vaal River catchment (DWA, 1986).



Map 1 Illustrated map of the Integrated Vaal River System

New water resources were required to meet increased energy demands and furthermore they had to be developed in close proximity to coal-fired power stations that were under construction at the time (Conradie & Messerschmidt, 2000). This initiative included the development of the power stations in the Eastern Transvaal Highveld, in today's province of Mpumalanga (DWAF, 1991). Key to this development was the construction of Grootdraai Dam on the Vaal River upstream of the Vaal Dam which was commissioned in 1981.

The main components making up the modern day IVRS as illustrated in Map 1 include:

a. **Bloemhof Dam:** This was completed in 1970 to relieve the Vaal Dam from supplying water for downstream irrigation users (not shown on map).
b. **Tugela-Vaal Project:** Transfers water in times of need from the Tugela River to the Vaal Dam via the Sterkfontein Dam, using an Eskom pumped storage hydro-electric scheme.
c. **Usutu-Vaal Scheme:** This scheme supplies water to Eskom and Sasol. The main component is the Grootdraai Dam, which receives additional transfer water from the Heyshope and Zaaihoek dams.

d. **Lesotho Highlands Water Project (LHWP):** The LHWP comprises the Katse and Mohale dams, the Motsoku Weir and the connecting conveyance and transfer tunnels delivering water to the Vaal Dam.
e. **A further phase of the LHWP** is currently underway with the construction of the Polihale Dam, with an estimated completion date in 2025.

Water quality in the Vaal Barrage

The water quality deterioration in the Vaal Barrage was recognised from the early days of the operation of the Barrage. In 1943, some 20 years after the Barrage came into operation, J Leslie an engineer at Rand Water, wrote about the water pollution facing the Barrage (SAWHAR, PAM2305, 1943). In an extract from Minutes of a Rand Water meeting, Leslie described the problem in some detail. Graph 1 provides a graphic representation of the water quality monitoring data. The electrical conductivity of the Vaal Dam water released into the Barrage is compared to the quality of the Vaal Dam. That is then compared to the quality of water released from the Barrage (V17) in further comparison to the water quality of the main tributaries (namely Klip, Suikerbosch and Riet) entering the Vaal Dam.

In the late 1970s significant concern was raised regarding the continued deterioration in the quality of water supplied to the Witwatersrand (Clarke & Holt-Biddle, 2002, Van Rooyen & Herold, 1992). As already mentioned, the main cause of this water quality deterioration is the discharge of urban, industrial and mining effluents and return flows directly into the Vaal Barrage. This polluted water was then being abstracted for urban use (Wepener, Van Dyk, Bervoets, et al., 2011).

Given the fact that the Vaal Barrage is located downstream of Johannesburg and its developments, the natural run-off returns to contaminate the main water supply. This explains why both the volume and pollution loads entering the Barrage increased. The salinisation of the Vaal Barrage became a topic of intense public and scientific debate (SAWHAR, WLC C1464k, 1994). An advisory committee investigated various options for controlling the salinity of the water supplied from the Vaal River system. The founding members of this committee were: The Department of Water Affairs, Rand Water Board, Johannesburg

Municipality, National Institute for Water Research and the Water Research Commission (DWA, 1986).

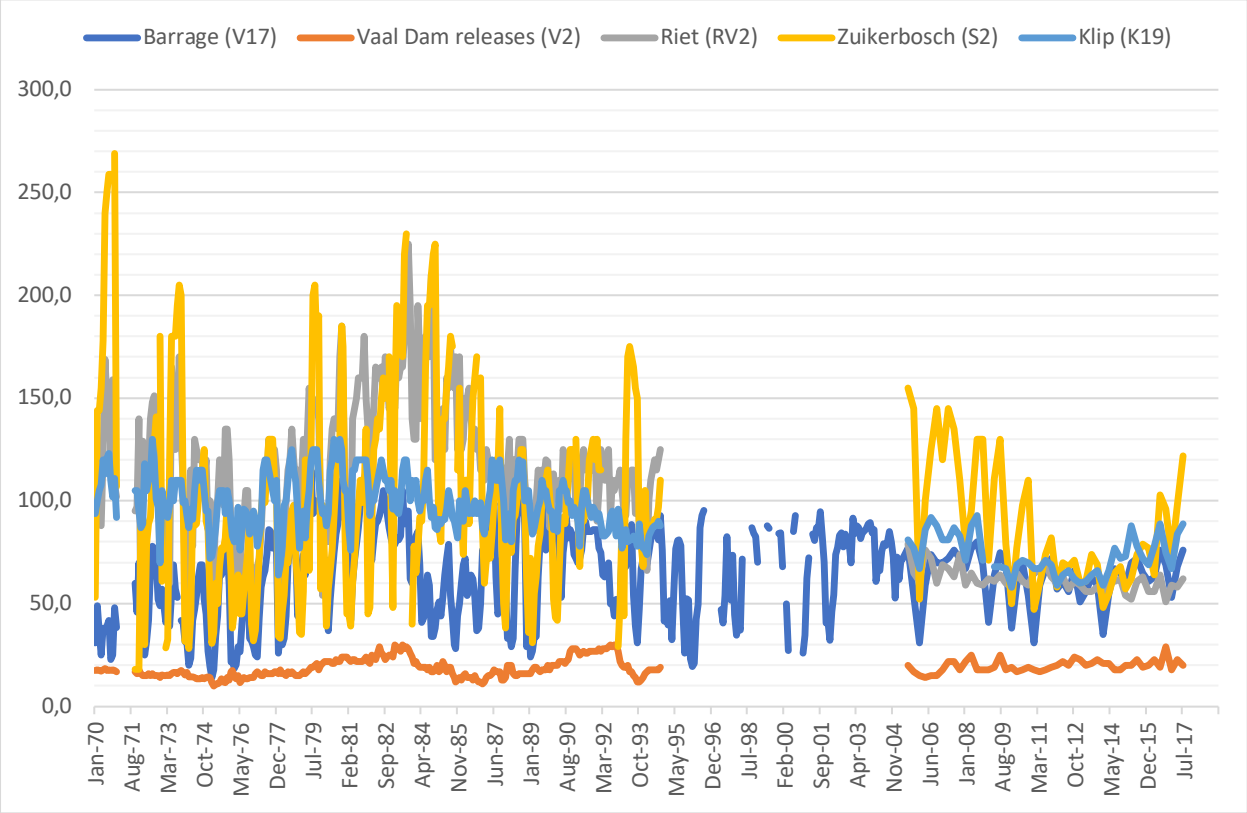
A number of options for addressing the issue were investigated. Research outputs included a first-of-its-kind hydro salinity model by Herold (Herold, et al., 1980). Further, the Heynike study determined the cost to the economy of the high salinity in the urban water supply (SAWHAR, CHC 6/84).

The solution adopted was to blend appropriate quantities of Vaal Dam water (with a considerably lower salt content) with Vaal Barrage water that had a significantly higher salt concentration. In this way, the water supplied from the Barrage would be of an acceptable quality. Applying some form of dilution seemed to be a logical solution. But embarking on a dilution process required extensive experimentation to determine the appropriate blending ratios.

The research undertaken included comparing various options to respond to the severe salinity problems being experienced in the Vaal River and the important Rand Water supply. Hydrological models were developed to gain a better understanding of the problem. Herold developed daily and monthly time-step catchment hydro-salinity models for the entire Vaal River system (Herold, et al., 1980; Herold, 1982). With this tool, operating rules could be simulated which could account simultaneously for both hydrology and salinity. This was a world first in that quantitative and qualitative modelling could be combined for purposes of planning on the complex Vaal water resource system.

The tools at the disposal of the system's managers include blending and dilution. The blending option involves the mixing of high salinity Barrage water with Vaal Dam water in a specified ratio to reduce the salinity of the water supplied by Rand Water. The dilution option involves releasing surplus quantities of water from the Vaal Dam to dilute the water quality of the Barrage which in turn is abstracted by Rand Water. The optimal ratio of blending or dilution has to be carefully monitored. Economic models have been developed to determine what the optimum salinity level in the water supply was, considering the negative impacts of the salinity (Bath & Quibell, 1997).

The PWV blending option, implemented in 1981, was according to Herold, highly cost effective with a benefit to cost ratio of 30. The impact of this approach on the system yield also had to be determined since this would require additional releases of water from the Vaal Dam. Not all planners favoured the option. Today the successor to the blending option, the dilution option, is still in use (Wellmanns, 2016).



Graph 1: Electrical conductivity (as a measure of pollution) from the main tributaries entering the Vaal Barrage from the Gauteng side (Riet, Suikerbosch and Klip) against the Vaal Dam releases (V2) and the water quality samples at the Barrage (V17)

Relationship between Vaal River and Emfuleni

Emfuleni Local Municipality, via Rand Water, receives its bulk water supply from the Integrated Vaal River System through water abstracted from the Vaal Dam. Water losses from the municipal infrastructure are high because of non-payment for water and physical losses due to aging, poorly maintained and operated infrastructure. On the wastewater side, treated sewage effluent from Emfuleni's

wastewater treatment works at Sebokeng, Rietspruit and Leeuwkuil is discharged into the Vaal River Barrage, contributing to the deteriorating water quality in the Barrage. Of most concern (and widely reported) has been the vast evidence of untreated (raw) sewage discharged into the Vaal River from the municipality's wastewater treatment works. The first manifestation of the Anthropocene, in the era of post-industrial development, tends to speak to the considerable history of raw wastewater treatment plant water that has been flowing into the Barrage since the 1990s.

In addition to the direct impacts of water abstraction and wastewater discharges, Emfuleni's geographical location is such that it is in close proximity to the Vaal River, which has both advantages and disadvantages. An advantage to being near the river is the revenue generated by rates levied on river properties. These properties tend to belong to wealthy people who are attracted to the exclusive lifestyle of living on the bank of a river. A disadvantage for the municipality is the direct association of any pollution entering the Vaal River, specifically of raw sewage. The inequitable access to the river is also a significant concern given the limited access to the Vaal River by non-river front property owners.

Case descriptor: The Water-Energy-Food (WEF) nexus

Water, energy and food, as valuable resources, are unquestionably connected in a nexus. The WEF nexus is an approach that emphasises an understanding of the inter-connections and relations between water, energy and food. This approach offers views on how to implement integrated solutions of managing resources (UN, 2016). In 2008 the concept was used at the World Economic Forum summit in Davos to highlight the critical need for greater water security (World Economic Forum Water Initiative, 2011). Three years later the nexus approach was accepted by the global water sector as a framework to stem challenges arising from global climate change, population growth, urbanisation and slow economic growth (WEF, 2011). The Bonn 2011 Nexus Conference had consensus that the nexus approach could deal effectively with global socio-economic development (FAO, 2014). In effect there was a firm understanding that lapses in one sector of the nexus, are detrimental to the other two. The solution is to minimise the negative causes and effects of any disruptions to the nexus (Hoff, 2011).

Apart from the fossil-based energy sector, water is also required for renewable energy production, such as hydro-electric power, or as an input in bio-fuel production processes and the advanced treatment of wastewater for energy purposes (Vanham, 2016). Furthermore, water is used largely for agricultural livelihoods, food production, processing, household cooking and for hygiene purposes (Stevens & Gallagher, 2015). Food production relies heavily on water and energy. Food requires energy in, for example, surface and groundwater extraction and distribution in irrigation agriculture operations, food preparation, and preservation; and a multitude of food-related household activities (Scott *et al.*, 2015). Energy also forms a major part of activities responsible for the wellbeing of people. Examples include the transportation of humans, goods and services. The household uses of energy are generally energy intensive such as cooking and heating (Asif, M. & Muneer, T, 2007).

WEF nexus in the Emfuleni case study

The WEF nexus plays a significant role in promoting positive ways for resource use and management. This study explored the views held by people living in areas around the Vaal River Barrage to see what they felt about waste and wastewater management, water security and water pollution. In the local hydrosphere water is the major component in the nexus. Access to adequate, safe water for all is essential for development and socio-economic growth. The Vaal River Barrage's pollution poses a threat to downstream food and energy industries. The river also becomes a threat to the general wellbeing of people and the environment. Poor waste management also has an impact on food production and food safety. When households only have access to poor quality water it has an impact on energy consumption and this may lead to energy insecurity. In the absence of access to safe water people may end up travelling long distances to fetch water, which requires energy. Unsafe water also has an impact on farming activities and livestock rearing. Therefore, it is very relevant indeed to explore the WEF nexus linkages and connections in the Vaal River Barrage and how challenges faced, may pose a multitude of threats to the security of the nexus components.

Views on the WEF nexus in the context of Emfuleni

At the time of the research team's fieldwork, the respondents were primarily grassroots residents of Emfuleni. Their views on the wastewater crisis and their gloomy, dissatisfied disposition was typical of residents of a dysfunctional local municipality. A number of clear WEF-nexus connections could be made by members of the research team. The potable water supplies of Emfuleni are purchased in terms of an agreement between the local municipality and Rand Water which provides water to the local municipality at a wholesale price; this water is then for sale to the residents and local industrial and business operations. The quality of the water is sound. This is worth repeating: the greater part of Emfuleni does receive proper water supplies.

In the case of identified poverty-stricken homes special arrangements are made for sufficient supplies of water. As a rule, all households are entitled to 6KL of

water per month. It is uncertain to what extent consumers' supplies are reduced in cases when they consume in excess of the standard 6KL. Urban legend has it that people simply keep on consuming water and that there is no check on this. When there are water outages, some communities start protesting vociferously until supplies are restored. There does not appear to be any sensitivity on the side of local residents in terms of using water sparingly. There is a growing insistence by water sector management experts that urgent steps need to be taken on matters of water conservation and water demand management. It has to be along the lines of a growing culture of payment for potable water service delivery. It is the key to the restoration of proper water governance at the municipal level (Hazelton, 2019). Whilst there appears to be a marginal weakness in terms of potable water service delivery in Emfuleni, there are clearly lapses in terms of proper governance.

There were numerous comments by residents who had concerns about the effects of polluted water in Emfuleni. In a focus group discussion at Loch Vaal, one respondent explained how the river pollution has affected food security. Some local people have always (and continue to do so) engaged in catching fish from the river. They sell their catch of the day at local informal and formal townships. Reports have it that there have been deaths after consuming what could potentially have been 'sick', contaminated fish from the Loch and the nearby Rietpruit and Barrage area (HJPA/20190713/FGD5/Lochvaal, 2019). This shows how unsafe the river is and the negative impact it has on food security.

In an interview in Sharpeville one respondent explained that

> *...the problem of sewages spills in this area is causing us great distress. It is everywhere in the streets including in front of our local shops. We find it very unhealthy that there is raw sewer just in front of our butcheries and fast food stores. The problems with sewerage is affecting businesses, no one wants to buy cooked food from a place where it smells of sewage* (HJPA/20190709c/Sharpeville, 2019).

In another interview a fisherman said the quantity of fish they had in the river was decreasing (NMPA 20190709b Sharpeville Fisherman, 2019). Furthermore,

whereas they used to catch a great variety of fish, in recent times most of the fish have died off or have migrated elsewhere in the river (NMPA 20190709b Sharpeville Fisherman, 2019). River pollution was said to be the prime factor for the dwindling fish population. At Loch Vaal one respondent explained how they used to see different types of fish jumping above the water but explained that these had also disappeared. In another interview a respondent explained how the fish in the river have changed in colour, presumably due to the changing environment of water quality (HJPA/20190713/FGD5/Lochvaal, 2019). It is clear that fish, as a potential source of food, are becoming scarce as a result of the quality of river water. The water-food nexus components are therefore vulnerable.

Dlomo Dam in Sharpeville serves the community by providing the fishermen with several fish species to catch and sell for an income (NMPA20190709a 1:1 Sharpeville – Steven Lerato Matswameng). Carp (*Cyprinus carpio*) is one of the community's favourite fish species and is a good source of protein. Unfortunately, the carp is an invasive species initially from areas in Asia and Europe (Anon, 2019a). This particular species disappeared from the Dlomo Dam for a long period of time and only returned approximately four years ago. The reason for its disappearance cannot be pinpointed directly. The decrease in the amount of other fish found in the dam can, however, be explained because the carp has highly competitive behaviour in its search for food and habitat, causing stocks of other fish species (which occur naturally in the Dlomo Dam) to die out.

A farmer in Lochvaal explained how farmers use water for irrigation. He found it most disconcerting that he did not know what impact the polluted water could have on his crops and how it might affect humans when the food was consumed (HJPA/20190713/FGD5/Lochvaal, 2019). Another respondent explained that her family had been farming herbal rosemary for over a decade, but recently their plants showed signs of an unfamiliar disease. An expert horticulturalist advised her that the disease was caused by environmental pollution. Apparently pollutants in the water could be transmitted in the atmosphere to plants at some distance from the river (HJPA/20190713/FGD5/Lochvaal, 2019).

Another farmer remarked on the importance of water in food production, but voiced his concern about the dysfunctional wastewater pumping station in Sebokeng. He felt that this posed a threat to accessing high-quality water for local agriculture (HJPA/20190706/Everton, 2019). Polluted water is certainly a threat to small livestock in the area. At the same time inefficient governance makes it extremely difficult for small-scale farming in the townships. The rural development plans of the local and regional authorities do not make any provision for small scale farming in informal settlements (HJPA/20190706/Everton, 2019). This is a setback to the general socio-economic development of individuals and communities. Promoting small-scale food production for households could go a long way towards promoting self-sufficiency and independence of potentially vulnerable families.

Local farmers have been creative in finding solutions to potential obstacles. In one case a small farmer in Sebokeng explained that local water supplies were simply insufficient for farmers to plant crops. As a contingency measure he teamed up with fellow cultivators and together they sunk a borehole. They relied on two 5000L tanks for storage and were thus able to water their crops (TPA 201907806b, 2019).

Furthermore, the study found that people in some of the areas visited have challenges in accessing electricity and cannot meet their daily energy needs. In Evaton West the study found that access to electricity is a huge problem (HJPA/20190706/Everton, 2019). Households sometimes go for months without electricity especially when there is a breakdown of infrastructure. One respondent claimed that it sometimes took a long time before electricity was restored. If this happens, residents have to improvise and use other energy alternatives such as firewood and paraffin. People sometimes tried to fix the electrical problem themselves at posing great danger of electrocution (HJPA/20190706/Everton, 2019).

Some households in the townships receive free basic electricity of 50 Kilowatts/m from the local authority. This does not help a great deal because residents are now forced to boil their water before they can use it for consumption purposes

(HJPA/20190706a/Sebokeng, 2019). The increasing need for energy in the form of electricity to purify water in households has a negative impact on households' access to food. They now have to channel more money to pay for energy – money that otherwise would have been used to buy food to eat for bodily energy.

Property owners and small business owners explained how the situation influenced their lives negatively. The smell caused by sewage leakages and the actual spills made prospective customers shy away from their premises. The problems caused by faulty waste management leads to a loss of livelihood for many people. It has a marked effect on both food and energy security. People need some form of revenue to purchase these essential resources. In meetings with business people one respondent explained that the value of property was falling and no one wanted to buy property in parts of Emfuleni. This meant that soon there would be even more people in Emfuleni without jobs and unable to put food on the table (HJPA/20190709/FGD4/Riverspray, 2019). There is need to find quick and sustainable solutions to challenges such as these.

Case descriptor: Water quality monitoring

For the purposes of this part of the study, attention was given to the water quality in various locations in the Vaal River Barrage catchment. The standard used was the principle of “drinking water quality”.

The preliminary hypothesis for the assessment was: *The water is not clean enough to use for drinking in the Emfuleni Municipality*.

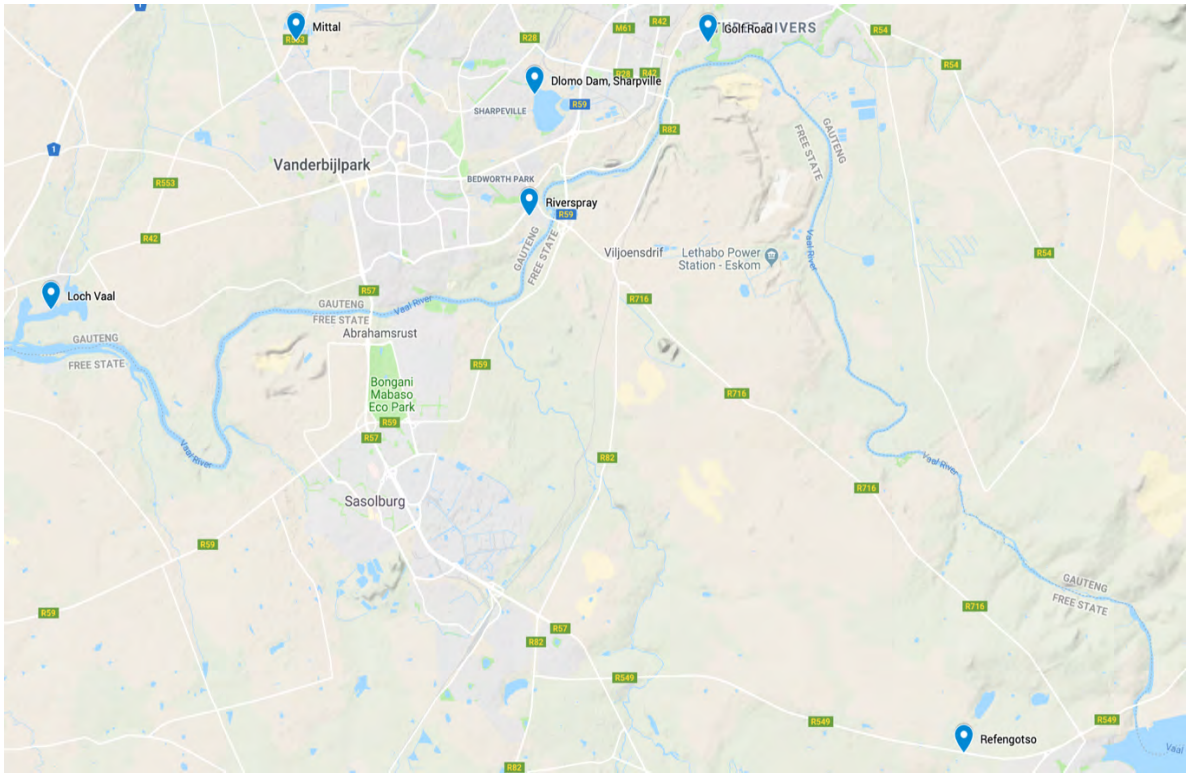
The aim was: To determine the water quality of Emfuleni.

The objectives were: To take water samples in various places in Emfuleni and specifically in the catchment of the Vaal River Barrage. Each sample was to be subjected to analysis by an independent laboratory. The resultant data would then be used for describing and analysing the local circumstances, guided by the insights gained while doing research fieldwork with the members of the research team.

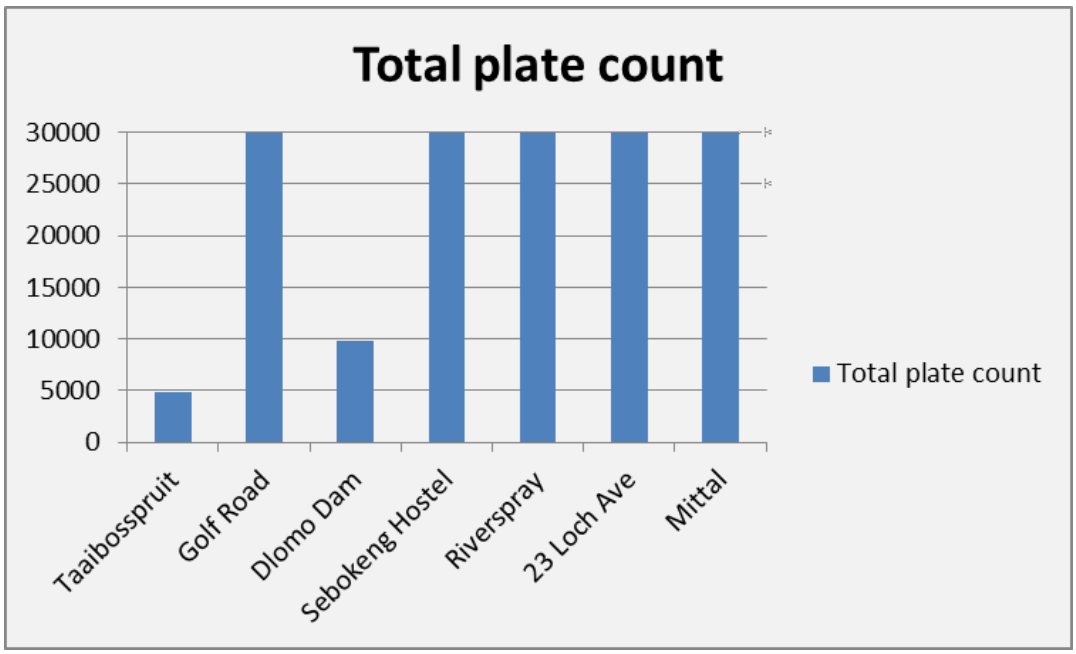
Results

Table 2: Results of microbiological water tests

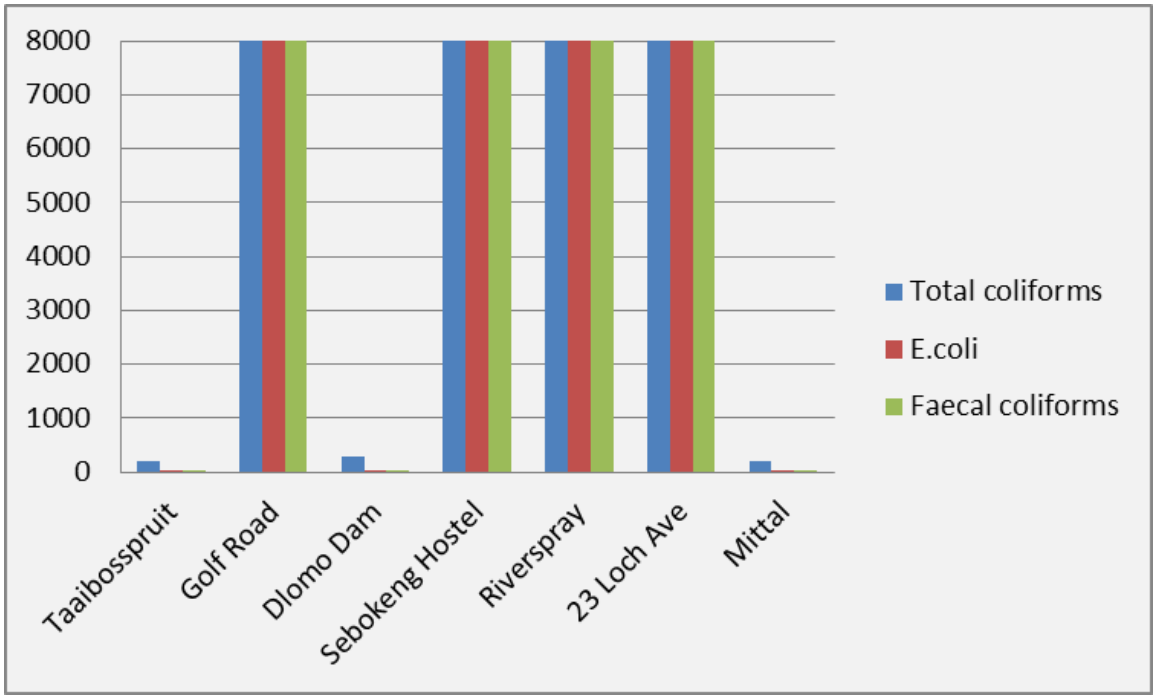
Sample location	Total plate count TEC-08 (cfu/ml)	Total coliforms TEC-27 (cfu/100ml)	Escherichia coli TEC-27 (cfu/100ml)	Faecal coliforms TEC-10 (cfu/100ml)
Taaibosspruit	4800	200	28	29
Golf Road	>30000	>8000	>8000	>8000
Sharpeville	9800	300	23	31
Sebokeng Hostel	>30000	>8000	>8000	>8000
Riverspray	>30000	>8000	>8000	>8000
23 Loch Ave Lochvaal	>30000	>8000	>8000	>8000
Mittal	>30000	200	11	19



Map 1: Locations where water samples were taken for purposes of the assessment



Graph 2 Total plate count for all the samples in Emfuleni



Graph 3: The total coliforms; E. coli and Faecal coliforms from all the samples

Discussion

Water is an important resource for all living creatures, including humans, animals and plants. Organisms, even the smallest bacteria, also rely on water. The water we use today is millions of years old; it is not a source that we can renew or grow on a tree! About 97% of all the water on earth is salt water and 3% is fresh water (Anon, 2019e). Of the remaining 3%, less than 1% is available for human consumption. The rest is found at the poles in the form of ice (Anon, 2019e).

We use the term "water quality" to describe the biological, physical and the chemical characteristics of water (Anon, 2019d). These characteristics are influenced by several substances that either dissolve or stay suspended in the water (Anon, 2019d). The quality of water needed for different purposes varies. High quality water is required for household use and a lower quality is needed, for example, when you wash your car or water your vegetable garden (Cilliers, et al. 2019. Bl 181).

Total plate count is the measure of activity of all the bacteria, yeast and fungi that grow in aerobic conditions in a sample (Anon, 2019c). These tests are done at temperatures of between 20-45˚C (Anon, 2019c). The standard water quality for

drinking water should not contain any coliform bacteria. Water used for swimming can contain up to 200 coliforms whereas water in rivers may contain as much as 1 000 colonies (Anon, 2019f).

Faecal coliform are bacteria that live in the digestive systems of humans and all animals (Oram, 2019). *Escherichia coli* (*E. coli*) is a very common sub-group of the faecal coliforms. Most faecal coliforms are indicator organisms. These organisms may, if other bacteria with pathogenic traits are present, also become pathogenic (Oram, 2019). If faecal coliforms are present in rivers it is an indication that the water is contaminated with faecal material. The water is at the same time contaminated with diseases that spread from faecal material. This causes a serious health risk (Oram, 2019).

Coliforms add an excessive amount of organic material to the water and when the organic material decays it depletes the oxygen in the water leading to the death of fish and other aquatic life (Oram 2019). In drinking water there should be less than 1 colony per 100 ml with no *E. coli* present according to the standard water quality measurements. For close body contact the water should contain less than 200 colonies per 100 ml and for fishing the reading should be less than 1 000 colonies per 100 ml (Oram, 2019). For water heading to the water treatment works the colony count should be less than 2 000 per 100 ml (Oram, 2019).

Escherichia coli (*E. coli*) are bacteria that are able to grow in the most elevated temperatures. *E. coli* is only found in warm-blooded animals' faeces (Oram, 2019). E. coli is usually found in water contaminated with raw sewage. People ingest the bacteria when they drink the contaminated water or eating raw vegetables and even beef (undercooked) which is contaminated with the bacteria (Anon. 2019b). Ingesting the particular bacteria *E. coli* O157:H7 can cause the following symptoms: diarrhoea containing blood; vomiting as well as abdominal cramps. The bacteria can spread via personal contact, especially when the infected person does not focus on proper personal hygiene such as washing their hands thoroughly (Anon. 2019b).

At the wastewater treatment works the water that is contaminated with *E. coli* is treated with chlorine and ultraviolet light to kill the bacteria. With sewage spills, the untreated sewage enters the water system and will flow or seep into local rivers and dams, spreading the bacteria (Anon. 2019b).

In 2015 the South African National Standard (SANS) for water quality was determined for water that was used for drinking. SANS 241-1: 2015 indicates the values for drinking water quality as the following: Total plate count ≤1000; Total coliforms ≤10; *E. coli* and faecal coliforms should be less than 1 (Anon, 2015).

All the water systems are interconnected so if there is a problem at one of the pump stations in the area, the problem will soon enough affect the entire area. Water has the ability to move and transfer the sewage to "clean" areas (AKPA 20190705 Vaal River Catchment Exploration).

Emfuleni, Metsimaholo and Midvaal may have different provincial leaders and councillors, but they all have the same problem when it comes to wastewater management. These problems must be addressed by concerted action in higher places of authority (AKPA 20190705).

Deneysville

The information from one respondent was particularly worrisome: There have been multiple attempts to repair and upgrade the local pumps and water works, but shortly after the upgrade the pumps were vandalised – and sewage spills made their appearance all over again. The community is too numerous for the current pump systems to cope so the local authorities altered the wastewater systems to by-pass the pumps and water treatment works. The water is consequently not cleaned properly at the plant. Local animals are also suffering. Horses and cattle are grazing knee-deep in wetlands of sewage water (AKPA 20190708j).

Water samples were taken at Taaiboschspruit and Refengkgotso (AKPA 20190708). The results indicated that according to the SANS 241-1: 2015 the total plate count was above 1 000 with a score of 4 800. The total coliforms were measured as 200, whereas the maximum for safe drinking water is 10 and less.

The *E.coli* in the water in a sample of 100ml was 28 whereas it should be less than 1.

Dlomo Dam, Sharpeville

Dlomo Dam in Sharpeville serves the community by providing local fishermen with several fish species to catch and sell for an income (NMPA20190709a 1:1 Sharpeville – Steven Lerato Matswameng). A water sample was taken at Dlomo Dam in Sharpeville (AKPA20190709c Sharpeville Dlomo Dam Sample). The results indicate a high total plate count of 9 800 and a high total coliform of 300. The number of total coliforms is unsafe for human body contact thus swimming in the dam is to take a risk with one's health. The *E. coli* score was 23 where it should be less than 1 and the faecal coliform count was 31. Individually they are safe for body contact but unfortunately, they are mixed in the water making conditions unsafe for swimming. The water exceeds the South African National Standard and is not safe to drink.

Dawn View Guesthouse

In Peacehaven there is sewage running over the road on Golf Road. The sewage is a thick, dark grey to black colour and it has a foul smell. One of the reasons why the pump stations overflow with sewage is because waste such as diapers, condoms, sanitary pads and plastic is being flushed down the toilets, clogging the pipes. If residents take care of the waste problem this particular aspect of the sewage problem could be resolved. To solve the bigger problem each person should make an effort at home. Waste must be discarded in the proper way e.g. waste separation (AKPA 20190709a 1:1 Darren Milani).

When this problem was identified, a water sample was taken at Golf Road near Dawn View Guesthouse (AKPA20190709b Peacehaven Golf road sample). The results indicate an excessive amount of *E. coli* and faecal coliforms in the water. The *E.coli* count was above 8 000 and the faecal coliforms score was above 8 000 as well. The water is definitely unfit to drink. It is imperative to avoid all contact with this water because the total plate count was above 30 000 and the total coliforms count was above 8 000. The water in Golf road is highly polluted and is a real health hazard.

Sebokeng hostel

It is not only humans who are at risk from the sewage. Animals are also influenced negatively. They drink from the dirty water and scavenge for food among the foul-smelling waste. They would obviously also suffer ill effects (AKPA 20190709d Sebokeng Hostel Sample).

The sewage causes a health hazard and these spillages are unlawful. Many of the people who live in the Sebokeng Hostel suffer from skin rashes after coming into contact with dirty water (sewage). The local clinic is unable to provide the necessary care and it takes a long time for these itching rashes to disappear. People reported that they were affected at numerous levels (details were not specified) of their daily existence in Sebokeng by the sewage (AKPA 20190709e FGD2 Sebokeng Hostel).

Section 24 of the Constitution of the Republic of South Africa from Act 108 of 1996 states that every person has the right to a healthy environment (Warnich, 2018). The constitution stipulates that the ambient environment should not be a danger and people should be protected against any potential harm.

Women are more likely to develop skin infections and rashes because of their duties as wife and mother which may bring them in contact with water contaminated with sewage. The housewife washes the dishes as well as the clothes where they could be in direct contact with such water. A mother takes care of sick children, who have rashes and these may spread when a person comes in contact with another infected person (AKPA 20190709e FGD2 Sebokeng Hostel).

Figure 5: Cat drinking wastewater at Sebokeng Hostels (Photo Annika Kruger)

A water sample was taken at the Sebokeng hostels (AKPA20190709d Sebokeng Hostel Sample). In the 100 ml sample tested the total plate count was above 30 000 and the total coliforms tally was above 8 000. Body contact should be avoided if water is as polluted as this. The laboratory results, as well as the oral disclosures of local residents to the research group, explain a possible reason for

the rashes that community members contracted when they came in contact with this water. The count of faecal coliforms in the sample was more than 8 000 and the *E. coli* more than 8 000. The water is definitely not fit for drinking. The quality is too bad for general household use.

Sebokeng wastewater treatment works

During the interviews it was reported that staff going on pension are never replaced, thus there is a big shortage of staff in the whole department. The SANDF was sent in to help at the water treatment works, but local people were very worried that their jobs would be lost. The water works have people with the necessary knowledge to fix the pump stations, but when the research fieldwork was being done in July 2019, the workers were waiting for the municipality to give them the correct vote numbers to secure funds for upgrading to take place and the pump stations to be repaired (AKPA 201907011a 1:1).

Riverspray

A number of residences in the new town housing complex were affected by the stench caused by local sewage flows. The management of Riverspray is eager to take measures to prevent the sewage situation from becoming even worse in future. At the time of fieldwork the property developers were planning to install a septic tank for each of the new developments in future. It will however not resolve the problem of the dysfunctional local municipal pump stations. The installation of septic tanks will however take some pressure off the pump stations (AKPA 20190711f 1:1).

In July 2019 sewage flowed through the complex from outside. The water was a greyish colour to it and the smell was unpleasant.

A water sample was taken at the Riverspray complex (AKPA20190711h Riverspray Sample). The results indicate that the water is highly contaminated and body contact should be avoided because the total plate count was above 30 000 and the total coliform count was more than 8 000. More than 8 000 *E. coli* bacteria was present in the 100 ml sample and the faecal coliforms count

was more than 8 000 as well. This water should certainly not be used for drinking purposes.

Emerald Casino

Sludge can be used with benefit for fertilising the soil for growing crops and seasonal grazing. When sewage is treated the result is a nutrient-rich organic component collectively called biosolids. These biosolids can be used as a fertiliser and will improve crop growth (Resek, 2019). Biosolids have to meet strict criteria before the sludge can be applied as fertilizer. Biosolids contain a lot of efficient nutrients, such as phosphorus, potassium, iron, nitrogen etc., all of which are beneficial for crop production (Resek, 2019). However, after using this fertiliser The casino's management received complaints from guests about the smell. Visitors thought that it was the lodge's fault, but in point of fact, the casino management has a municipal pump station on the property. A local private contractor keeps an eye on the pumps. Sewage spills in the region are a daily issue so the lodge was forced to stop hosting game drives which have attracted many guests over the years. According to a spokesperson for the casino the municipality does not reply to e-mails and do not communicate readily with the casino management (AKPA 20190711 1:1 Emerald Casino – Mark).

23 Loch Ave Loch Vaal

People in the community have told members of the research team that at one stage they wanted to take action and start cleaning the river but they needed authorisation to take sludge from the Loch Vaal and this was not forthcoming. The river should be declared a national disaster area because it is a hazard to everyone's health, animals included. The local biodiversity is taking a big knock. The number of bird species seen in the area is also declining drastically.

Cyanobacteria are regularly found in samples taken from the river. Cyanobacteria are oxygen producing photosynthetic bacteria. Certain species have the ability to secrete toxins into water; they therefore have an influence on water quality. Cyanobacteria can live in extreme conditions (such as hot, cold and even in water with high salinity levels). These organisms have specialised cells that give them the ability to fixate nitrogen. These special cells are called heterocysts and are

vegetative cells surrounded by a thick wall. This wall prevents oxygen from entering, which allows the enzyme nitrogenise to transform nitrogen gas to ammonium (organic nitrogen) (Cilliers, et al. 2019). Cyanobacteria produce two types of toxins, namely neurotoxins and hepatoxins. Neurotoxins affect the neurosystem and can lead to death. Species producing neurotoxins are Anabaena; Aphanizomenon and Oscillatoria. Hepatoxins affect the liver and can even cause liver cancer. The species producing hepatoxins are Microcystis and Nodularia (Cilliers, et al.).

One of the respondents in the group discussions asked if the toxins can end up in our bodies if we eat vegetables that were irrigated by the contaminated water. Unfortunately, the answer to this question is yes and it is called biomagnification (AKPA20190713a,FGD, Lochvaal). Biomagnification is the overall increase in the concentration of the toxin in the food chain. The concentration increases the more it moves up in the food chain. This means the toxins intake increases when we move up the ladder water (Cilliers, et al. 2019).

A water sample from Loch Vaal, next to 23 Loch Ave Lochvaal (AKPA20190713b 23 Loch Ave Lochvaal Sample) was tested. An excessive amount of contamination was found in this sample with a total plate count above 30 000 and a total coliform count above 8 000. More than 8 000 *E.coli* bacterium was found in the sample and more than 8 000 faecal coliforms were present in the 100 ml sample. The river should not be used for boating or fishing since the total plate count is far above 1 000. Swimming in the river is a health risk and should be avoided.

ArcelorMittal

The total plate count of the water tested at the west exit of Mittal was above 30 000 and the total coliforms present in the sample was 200. The *E.coli* present in the sample was 11 and the faecal coliform count was 19. The results indicate that the water from ArcelorMittal is the cleanest sample tested but is still not within the South African National Standards for drinking water.

Case descriptor: Resilience

In the 1970s, C.S. Holling pioneered resilience-thinking in his study of wolves in the wild and their capacity to respond to adverse conditions by means of strategies of adaptation (Holling and Sundstrom, 2015, Resilience Alliance, 2010). Subsequently the concept has become an influential theory in the social and environmental sciences. In essence it implies, as Darwin's evolutionary theory of adaptation suggests, that in order for a species to survive there is a need to make the transition to different circumstances so as to progress, to transcend, and even overcome existential obstacles. An influential variant of resilience theory has been panarchy – the continuous repetition of cycles of infinity under ever-changing conditions in which actors in social ecological systems adapt as they proceed in time and space. It is possible, for example, to identify creative destruction, the conservation of resources and states of destructive collapse that make it difficult for social ecological systems to persist at all times without the need for adaptations (Gunderson and Holling, 2002, Allen et al., 2014). Current thinking therefore neutralises the axiom of 'survival of the fittest' and instead promotes strategies seeking adaptation, without unnecessary disruptions, to changed social-ecological circumstances.

Resilience is also approached in this study from the perspective of coping or adaptation strategies to achieve sustainable development objectives (Perrings, 2006). Social resilience is the capacity of individuals to adjust and possibly envisage possible events in future and plan for interventions that cause the least potential damage to livelihoods (Perrings, 2006). Resilience looks at various coping and adaptive mechanisms used by humans to meet challenges they may face. Resilience provides a platform for understanding how plans, e.g. recalling former means and strategies used in similar situations, to resolve problems by managing available resources effectively. It implies building resilience and forbearance in critical circumstances of potential collapse.

Selected examples of resilience in Emfuleni

At the time of the fieldwork, respondents were asked what coping mechanisms they used to deal with the challenges they face. Various responses were given. In

Westside Park, Sebokeng, respondents reported that they made use of buckets to fetch and store water (HJPA/20190706-22/Personal notes, 2019). This means that the bucket system which is generally seen as an inferior method of accessing water remains firmly in place as a contingency measure. It also shows how common, how 'usual' poverty is in the community. Overcoming obstacles requires that coping strategies be devised in critical times. The bucket system does not ensure that people have adequate water for all their basic needs. It relies largely on the distance travelled to fetch water and the availability of human labour (energy). In Sebokeng Zone 10 another respondent mentioned using buckets to store water, long before it was no longer available at local taps. (HJPA/20190706-22/Personal notes, 2019). In both localities the respondents reported that they did not have access to boreholes as back-ups. The bucket then becomes a coping mechanism and an agency for resilience. Locals claimed that boreholes were far from their settlements to be of practical use (HJPA/20190706/FGD1/Westside Park, 2019). However, in another interview the respondent said they do not 'cope' with the problem ... they just 'keep on living'. This shows a sense of hopelessness and lack of appropriate avenues to cope with dire situations.

Others have resorted to not paying for water; they use their money for other purposes such as buying food and energy alternatives – responding to the WEF-nexus security challenges. There are also community measures of mutual-self-help in times of need. For example, residents of homes where the taps had run dry, were allowed to collect water from households whose water supplies were still operational. In addition, some respondents explained that they had been driven to a state in which they resorted to protests and demonstrations to ensure that the responsible authorities took note of their plight (HJPA/20190709c/Sharpeville, 2019).

Protest actions and demonstrations do not guarantee favourable responses from the authorities. In one focus group discussion in Sebokeng's Westside Park respondents said that demonstrations and other forms of unrest had had yielded little in the way of results (HJPA/20190706/FGD1/Westside Park, 2019).

According to the respondents the settlement was deprived of all services necessary for general wellbeing. They had no access to water, electricity, no schools or clinics and had to put up with an overwhelming odour of raw sewage.

They complained that most of the people in the settlement suffer from chest illnesses (breathing problems) and many children, according to some local residents, had died from a range of illnesses potentially related to the obnoxious environment in which the community lives (HJPA/20190706/FGD1/Westside Park, 2019). Despite these problems there had been no support from the municipality. Respondents explained that the government should create avenues for effective coping and adaptation, to help promote resilience. One working class resident of Sebokeng expressed the view that if and when she had the opportunity she would move to either Pretoria or Durban where she felt the prospects of living a better life and finding employment were far better than in Emfuleni (TPA 20190706a, 2019). This can be seen as a form of resilience on her part, albeit in an escapist and alternative mode.

There are also reported instances of failed resilience, with people committing suicide, ironically (in response to a wastewater crisis) in close proximity to a waterscape. According to residents in Sharpeville (NMPA20190709a 1:1 Sharpeville- Steven Lerato Matswameng) the Dlomo Dam is a well-known suicidal area. People go to the dam and drown themselves in the water. In 2017 a decomposing body was found by residents looking for a perfect fishing spot (Mathebula, 2017). Residents explained that the number of women committing suicide by drowning in the dam is considerably higher than that of men. Women choose suicidal methods that are less painful and although they are taking their own life they are concerned about their appearance and generally will not do anything that will deface or disfigure them such as a gunshot to the head (Gruszczynski, 2011).

Local business people, because they are fired by an entrepreneurial spirit, have clearly not lost faith in Emfuleni. Even downstream of the Vaal River Barrage, at Parys, there is a sense of optimism. A young consulting geological hydrologist explained that he had no intention of moving away from the river. A river lifestyle

appealed to him and his family and they were determined to play their part in creating a better environment for all in the circles in which he and his family operated (TPA TOA/20180825, 2018). In Emfuleni, one businessman explained there was something special about the local community. In times of crisis residents of Vanderbijlpark tended to stand together. He spoke of the special sense of togetherness which was evident in February 2019, when the High School Driehoek experienced a structural collapse in the school building, claiming the lives and injuring a number of learners of the school (TPA 20190725, 2019). Against that backdrop he explained that the sense of community stands out as one of the strong traits of the local community. It represents a form of coping that is an extension of resilience under circumstances of disaster.

In some of the more affluent residential areas of Emfuleni the wastewater crisis created a form of resilience linked to altruism. In the case of Three Rivers in Vereeniging, local residents and business people managed to pool R1.5 million to repair potholes in collaboration with the local authority (TPA 20190709a, 2019). By making an investment in their spaces of domestic residence, they invested morally in the restoration and beautification of residential areas that were often littered with uncollected domestic waste the municipality had failed to remove. Their response was one of turning things around. What might have led to a sense of dejection was instead turned into a sense of neighbourhood and local belonging. Neighbours had to collaborate in creating an environment that made each other's lives more pleasant. In Vanderbijlpark, residents started mowing the grass on the middle isle of Frikkie Meyer Boulevard, while another group took the initiative to maintain the local playground, Phoenix Park. They even organised a fun Park Run every Saturday morning (TPA 20190725, 2019). Examples of resilience of this kind suggest that the wastewater crisis acted as a catalyst for local residents to adapt to circumstances and cope. under circumstances of what the potentially considered to be a form of creative destruction. It implies that when things fall apart, there is an ability to recover by adaptation to an even more favourable conditions.

Resilience is also evident in contingency plans devised by local residents. In both Vereeniging and Vanderbijlpark residents have begun working on plans, while others have even started implementing their idea of moving off the municipal grid entirely. Attention is being given to solar panels for electricity supplies. Others have started working on water reticulating systems stored in JoJo tanks linked up to the household water system. In some extreme cases residents are planning to go off the wastewater grid by resorting to well-sealed French drains on their properties.

Case descriptor: The private sector

The economy of the local municipalities of Emfuleni, Midvaal and Metsimaholo are inter-connected by the waters of the Vaal River Barrage catchment. In the scenario planning process of the research project there was consensus amongst senior members of the research group on a number of realities. South Africa's diminishing economic performance in the Zuma era (2009-2018) has had a profound impact on local entrepreneurial initiatives. Any initiative to restore or improve the state of collapse in Emfuleni Local Municipality by June 2018, in the view of the research team, firstly had to focus on the role of the local private sector. Emfuleni's commercial, financial and industrial stakeholders, it was agreed, had extensive investments in the local economy. Furthermore, their entrepreneurial skills are an important form of resilience: they have the ability to see opportunities where other mortals may only see disaster.

Secondly, there was consensus that in the current post-industrial era of local development it was essential to focus on the Vaal River Barrage as a potential social-ecological asset that should stimulate Emfuleni's economy in the years to come. The proviso was that the Vaal River Barrage needed to be cleaned up in such a way that it conforms to high standards of environmental health.

Business and the sewer problem

Business sector respondents, at the time of fieldwork in July 2019, experienced wastewater problems in a variety of ways. The research shows that fundamentally the sewage leaks had the effect of creating an awareness of neglect, and a remarkable (even shocking) absence of basic environmental health awareness on the side of the authorities. There was evidence of humans and animals at the risk of ill health amid ever-present odours of raw sewage. A common theme that came across in all interviews was the impact that wastewater leaks had on property prices. Homeowners affected by the problem wanted to sell their properties, but local estate agents found it almost impossible to find buyers. There was a sense of uncertainty if and whether the problem could be resolved. Property owners had to face the reality that if they wanted to sell their homes and relocate elsewhere, they had to be prepared to take a massive financial knock on their

property. It implied massive losses on their long-standing investment (SMPA20190711a).

Leisure businesses such as bed and breakfast establishments confirmed that sewer leaks were responsible for a decline in their business (SMPA20190716b). The eco-tourism sector, featuring activities such as bird-watching, fishing, skiing, boating and overnight accommodation on river boats, experienced a sharp decline in trade due to sewage in the Vaal River Barrage.

There is consensus among the business people that in recent years Emfuleni has featured in a negative light on various social media platforms such as Twitter, Youtube, Facebook and WhatsApp. The matter also received extensive coverage on the television and radio news broadcasts at the local and national level. In other words, there has been a great deal of negative publicity of the wrong kind. Prospective weekend visitors, even people with holiday homes of their own on the Vaal River Barrage, chose to seek alternative places to spend their time and money on more pleasant pursuits (TPA 20190725, 2019). The net result has been a marked decline in business. It has even forced some businesses to reduce staff numbers, or close down.

A further theme to emerge from the engagement with business people was that some years ago, a moratorium, on the advice of Rand Water's monitoring officials, was imposed on Emfuleni Local Municipality preventing development along the banks of the river. This has stymied all further real estate development. The lack of proper infrastructure services has directly affected development.

Currently the sewer infrastructure and its already overloaded capacity, cannot process any sewerage. The situation stifles further expansion plans of existing leisure-related establishments. The same goes for housing projects, factories, malls, student accommodation and office blocks; all have been hard hit by the state of affairs. Stephan Olivier of the Golden Triangle Chamber of Commerce (SMPA20190729) cited numerous examples of members of the chamber wanting to expand businesses, but being hindered by the moratorium. A similar issue was raised by the management and local property owners at Riverspray (SMPA20190711) where an investor would be unable to develop further housing units on the existing premises. Riverspray, for example is an upmarket property

development project close to the growing education hub on the boundary between Vereeniging and Vanderbijlpark.

Riaan van der Merwe, a committee member of the community initiative that goes by the name of Proudly Three Rivers (SMPA201907), and Olivier of the Golden Triangle Chamber of Commerce (SMPA20190729) singled out the example of a national milling company backing out of a project to build a very large bakery in Vereeniging citing unreliable service delivery as a main issue.

There are large long-term projects that are earmarked for the Vaal, such as a possible freight airport, a River City and the extension of the Gautrain into the Vaal region (SMPA20190729). These projects cannot possibly go ahead until the sewer system and accompanying utilities are properly functional (Blom, 2018). These issues are having a crippling effect on the economy of the region. Lack of expansion translates to more unemployment, higher crime, related social ills and poverty.

Corporate Social Responsibility

The former Vaal Triangle has historically been an attractive investment area for large, medium and small companies largely due to the availability water from the Vaal River, cheaper land and building costs. Up to the present many companies operate in the Emfuleni area. The research specifically probed how companies could render support in terms of the sewage crisis. It is noted again that the different companies or communities have different views on their ability to aid in the crisis. Some organisations can rally together and help while others are willing to help, but the help is informally and overtly declined by the municipality. Consequently, some business people see the problem as being the responsibility of the municipality. One form of informal governance is the example set by the community of Three Rivers, collecting money to the tune of R1.5 million to repair potholes in the suburb's streets. It was an intervention done in concert with the municipal activities on road repairs. The engagement was interpreted by both the suburb's residents and the local municipality as the product of a 'mutually trusting relationship'.

Cape Gate, one of the long-established local steel industrial firms, reported that they have been fixing numerous water problems such as pumps and leaks. It was

in the interest of their business. They rely on a large supply of water from the municipality (SMPA201924). Apart from actions reminiscent of informal governance, the company has also extended a gesture of non-publicised altruism. They have provided the local residential community in close proximity to the factory with a clinic, a hothouse for growing vegetables and gave employees fully paid bursaries for further studies. In matters of the local sewer problems the company (at its own cost) engages a local expert plumbing company, whenever there are problems. The question is: how long can this informal system of governance prevail?

Since 2018 South Africa's steel industry has been facing adverse conditions. In August 2019 ArcelorMittal reported that in the past year the demand for steel in South Africa stood at 70% of the steel consumed in 2008. This was the direct result of South African steel producers being unable to compete with international steel prices. Between January and June 2019 ArcelorMittal's profits dropped by 5% resulting in a loss of R638 million. The primary intervention by August 2019 required the potential retrenchment of an estimated 2 000 workers (Mathe, 2019). The Vanderbijlpark plant, the largest operation of ArcelorMittal in South Africa, could fall victim to large scale retrenchments. At the time of interviewing another large local steel producer, in July 2019, there were no indications of retrenchments.

Even in civil society, supported by the private sector, there have been attempts to help in the restoration of parts of Emfuleni. The Emfuleni Rate Payers Association has tried to engage with the municipality to help but the offer of rendering assistance has apparently fallen on deaf ears in municipal quarters. In a desperate attempt to address sludge deposits in the loch, less than 30cm below the surface waters of Loch Vaal (JTPA 20190713, 2019) local residents, at their own costs, attempted to resolve the siltation issue by dredging. That was summarily halted by Rand Water's management who are responsible for oversight in the area (SMPA 20190713). Emfuleni did not intervene in favour of either the residents or Rand Water. The lethargy of local government defies description. It simply refuses to be responsive and committed in the interests of

Emfuleni's residents. Is this to be interpreted as an unwillingness to be responsive – or simply not caring to take charge of formal local governance?
Emfuleni's sewer problem is massive and is essentially defined by three dysfunctional water treatment plants and 45 pump stations that are barely working. In the final week of July 2019 a central government delegation to Emfuleni committed itself to R400 million for essential work to be done, especially in the Sebokeng section of the Rietspruit (TPA 20190729, 2019). But the information was not relayed to important business stakeholders in Emfuleni. It is general knowledge that sums of money have to be spent. Local communities and small businesses tacitly reported that they did not have sufficient funds to help in the bail out process. In the first week of August 2019, they were still not precisely aware of when or where the work was to begin making an impact on the dire situation. Local business leaders did manage to secure sponsorship of materials from Sasol and ArcelorMittal for pothole repairs, but not for any repairs to the sewer system. ArcelorMittal (formerly Iscor) at present remains the largest steel producer in Emfuleni, but it seems to have isolated itself from public engagement. Based on a reputation, dating back to the mid-1990s, when they were fingered for the severe pollution of the groundwater in their area of operations on the western boundary of Vanderbijlpark, they have chosen to shift into a phase of semi-isolation – said to have been the result of brazen attacks by local activists working in collaboration with national and international NGOs (SMPA 20190724). Currently, Arcelor Mittal's water is treated by an international water company in a sealed system, which it claims, does not pollute the Rietspruit (TPA TOA/20190220, 2019).

An attempt was made to speak to ArcelorMittal, but this was unsuccessful. A spokesperson cited a journalist who, he claimed, was critical of the company's operations in Emfuleni (SMPA 20190724).

Since the 2000s Emfuleni has been part of public-private partnerships, with engineering consultants and Sasol on strategies for reducing potable water leaks – a debilitating inflow factor that contributes to pollution in the Vaal River Barrage (Wegelin et al., 2007, Gibson et al., 2015). But in recent time there has been a

reluctance on the part of Sasol to make overt commitments to Emfuleni. Could it be that large corporates who thrive in a different sphere of engagements with local authorities are averse to informal systems of governance?

However, Sasol maintains the Sasolburg wastewater treatment plant in Metsimaholo. It is a non-municipal function. This was by design because the plant was built first and the town was then developed with Sasol taking care of the wastewater treatment. In the 1950s Sasol was responsible for the founding of Sasolburg (Meintjes, 1975). When Metsimaholo experienced a water loss problem Sasol stepped in and implemented an innovative technique using water meters, consumption loggers and pressure reducing valves which showed that night-time usage was up to 85% of daytime usage indicative of serious leakages. This resulted in easier leak detection and repairs, which saved the council R12m. This reduced the maintenance budget even further, cutting it by half to R25m per annum (Sasol, 2019). It is noted that Sasol does not want to engage with Emfuleni municipality which once again is indicative of the reputational damage that Emfuleni has suffered in recent years in its engagements with key local and regional stakeholders.

Case descriptor: Intervention initiatives and local bias

A number of water sector operators have been active in Emfuleni Local Municipality's wastewater sector for a long time. Consulting experts in state-of-the-art technologies for dealing with wastewater processes have been in the system since the first half of the 20th century. As a result of the strategic location of Emfuleni, formerly primarily the industrial towns of Vereeniging and Vanderbijlpark, the regional potable water utility Rand Water has been prominent in advising local government in dealing with wastewater on the banks of the Vaal River. The role of Rand Water, for a short period of time seemed to diminish, largely as a result of Emfuleni's unpaid bills for bulk water deliveries for sale to households, industries and businesses. Despite the soured relations in the first half of the 2010s, Rand Water resumed its activities of supporting Emfuleni's water services authority Metsi a Lekoa, in dealing with wastewater and water distribution issues (Tempelhoff, 2015, Tempelhoff, 2019a).

As a result of Rand Water's extensive operations in the Emfuleni municipal area, relations have consistently been sound, for as long as the municipality was aware and willing to support the strict measures that had been laid down for keeping the Vaal River Barrage area (one of its former locations of water extraction) in an environmentally healthy state.

The South African National Defence Force in Emfuleni

When the South African National Defence Force (SANDF) marched into Emfuleni at the end of 2018 it marked the start of a direct intervention by the national government in a disaster situation that could not be summarily resolved by local, or even regional and provincial role players. They were welcomed with open arms by the regional society. They were known to have had extensive experience of similar conditions, having worked on a similar project in the Democratic Republic of the Congo. There was a sense of relief, but also a critical awareness that it would not be a quick fix (TPA TOA/20181108, 2018, Phakgadi, 2018, Simelani, 2018, Shelolo, 2018, Gous, 2019).

As early as April 2019 Rosemary Anderson, chairperson of the Emfuleni Tourism Association, let it be known that the activities of the SANDF were not quite yet achieving all their goals. Primarily, it was a matter of government putting sufficient funds at the disposal of the SANDF to perform the work. Up to April 2019 the SANDF contingent had been using its own funds to keep the operations on the go (Pretorius, 2019a).

Figure 7: Local entrepreneur and Vaal River barrage activist, Rosemary Anderson, has made a thorough study of Emfuleni's wastewater infrastructure to improve the river's environmental health (Photograph: S Mahabir)

In July 2019 the research group engaged with a diverse community of respondents on the wastewater crisis. The SANDF naturally formed part of the discussion. It was soon evident that there were divergent views about the presence of the military. For those who were aware that the SANDF was in the region there was surprise that the wastewater leaks of Emfuleni had not yet been fully repaired by the end of July 2019. There were also critical comments amongst those members of the team who were aware that things were standing

still because of the lack of government funding. There were rumblings that the SANDF presence was not proving very useful. It was considered a matter of urgency that an assessment be made of the state of the WWTWs, especially that of Sebokeng (TPA 20190705, 2019). One resident of Sebokeng suggested that instead of using the SANDF, community policing forums were ideal for the job. It was also argued there were enough police officials in the area to do the work (TPA 20190706a, 2019).

Views about the SANDF differed significantly in the areas where they had been deployed. In the Evaton West area, one participant indicated that there had not been any significant changes since their arrival in December 2018 (NMPA 20190706b Evaton West, 2019). At Westside Park residents had similar sentiments. They mentioned that the SANDF has assisted in the training of a few selected community members in combat and self-defence to halt crime in the area (NMPA 20190706c Westside Park, 2019). Other than that, many felt that the SANDF had not made any strides in resolving the sewage crises in the area (NMPA 20190706c Westside Park, 2019). One resident of Sebokeng argued that the SANDF presence in the area involved a substantial number of people. They consumed a lot of food while at the same time in the nearby community there were people who were going hungry (TPA 20190706a, 2019).

A participant in Sharpeville, gave a different account of the SANDF. It was claimed that the SANDF had been successful in stopping the spillage of raw sewage inflow to the Dlomo Dam at the local pump station (NMPA 20190709d Sharpeville, 2019). Also, a senior official at the Sebokeng regional wastewater works gave a positive account of the presence of the SANDF in the water works. They had reduced theft, he said and damage to infrastructure had been cut by more than 90% (NMPA 20190711f) (TPA 20190711a, 2019). He mentioned how community protest had previously hindered operations at the Sebokeng wastewater works. He claimed that after the arrival of the SANDF protests had stopped which allowed for the proper maintenance of the infrastructure. At the same time construction work on the local plant's upgrade could be continued (NMPA 20190711f Sebokeng Water works, 2019).

Private sector representatives argued that the involvement of the SANDF had an impact on the workings of the wastewater treatment plant, but it had little or no impact on the pump stations. It was claimed that the SANDF made idle promises and no action had been taken (SMPA20190725). At the site of a pump station situated on the premises of an international business consortium, the management threatened the Emfuleni Local Municipality with court action because of the unacceptable behaviour of SANDF officials on duty on the property, keeping watch over the local plant and its operations. The management of the company, of its own accord, re-hired the private contractors who had done the work prior to the collapse of Emfuleni's waste water infrastructure in 2018 (TPA 20190711, 2019).

It was noted that the SANDF did not have the requisite skills and money to deal with the problem effectively. A council advisor explained that even though Emfuleni was placed under financial administration in June of 2018, there was at the time, no accompanying management plan for implementation. Although the current serving document dates back to September-October 2018 (Emfuleni Local Municipality, 2018), its implementation only started in March 2019. By July 2019, only a few issues had been addressed, notably the purchase of compactor trucks and the restoration of municipal garbage collection services. In many respects the SANDF had fallen victim to delays in funding and had not reach the sites where work had to be done (NMPA 20190711, 2019; NMPA 20190713, 2019).

In a briefing to the National Assembly, Colonel Andries Mahapa, the local operation commander, indicated that the cost of the work would be R1bn and the expenditure had not yet been guaranteed (Parliamentary Monitoring Group, 2019), he also indicated that the SANDF faced a challenge of "*transport capability for the rotation of troops and needed a high pressure jetting truck with a suction unit and sewer unit trailer"*. This, he said made the work of the SANDF a lot more difficult (Parliamentary Monitoring Group, 2019).

Respondents in group interviews were of the view that the SANDF had made idle promises. Accusations of SANDF officials partying, drinking and entertaining prostitutes at some pump stations (SMPA20190725) were made and verified. It was also noted in various discussions that the SANDF did not have the requisite skills to deal with a broad spectrum of wastewater technologies under all circumstances. By July 2019, very few issues had been addressed, notably the purchase of compactor trucks and the restoration of municipal garbage collection services. In many respects the SANDF had fallen victim to delays in funding reaching the sites where work had to be done.

A local bias

Local activists forming part of the research group's fieldwork suggested that the work done on the construction and maintenance of the wastewater treatment works infrastructure had to become the responsibility of the community. Local people had to be employed. The community would take ownership of the recovery work under way (TPA 20190705, 2019). At first sight statements of this kind imply a sense of local patriotism. But the intrinsic problem of getting the work done and finished on time, appears to be more deeply seated.

In the portals of local power there was a discourse that Emfuleni Local Municipality had experienced great difficulties in engaging with other governmental stakeholders. Local government appeared to have been 'over-regulated' with all operations subject to scrutiny and approval by provincial authorities, as well department of cooperative governance and traditional affairs (COGTA). At all levels there had to be a direct correspondence in setting up a financial budget, subject to the approval of the national treasury. The problem of interaction was not exclusive to the executive political levels of local government. It was also evident in the departmental administrative and management activities. Since Emfuleni was placed under financial administration in June 2018 it had also been subject to greater scrutiny and support by central government (TPA 20190715b, 2019). The political leadership was aware of a shortage of sufficient skilled human resources to deal with Emfuleni's wastewater infrastructure and its

operations. In many respects the presence of the SANDF, even if it were only in a form of moral support, contributed to restoring some order in Emfuleni.

ERWAT

At the time of the South African Human Rights Commission's hearings on Emfuleni in November 2018, the two metropolitan municipalities of Johannesburg and Ekurhuleni submitted evidence on how their wastewater could not possibly affect operations in Emfuleni. Both metros' officials were articulate in their expositions on the way in which they treated wastewater in these two prime metropolitan areas of Gauteng Province. Ekurhuleni's East Rand Water Authority (ERWAT) in 2019, as was the case with Johannesburg's Municipal wastewater management officials, were adamant that they were not a contributing factor to Emfuleni's wastewater woes (TPA/TOA20181120, 2018).

Local bias

Residents of Emfuleni, as well as some local officials, with good reason, were not of the same view on upstream wastewater deposits. Following a visit in April 2019 to Emfuleni, representatives of the SAHRC and officials and the political leadership of Emfuleni agreed that the incorporation of ERWAT, to help deal with Emfuleni's wastewater crisis, could be of value. By July 2019 there was confidence that the Ekurhuleni-based operation did have a great deal of expertise and would be in an ideal position to help in the recovery of Emfuleni's infrastructure (TPA 20190711a, 2019).

At the time of a research engagement with the wastewater stakeholder leadership in August there were firm voices opposing the ERWAT engagement in Emfuleni. It was claimed that Ekurhuleni's operations were largely responsible for the wastewater flowing into the Vaal River Barrage. The website of ERWAT also bore witness to significant operational difficulties. It was said that instead of spending money from the central government on a neighbouring municipality, it made

more sense to appoint local water sector operators who were far more familiar with the local wastewater situation (TPA 20190815, 2019).

Caveat to local bias

Having a local bias and working in the interest of the local economy, local job opportunities and a commitment to investment in Emfuleni's welfare is fine, but for some time there have been rumours that 'all was not right' at the construction site of Sebokeng's regional wastewater plant. First it was the protests by local residents seeking job opportunities. Later it was protests by the workers on the site insisting that their safety was jeopardised. They needed protection. The conundrum of jobs and a construction project in urgent need of completion suggests that more sinister forces may have been at work behind the scenes.

As early as 2017 Consulting Engineers South Africa (CESA), warned government of consulting engineering firms with no record of delivery, operating like gangsters on vulnerable construction sites (Creamer media reporter, 2017). By 2018 labour-related protests at Sebokeng's wastewater construction site caused delays (Tempelhoff, 2019a). As the reported incidents of gangster-type behaviour at construction sites increased, the Black Business Council in the Built Environment (BBCBE) also added its voice of concern to the government (James, 2019b). This was after the South African Institution of Civil Engineers (SAICE) expressed grave concerns about a mafia-type culture developing in the construction sector where gangs of armed men would arrive on construction sites, disrupting operations (James, 2019a). A similar warning was issued by the Association of South African Quantity Surveyors (ASAQS) (James, 2019a).

In the run-up to the national election of 2019 government promised to clamp down on corrupt activities. Patricia de Lille, the former Mayor of Cape Town, was appointed as minister in the new cabinet of President Ramaphosa to ensure that public works and infrastructure projects were operating on a clean slate (Creamer, 2019b). As late as August 2019 the working environment had not yet been cleared up. In a cynical aside an influential public commentator, Anton van Niekerk, pointed out that whereas the state had made available R947bn in the

2017-18 financial year for infrastructure development, the amount, as a result of the government's austerity measures, had shrunk by 12% to R834bn for 2019-20). Apart from job losses, the country's construction sector at the start of a new financing cycle had to come by with less state funding. Van Niekerk warned that it worsened the situation in the aftermath of former President Zuma's calamitous 'radical economic transformation'. Gangsterism in the infrastructure construction sector appeared to be the hallmark of a corrupt legacy pre-dating the Ramaphosa era (Van Niekerk, 2019).

The idea of a local bias, in favour of local people securing job opportunities, and local companies taking charge of infrastructure projects is fine. However, when it comes to skilled human resources for specialised jobs, there must be an awareness of sound security and a stable environment in which much-needed infrastructure construction projects can be completed. There has to be greater transparency in procurement and tender processes, especially in cases where crucial services are dysfunctional and infrastructure is in a state of crisis.

Interpretation: Diverse views of residents on Emfuleni and the Vaal River Barrage

Governance

From what has been reported thus far, it is evident that in mid-2019 Emfuleni Local Municipality (ELM) found itself in a vulnerable position. Not only had it been placed under administration, it faced the daunting task of having to mitigate its way out of the 2018 wastewater disaster event. The objective of this research project has been to contemplate aspects of governance, literally from the bottom up – from the perspective of local residents at grassroots level. At the same time members of the team worked hard at considering the conundrum from the perspective of outsiders. What potential strategies could be considered for ELM to work itself back to the status of a respected service provider? A number of diverse issues are discussed below. Many of the insights were generated from group discussions, interviews and hours of deliberations with a broad spectrum of people who have a vested interest in the welfare of Emfuleni Local Municipality.

The anathema of corruption

At the time of internal research group discussions, the issue of the stigma of corruption was singled out as the prime issue that needed to be addressed in the context of Emfuleni Local Municipality. It was identified as a prime requirement for restoring proper systems of governance. Any symptoms of corruption may be seen as a leadership attitude amongst politicians and officials who assume they need not act in an accountable manner. Their actions have to be transparent and well-communicated (NMPA 20190725). Corruption in municipal wastewater is not confined to Emfuleni (Timse, 2019). In August 2019 a leaked forensic report suggested that in 2018, Emfuleni had spent as much as R1bn on vehicles, without respecting existing official service level agreements (Mabena, 2019). The reluctance of officials and conniving politicians to be transparent in their dealings with local government funds are doing local government a disservice. For

example, officials, in one focus group discussion, advised on the need for the decentralisation of power, to reduce corruption and ensure fairness in providing services. One official, explained:

> *(S)ometimes when you receive a complaint and take it up to the bosses we are told that we have to solve problems in some areas while the problems (in) other areas are ignored* (HJPA/20190711/FGD3/SWCW, 2019(NMPA 20190725).

Local residents, in discussions with the research group, contended that in some cases funding given to promote service delivery could not be accounted for. Some projects had been signed off but without proper planning of implementation or supervision of the process. There is a need, an absolute necessity, to follow correct procedures; this promotes good governance which boosts development and economic growth (HJPA/20190706-22/Personal notes, 2019).

In almost every discussion with residents of Emfuleni, NGO representatives, as well as local officials, there were grave concerns about corruption. The wastewater stakeholder leadership deliberations with the research team had significant local political-style debates starting up between members of the parties in Emfuleni's council (TPA 20190815, 2019). A major shortcoming was the apparent unwillingness of the political leadership to engage in a proper process of communication with Emfuleni's residents. The only way to clear the political air, would have been positive engagement with all the residents of Emfuleni, to give them the assurance of eliminating corruption at all levels of local government. This assurance was not forthcoming.

Loss of confidence

At the time of an engagement between the research group and officials (not senior management) it was evident that there has been a loss of confidence in Emfuleni's local government. The spillage hotspots in Emfuleni in April 2019 were: Peacehaven, a residential area in Vereeniging; the Shingwedzi apartment building in General Hertzog Road; and Vereeniging's CBD, where some buildings were said to be 'sinking' under sewage. The a prime recipient of the untreated

wastewater of the Sebokeng and Rietspruit wastewater treatment works was Loch Vaal, close to the Barrage weir on the Vaal River where extremely high counts of *E. coli* were registered. The testing process revealed a count of as much as 130 000 000 ppm/100ml. The legal count is a maximum of 400 ppm/100ml (Pretorius, 2019b). Matters had not changed much by July 2019 when the research group began working on the project.

Figure 8: A makeshift brick weir channelling a comprehensive raw sewage leak to a storm water drain in Peacehaven, Vereeniging, August 2019

At a session with the research group, a group of Emfuleni's water officials explained that they felt hamstrung. As a result of Emfuleni being placed under financial administration, officials did not have a proper budget to pay for essential items such as water meters, critical equipment and the execution of certain executive decisions at a basic operational level (TPA 20190711a, 2019). Water sector workers were very aware of local residents having lost faith in municipal operations. They pointed out that they were unable to take proper charge of

critical matters because of the lack of funds (TPA 20190711a, 2019). The research group was told that the officials' confidence to act in the interest of residents, had been dealt a hard blow.

At the time of interviews with a broad spectrum of residents and officials, respondents reported very weak checks and balances in ELM. There was a centralisation of power in certain individuals; this caused setbacks in service delivery processes. Water officials had to wait for months for authorisation of funding on projects that needed to be executed urgently. There is clearly a need for various avenues to reduce red tape in government systems (HJPA/20190706-22/Personal notes, 2019). To what extent unlawful procurement practices in goods and services might have been behind the lethargy in the ELM, was not disclosed.

The lack of confidence in political leadership also featured in discussions between members of the wastewater stakeholder group. It was explained that some senior management officials, as well as elected councillors were not resident in Emfuleni. Not only were they unaware of what was happening in Emfuleni, they were spending the money they earned in Emfuleni in either Johannesburg or Ekurhuleni (TPA 20190815, 2019). At the time of interviews, residents of Sebokeng mentioned that their councillors were not resident in the wards they represented. This was seen as a serious shortcoming of basic civil courtesy towards Emfuleni's residents. In NGOs such as OUTA, there were reservations expressed about the effectiveness of ward councils, whose members came from various areas of Emfuleni. One resident of Vereeniging explained that his local councillor served a diverse group of people, ranging from members of the commercial sector to those resident in old and well-established suburban areas (TPA 20190709a, 2019). It appeared as if the councillor was unable to rise above his political allegiance and work in the interests of the ratepayers in his ward.

Remorse

There has been no admission on the side of Emfuleni Local Municipality of any wrongdoing. Reports of malfeasance have been circulating in the local and national media for a considerable period of time. Neither has there been any

indication of remorse in matters related to corruption and/or the actions or inactions of local officials in the execution of their tasks. By making an admission that there were certain irregularities in former times, but that in 2019 there is now the will to set things right, the political leadership and management officials might engender a sense of understanding from Emfuleni's residents. According to wastewater sector leadership stakeholders, a statement of some sort by the ELM should speak of finding common grounds for trust between the local government and its residents (NM/LN 20190815, 2019).

There is also the need for the local authority and its leadership to articulate why this crisis has emerged: what was different in 2019? The wastewater system that prevailed previously was adequate although far from exemplary; why has it now collapsed? Members of the wastewater stakeholder leadership group appear to be cynical on the answer here. One spoke of 'reinventing the past', which in in the case of wastewater, did not have a long history of positive outcomes (TPA 20190815, 2019). Once again, the need for proper channels of communication between the local authority and its residents is of cardinal importance.

Government 'not enough' money

The lack of the effective control over spending has been a problem for officials at Emfuleni's water services authority, Metsi a Lekoa. It has been unable to install meters because the responsible division had no budget allocation because Emfuleni is under financial administration (TPA 20190711a, 2019). There was simply insufficient money. In April 2019 government announced that R341 million was available for dealing with ELM's sewage crisis. Part of the plan was to train as many as 2 000 young people as carpenters, plumbers and builders – and as guards for keeping an eye on the sewage pump stations of Emfuleni (Pretorius, 2019b). Even in the preliminary phases of planning the programme to address the crisis, estimates suggested that at least R800 million would be required to do all the work. It seemed as if the local authority merely sat back with their arms folded and relied on central government to pay for whatever happened in the local water sector. For local authorities, water rates represent a source of sound

revenue. There appears to be a lethargy on the side of Emfuleni's politicians and officials to explore this avenue further. It is a matter that needs concerted attention. All Emfuleni's residents should be surveyed to ensure that all residents who are in a position to pay for services should be urged to do so.

The factor of distrust in the operations of the local authority is deep seated. People want greater transparency. At the stakeholder wastewater leadership session, participants stated that there was a need, literally on a daily basis, for reporting back on all expenditure made by Emfuleni Local Municipality (TPA 20190815, 2019).

Communication with stakeholders

At the municipal leadership level, politicians admitted that there was insufficient communication with the public (TPA 20190715b, 2019). Officials, in turn, have also been alerted to the fact that its customer engagement programme does not operate appropriately (DWS). At the time of formal engagements with officials there was clear evidence of a significant shortfall in the number of officials who had to respond to the public's queries at Metsi a Lekoa's customer care centre (TPA 20190711a, 2019). Private sector partnerships with Emfuleni Local Municipality are important. A far-sighted and responsible local authority should nurture these partnerships in times of crisis. In discussions with local entrepreneurs the response to questions of communication with Emfuleni Municipality varied from 'very amicable and constructive', to 'most unhealthy' (SMPA20190712, 2019, SMPA20190725, 2019).

The unhealthy relationships are characterised by conflict, mistrust, legal action and accusations of fraud on the part of the municipality (TPA 20190815, 2019, TPA 20190711, 2019). Respondents who were interviewed cited a complete lack of communication between the public and Emfuleni Local Municipality. Residents argued that municipal officials were rude and unhelpful and did not bother to respond to emails. An anonymous participant claimed the municipality had been involved in a questionable award of a contract to repair a pump station, as well

as setting fire to a municipal building to destroy evidence of fraudulent activities (SMPA20190707).

One of the leading proponents of Vaal River Barrage tourism, the entrepreneur, Rosemary Anderson, indicated that there was a complete lack of public communication with the municipality. Even in the confines of the municipality there are no communication channels between officials (SMPA20190716b). It appears that there is a lack of understanding of the true nature of the problems, as well as a lack of expertise. Anderson insisted that stakeholders need to understand the issues at hand and be informed regularly of good and/or bad news. Ultimately ELM is running on taxpayer's money and taxpayers themselves had the right to know what was going on.

Figure 9 Members of a wastewater stakeholder leadership group sharing their views on Emfuleni and the Vaal River Barrage (Photograph: J Wessels)

At the time of the wastewater stakeholder leadership session, there was a sense of eagerness on the side of the public to establish co-operative relations with

Emfuleni Local Municipality (NM/LN 20190815, 2019). A friendly atmosphere prevailed in the first round of discussions when the wastewater stakeholder leadership was asked to outline the problems with the wastewater situation. At the second engagement, when they were asked to speak about *solutions*, stakeholders steered deliberations in the direction of altercations between councillors (elected representatives of the various political parties) in Emfuleni. In some cases civil society organisations, such as the Emfuleni Ratepayers Association (ERPA) and the Vaal Action Group (VAG) pointed out that they had been trying to engage with local government in the search for solutions. These endeavours had stalled because their representatives were at 'two ends of the stick' and could not find any common ground (TPA 20190815, 2019).

In recent times there have been some communication initiatives. Constructive relationships were noted by the Golden Triangle Chamber of Commerce and Proudly Three Rivers. These two organisations meet at a newly formed ELM/Business forum which is an initiative initiated by the current Emfuleni Municipality and Mayor Gift Moerane. The forum is intended to be participatory and a memorandum of understanding is already underway. According to Stephan Olivier, the management of the Chamber of Commerce has made an agreement with Emfuleni Municipality that members of the chamber would come together and sponsor materials for the repair of potholes in Emfuleni Municipality. The relationship is one of mutual trust and cohesion and is indicative of a determination to work together to resolve issues (SMPA20190729).

However, while conducting the fieldwork, the research team encountered evidence that all ties of friendship have not yet been restored. A senior manager at a local steel manufacturing plant indicated that historically, relationships with Emfuleni have been good, but in recent years these have become more strained due to court actions taken against the municipality over electricity load shedding (SMPA 20190724). It is unclear why some organisations have these unhealthy relationships with the municipality. This is contrary to the tenets of participatory governance emphasised by advisors to the political leadership of Emfuleni (SMPA20190715). The wastewater stakeholder leadership is of the view that

judicial measures have in the past proved ineffective in resolving Emfuleni's wastewater issues (TPA 20190815, 2019). However, under extreme circumstances local business leaders feel that legal measures are perhaps the only way to ensure that their operations do not suffer crippling losses (TPA 20190711, 2019).

In the interviews conducted by the research group, business people stressed that the integrated development plan (IDP) required of the municipality to consult with communities on their needs. However, this consultation did not seem to be happening with certain communities. Examples were cited of student accommodation close to one of the local institutions of higher education. What used to be normal suburban homes have been turned into hostels with as many as 19 bedrooms, and only one kitchen and a bathroom-toilet chamber. This placed a severe strain on the existing municipal infrastructure and posed a major environmental health threat with blocked drain pipes frequently flowing into the streets, a public throughway used by many pedestrians, including the students (TPA 20190725, 2019).

From the municipal leadership side, it was argued that ELM has struggled with service delivery over the last five years. One may speculate whether it is the unhealthy relations between the municipality and the private sector that have caused the poor record of governance by Emfuleni. Some stakeholder leaders explained there was an (institutional) culture problem at Emfuleni Local Municipality (TPA 20190815, 2019).

The present mayor, Gift Moerane, was appointed in January 2019. In an interview held with one of the mayor's senior colleagues, it was said that mid-2019 was still 'early days'. Emfuleni was working on resolving issues but needed 18 months. Emfuleni, he said, was the first of a kind. It was the first local authority being placed under administration. In effect, it had been agreed by government that in future, before municipalities would be placed under administration, there should first be a proper audited plan in place. This would be a plan of listed problems and their proposed solutions before steps were taken to place the authority under administration (SMPA, 20190715, 2019).

And yet, inexplicably, many of the plans for setting things right have, up to the present, not been communicated to the residents, the members of the public who after all are impacted most closely by the crisis. Importantly, by the end of August 2019, there were still no signs of the wastewater infrastructure crisis being addressed in any significant way.

Poverty and governance

In respect of poverty and governance, local residents in Sebokeng told the research team that there was a distinct divide between Emfuleni's poor and the rich. The poor tended to be somewhat more excluded and 'at an even greater distance' from the authorities. There is evidence of poverty in many parts of greater Sebokeng. In an interview, one working-class resident observed that people did not have money. In addition, they were unwilling to do anything for nothing (TPA 20190706a, 2019). There also appeared to be a significant number of people who were no longer seeking jobs. They had 'given up'. They were too demoralised and were 'hanging about' in an area with limited employment opportunities. Some jobless people argued that nobody cared about them so it was in order to simply ignore basic conventions of a sense of civility in the community of residents. The hopelessness was said to register profoundly in a distinct divide between the poor and the rich. The poor only become poorer.

From discussions with a broad spectrum of residents it was evident that the wastewater crisis was not exclusively a divide between the rich and the poor residents of Emfuleni. At a meeting of stakeholder leaders on the wastewater crisis, one member spoke out on the need to give attention to social justice and to redress disparities between the rich and the poor residents of Emfuleni Local Municipality (TPA 20190815, 2019).

Ultimately, all people in Emfuleni are affected. However, their responses vary. Whereas residents in the more impoverished parts of Sebokeng tend to resort to violent protest, most working class residents of Sebokeng, Vanderbijlpark and Vereeniging resolve to slog away and keep on by paying rates and taxes. Although in the interviews there were some ratepayers who took a strong stand in favour

of withholding their monthly payments to the local authority, it appears that this has not materialised in any organised manner. In some quarters there was even talk of 'ringfencing' certain payments (SMPA20190802). Ratepayers of Emfuleni were also at the forefront of direct face-to-face engagements with officials at the municipal offices but apparently, more than often issues were unresolved.

Feelings of disrupted living conditions, have angered all residents. Amongst well-informed residents, there was consensus that wastewater poses a major environmental health threat. The residents in poorer areas were also angry, but tended to feel helpless about improvements and were not quite aware of the health implications of exposure to wastewater. There was evidence amongst the poorest of the poor of a loss of trust in the local authority and its ability for setting things right (HJPA/20190709c/Sharpeville, 2019).

Figure 10: A working class suburb of Sebokeng Zone 10, where streets have potholes as a result of persistent wastewater overflows

Amid the poverty there was also evidence of human kindness. In parts of Emfuleni people have started joining hands. In Sharpeville, members of one family reported

a gesture of good-neighbourliness in a poverty-stricken area. A local resident told a member of the research team that their house was on the verge of collape. They had not received any assistance from the authorities. However, after seeing the decrepit state of their house, another resident donated a shack for the desperate family to live in (LNPA20190709d, 1:1, Sharpeville).

The poorest people appear to be settled in the peripheral areas of Sebokeng. At the core of the well-developed parts of Sebokeng, residents are closer to shops and transport facilities. People in the outlying parts of Sebokeng have to commute over long distances to their jobs. It means that some do not have much money left for their personal livelihoods, once they have paid transportation fares (TPA 201907806b, 2019). From a governance perspective, public transport should become more readily available and affordable, specifically for servicing peripheral communities. It speaks to the energy component of the WEF nexus that translates into payment for water services and the procurement of food supplies for poverty-stricken households.

Figure 11: Chemical toilets at informal housing in Westside Park, Sebokeng

There are numerous households in Sebokeng without reliable access to basic services. In Westside Park residents have reasonable access to water and energy, but have no health services. Their sense of material poverty is deepened by the cognitive awareness of the growing incidence of crime and a high local death rate. Women are being raped in open spaces and there are reports of children who die at a very young age. Residents are aware that the bodily remains of people have been found in the open spaces of Westside Park (HJPA/20190706c/FGD1). Most respondents, at the time of the interview, were unemployed. Some did not even receive government grants. These people have limited choices to help themselves. At the Sebokeng hostel poverty is evident everywhere and the stench of sewers pervades. Events of sewage flooding are frequent (HJPA/20190709/FGD2; NMPA/20190706c2019).

The respondents who are resident in West Side Park gave evidence that they feel they have been neglected by politicians who only remember them during elections. One explained that they still relied on 'mobile' (chemical) toilets with buckets, which are seldom cleaned. There are reportedly worms there, that make it impossible to use outside toilets late at night. According to the respondents interviewed, contractors who are supposed to do maintenance of these buckets are aware of these problems in West Side Park, but choose to ignore the people's plight (HJPA/20190706/FGD1). People said that they were sick as a result of living in what appeared to be a 'hopeless area'. In addition, they intimated that the municipality was aware of the high local death rate amongst children in West Side Park (NMPA/ 20190706c). The area appears to be hazardous to everyone living there. Some people in a nearby informal settlement have reported finding snakes inside their homes (NMPA/ 20190706c).

As a sample survey, outside the Emfuleni area, members of the research team interviewed residents of Refengkgotso near Deneysville, on the Free State side of the Vaal River Barrage. There was evidence of local residents who had started their own gardens to secure food supplies, albeit not at all homes (LNPA20190708b, 1:1, Refengkgotso). There were few examples of residential vegetable gardens in Sebokeng, presumably because local residents were in a

more advanced phase of urbanisation, finding themselves in a money-based local economy. In Refengkgotso, on the other hand, people merely spoke about being unemployed and even asked members of the research team, if they knew of any job opportunities.

Figure 12: Livestock grazing in wastewater wetlands outside Refengkgotso. The local wastewater treatment works are not operational and water is diverted to the Taaiboschspruit. This water then flows into the Vaal River Barrage

Local government and water services management

At the third tier of government, be it a metropolitan, district, or local municipality, a formal water services authority (WSA) has the responsibility for water-related services in terms of the Local Government: Municipal Structures Act, No. 117 of 1998 and its subsequent amendments. The legislation, however, only refers to infrastructure that enables a municipality to generate revenue and serve the interests of residents (Republic of South Africa, 1998). The WSA typically drafts a water services development plan (WSDP) for the area in which it operates. Its operational rules are outlined in the Water Services Act. This means, inter alia, that the WSA has oversight over water services and water service providers in its

area of supervision. Because not all urban areas in South Africa are the same, it is required of the WSA to operate within a framework, delineated by the Department of Human Settlements, Water and Sanitation (HSWS) to formulate a set of by-laws and the regulation of contracts (Tissington, 2011).

In the case of the WSA of Emfuleni, Metsi a Lekoa, Rand Water – as is the case in the rest of Gauteng – is responsible for providing potable water. Emfuleni Local Municipality's WSA for all intents and purposes, needs to dedicate most of its attention, indeed its primary attention, to developing a comprehensive wastewater infrastructure system. The fact that it renders both direct and indirect services to the metropolitan authorities of Ekurhuleni and Johannesburg, as well as to Midvaal Local Municipality, implies that there are certain revenue opportunities from bulk services that cannot be generated effectively. It is uncertain what material benefits Emfuleni has from processing the wastewater of neighbouring local authorities. If Emfuleni is a beneficiary of rendering wastewater services, there may at present be a dangerous shortfall of capacity. Emfuleni's inability to respond properly to its bulk customers would then have a knock-on effect for its small domestic and commercial local customers.

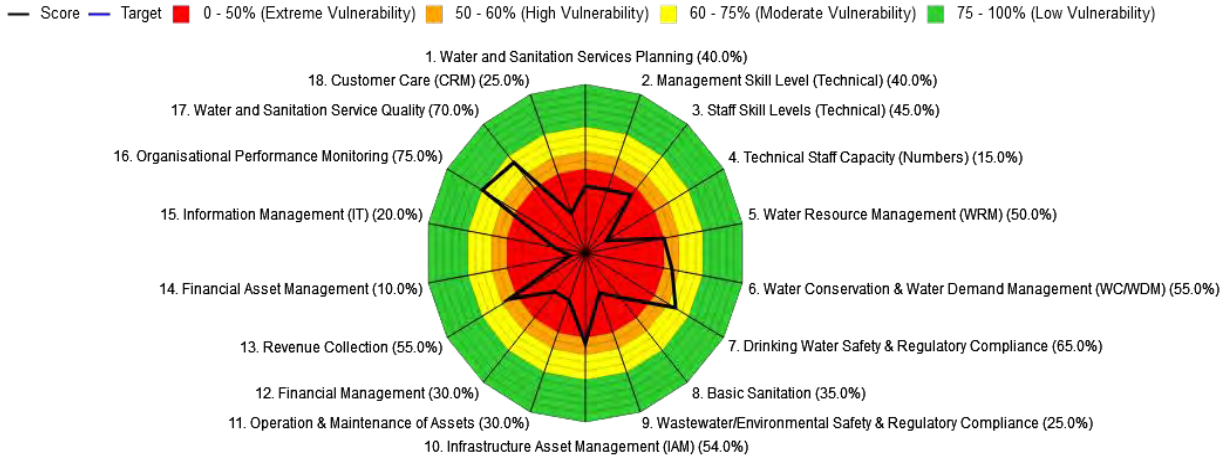
The situation of Metsi a Lekoa

The best way to form an impression of the most desirable governance measures is to assess the operational performance of Emfuleni's wastewater treatment operations. According to the DWS, 64% of South Africa's municipal wastewater treatment plants are not implementing up-to-date and council-approved water and services development plans. At least 61% of the officials working at municipal wastewater treatment works do not attend the additional training and development sessions offered by the national department and other service providers. There is also is a lack of foresight. At least 58% of water services authorities (WSAs), like Emfuleni's Metsi-a-Lekoa, do not have comprehensive water conservation (WC) and/or water demand management (WDM) plans in place. As a result of these conditions, at least 42% of WSAs water supplies finish

up as non-revenue water, i.e. it is not paid for by consumers (Department of Water and Sanitation, 2019).

If Emfuleni's municipal authority intends to turn the Sebokeng Regional Water Care Scheme into a locally operated, state owned entity (SOE) it would require, as Gumede points out very explicitly, substantial business savvy and a well ordered local governance infrastructure planning framework (Gumede, 2019). In the case of Emfuleni some of these skills may be amiss or absent. The DWS in 2018 pointed to a number of weaknesses in Metsi a Lekoa's system (See Figure 2). An assessment was done in collaboration with all officials of Metsi a Lekoa. At that time the vulnerability index (displayed in a spider diagram below) displayed disconcerting indicators.

Figure 13: The municipal strategic self-assessment of Emfuleni's WSA in 2019 confirmed that in terms of the spider diagram below, it had a vulnerability rate of 0.91 - well above the South African average (DWS ELM SALGA, 2018)



Matters that needed attention included the need for: improved staff skills (45%); water and sanitation services planning (40%); better management skills (40%); the proper operation and maintenance of assets (30%); and financial management skills (30%). As far back as 2011, Tissington warned that institutional and financial challenges at the local government level, along with the absence of a political will, contributed to conditions in which basic sanitation principles were not compliant with existing legislation. There was also a lack of the necessary enthusiasm to drive proper service delivery (Tissington, 2011). In the case of Emfuleni Local Municipality those fault lines were more apparent than ever before, in the case of Metsi a Lekoa.

Governance informalisation

In many ways there is evidence of an informalisation of systems of governance in Emfuleni Local Municipality. In the upper echelons of residential interests there are those who argue: 'We do not want to take over local government, we only want to work with the authorities.' At the lowest level there are residents who argue: 'Local government has to be responsive to the prescriptions of national government and provide proper service delivery.' It is then assumed that governance implies that the non-payment for services is permissible. It is part of the system of governance. In the middle there are the officials who have their administrative governance tasks cut out. However, they remain subject to the elected political representatives of the residents who interpret, if and when they are committed to their constituencies, to rule in in the interest of all the people (i.e. the residents of Emfuleni).

Figure 14: A local Vanderbijlpark industry has for some time been spilling wastewater from a broken wastewater drainage on the main road between Vereeniging and Vanderbijlpark. The leak has now been transferred to the local storm water drainage system. It causes a terrible stench at local sporting amenities and at a shopping centre

Symptoms of informal governance are evident in action when a local authority requests a rate-paying local industry to help restore and pay for equipment when a municipal pump station breaks down (TPA 20190724, 2019). Whenever the governance authority's officials act in contravention of prescribed guidelines for providing services to ratepayers, there is evidence of informalisation. This has profound consequences for the way in which officials can perform their tasks with a sense of dignity and in line with existing legislation (TPA 20190711a, 2019).

Informal governance paves a potential path dependency for a sub-culture of governance that is unlawfully influenced by passions of greed. Greed can be defined as "a selfish and excessive desire for more of something (such as money) than is needed". It is noted that greed is a selfish process exercised to enrich one's own self, most likely without the consideration of others, or indeed more often at the expense of others and notably the poor. The word 'excessive' denotes a high level of going beyond what is needed. In the context of corruption in political spheres, such as municipalities, government officials have a certain base income which is perceived by them as not being enough. They thus resort to corrupt activities to steal state funds. This may vary in terms of how much is stolen, but in some cases, it is more excessive than in others. This leads to informal governance and mediocrity in municipal governance.

If the money is taken out of the hands of government officials and placed in the hands of the private sector or business for 'better' governance, one could argue whether this is perhaps better than what happens in the public sector. Business wants to control or 'ringfence' (SMPA20190802) the money obtained, for example Emfuleni's electricity payments, which would ensure that there is a consistent supply of electricity to their businesses. This approach ensures the success of their businesses. It also keeps people employed and promotes responsible service delivery. However, it would be vitally important to place i.e. 'ringfence' electricity rates payments under independent auditing. Otherwise, the move by business can also be interpreted as a form of undesirable informal governance. The ringfence strategy should be seen as a short-term measure, until effective local government has been restored.

A resilient society is one that adapts to changing circumstances and upholds the notions of awareness, self-control, self-consciousness, acceptance and honesty. The Emfuleni research study reported here found that at all levels of society people do not understand what is happening. There is confusion and uncertainty. People have no answers to why there is such defective service delivery in ELM. In many cases they have lost confidence in the municipality. In a resilience context each potential class component in a society, should typically be aware of potential resilience alternatives and adapt effectively to them in an appropriate manner (HJPA/20190706-22/Personal notes, 2019). In Emfuleni Local Municipality resilience can be explored by working on proper disaster management planning in collaboration with all local and regional stakeholders.

Three approaches to dealing with a wicked governance problem

In a recent study on water quality which was sponsored by the World Bank, the governance of a problematic situation is presented from three perspectives on how to deal with a 'wicked problem'. It is suggested there are three types of governance approach. The first is the *Passive approach*. It is notable for an apparent policy of inaction and the non-execution of procedures to put an end to the problem. Information is taken up, but otherwise there is a near-static response to addressing the issue. The second is a *Pro-active approach*, in which strategies are employed from the outset to prevent, abate, and/or mitigate the wicked problem. The third strategy, a *Reactive approach*, simply aims to treat or purify the system (Damania et al., 2019). In effect these approaches may also be used as phases in the process of resolving wicked problems.

Of primary importance, if we bear the Emfuleni wastewater problem in mind, appears to be the Proactive response. It requires a responsive authority to issue regulations; to implement or formulate relevant legislation; and it sets out immediately to devise strategies for addressing the problem. In the case of Emfuleni, it is more than evident that we have existing legislation in place to address many of the critical issues. However, it requires persistence to implement plans for resolving the critical problem. Of importance in a secondary phase of

development in dealing with the wicked problem, it requires a reaction, where appropriate plans are made to secure funding; and it also calls for the design of a project that is executed systematically by all stakeholders. In the final phase of development, a passive approach to wicked problems may be an affordable luxury, providing sufficient space for taking a long term view of dealing with subsidiary problems of a lesser nature.

The case for catchment management agencies

Despite South Africa having some of the best water legislation in the world, not all aspects of that legislation have been implemented as yet. One institutional structure in the water legislation, catchment management agencies (CMAs), as outlined in the National Water Act (RSA, 1998) has not yet been properly realised. In only two of South Africa's catchment management areas (Incomati and Breede-Gourits River) have CMAs been established. In many respects these institutions are important for regional oversight and proper water-related governance. In the case of a disaster event a CMA, being closer to the operational spaces of local authorities, would be in the best position to provide support and guidance.

In terms of the Department of Water and Forestry's 2003 Strategic Framework on Water Services, the provincial government, as well as the national government have the constitutional responsibility to strengthen the capacity of local government in fulfilling its responsibilities. Establishing a link between municipalities and their regional catchment management agency, should typically be a procedural process. In 2004 a National Water Resource Strategy was introduced by the then Department of Water Affairs and Forestry (DWAF). In this comprehensive document that passed through a meticulous stakeholder consultation process, there was the firm understanding that ultimately the regulation of water services, typically wastewater services, would be regulated by catchment management agencies (DWAF, 2004).

At the national department level, the accommodation of the catchment management agencies in the system has passed through a difficult phase in recent years. It was almost scrapped as a consequence of the actions of a former

minister's mistaken interventions (DWS, 2017). The matter of CMAs and their role in providing effective support to local authorities needs to be revisited in any legislative adjustments under consideration. According to confidential information disclosed to CuDyWat, the HSWS is currently busy with a consultation process to secure the views of all stakeholders on the latest National Water Resources Strategy (NWRS). The strategy, based on a widely consulted regeneration process of the whole department, does provide for the continued development of CMAs (DWS, 2019).

Emfuleni and neighbouring local authorities situated on the banks of the Vaal River downstream of the Vaal Dam, need to engage with the national department to secure a CMA that can service the Upper Vaal River and the Eastern sub-section of the Integrated Vaal River System (IVRS). Both the water and energy components of the WEF-nexus may potentially come under threat in future if timely measures are not put in place in this current era of the Anthropocene. There is also a need for a consolidated institutional management team to take charge of disaster management in cases of drought and flooding conditions. Local institutional knowledge and a well-informed national governance authority can make a significant contribution to creating local and regional partnerships for collective problem-solving.

Sustainable development Goals 2030: Local and national alignment required

A national water and sanitation department has been working since 2015 on meeting South Africa's commitment to the United Nations' 2030 Sustainable Goals (specifically Section 6). Although the planning is in the process of execution at the national level, very little information and guidance has been passed down to the governance partners at the regional and local level. Compliance with the development of potable water and wastewater infrastructure systems should be coordinated for the creation of a systematic programme of maintaining and upgrading infrastructure throughout South Africa.

The burden of legacy issues in municipal water and sanitation service delivery

Although there are convincing arguments in favour of singling out the legacy of apartheid as the origin and source of the current social and economic collapse of local governance in South Africa (Tshishonga, 2019), there are deeper factors that must be considered, issues with their origin in South African history after 1994. At the time of South Africa's transition to a new dispensation, a government of national unity was formed, with the victorious African National Congress (ANC) and its Alliance partners, incorporating the former ruling National Party (NP) into a single government – a Government of National Unity. Opposition parties, included the Democratic Alliance (DA) and smaller parties that formed a weak opposition. However, this transitional government did not last long. In 1996, as soon as a new Constitution (RSA, 1996) was approved by parliament, the National Party withdrew from government. As the remnants of the subsequent New National Party were gradually absorbed by the ANC, the DA and a number of smaller parties, South Africa's local authorities grappled with transitional councils that were scheduled to form a series of local, district and metropolitan municipal authorities in the new millennium.

The withdrawal of the NP from the government of national unity in 1996, implied that there was a growing lack of consensus in governance and legislative processes at the local, provincial and national level of government (Hemson, 2000). This lack of consensus was destined to have a profound effect on the type of local governance that emerged by 2002. For one, the country's borders became more porous (Bond, 2002b). In most of the municipal wards of a now burgeoning urban South Africa the ruling ANC had a significant majority and the drive towards the decommodification of services, as well as the human right (guaranteed by the 1996 Constitution) for all residents to clean drinking water and an environment that is not harmful, became of paramount importance amid significant social economic disparities in the urban areas of the country (Bond, 2002a). It was therefore possible to introduce a system of local government that primarily served the needs of previously disadvantaged communities.

There seemed to be an absence of sufficient voices to contribute to a sounder, more balanced system of local government for all urban residents. Despite the call for a collaborative awareness of the principles of environmentally friendly sustainable development for all (Ntsime, 2003) there was no real endeavour to make a steady, efficient start. Then too, many white officials, some with years of experience behind them, were leaving local government as a consequence of the growing trend of affirmative action. There was a spontaneous local government brain-drain that prevented the gradual evolution towards locally determined identity and collaboration at the local government level.

Even before 1994, the primary discourse amongst influential white South Africans was that: a) it made sense to have a proper African majority in control of central and provincial government; b) the new constitution supported the rule of law and it was reasonable to accept that democracy would determine the way forward; and c) importantly, local government had to maintain a firm and considerate balance of power sharing between people of different races and classes for local communities to live in harmony side by side. Local sensibility, it was argued, could lead to the co-emergence of a new sense of belonging to urban communities in a diverse South Africa, popularly described as the Rainbow Nation.

However, by the early 2000s it transpired that the breakaway of the NP from the government of National Unity in 1996, had weakened the systematic, constructive evolution of a complex system of local government. There were no convivial relations between members of civil society at grassroots level. Instead local discourses on race, poverty, the long legacy of discrimination and the need for empowerment in a new dispensation, allowed for local communities to drift apart. Former white residential areas became spaces in which local residents paid for water, sanitation and electricity services, while formerly deprived areas had to rely on local government to see to their welfare. The influence of white residents only registered at the local community level in a local authority like Emfuleni in terms of their contributions as ratepayers and their leadership at the helm of local business activities.

Under circumstances of growing entitlement, many residents in towns and cities, like those of Vereeniging and Vanderbijlpark and Meyerton, in the former Vaal Triangle, started caring primarily for their nearest kin and kind. Charity began at home and extended to the immediate local community to which families committed themselves. For the evolution of local government after 2002 an emergent dualist governance increasingly became more problematic. It registered profoundly in the economic sphere of local development.

Diamond's comprehensive study on the way upheavals enable nations to cope with crises and change, features a case study on Chile's evolution from an authoritarian dictatorship in the 1970s, to a non-racial democracy which, despite a number of typical South American socio-political problems, appears to be making sound economic progress (Diamond, 2019). Although both the former 'oppressors' and their liberal opponents, did not see eye to eye, they were willing to seek levels of cooperative tolerance that made it possible for the 'old guard' and the new rulers to work collaboratively at creating a government of cooperation. At the heart of the agreement was the consensus that Chile needed a strong, stable government to attract business and economic growth. Despite deep-seated anger over brutality and extreme human rights transgressions, there was the awareness that it required sensible minds and mature leadership to overcome what appeared, at the time of transition in the 1990s, to be insurmountable obstacles.

South Africa's history, especially as of 2009, has not followed a similar development path. Growing intolerance of a racial kind, blatant discrimination and an apparent preference for a socialist system of government, started driving South Africa into a state of economic decline (Southall, 2015). This registered most profoundly at the local level of government where more municipal authorities began to under-perform. Central government, seemingly financially strong, helped in some cases, but as corruption crept into the fibre of the country's governance sector, the chances of recovery diminished. The marginalisation of people on racial grounds, along with the absence of influence

in local government, worked to the detriment of municipal authorities, of which Emfuleni Local Municipality is but one example.

Golfing on the banks of the Vaal

The Vaal Triangle prides itself on having some of the country's most attractive golf courses largely due to golf courses being situated along the "beauty" of the Vaal River. Courses include Riviera Golf Course in Vereeniging; Maccauvlei Golf Course, situated across the river from the Riviera on the Free State side; Emfuleni Golf course in Vanderbijlpark; the newly established Heron Banks Golf course in Vaalpark, Sasolburg as well as two golf courses in Parys. All these golf courses are situated along the river which adds a certain charm – and a distinct challenge to a golfer.

Figure 15: The scenic beauty of the Rivera golf course, with Vereeniging's famous Rivera Hotel in the background; it is often a victim of nauseating sewage spills

Any sewage spills into the river will undoubtedly create an unpleasant stench and make the golf course aesthetically unappealing. However, Riviera Golf Course is

impacted to a greater extent because sewage spills from the Vereeniging/ Peacehaven area flow through the golf course to enter the Vaal River. Furthermore, the polluted Klip River is a border on the eastern side of the golf course which further exacerbates the problem at the Riviera Golf Course. Riviera Golf Club has lost many members due to the severe sewage problem associated with the area. This has meant a loss of income in terms of green fees as well as the sale of golfing equipment at the club's pro-shop.

Furthermore, the wastewater woes are having an impact on the financial income of the Riviera Golf establishment although this could perhaps be attributed to other factors as well, such as increased competition in the golf market due to the opening of the Heron Banks golf course in Sasolburg. It should also be noted that Emfuleni golf course which in recent years has been poorly managed has lost many of its customers. It has recently been taken over by the estate's residents and restored to its former condition, resulting in the return of many of its former customers. The competitive factors discussed above could, in addition to the sewer problem, have contributed to Riviera's decline of fortunes as a business. It should also be noted that the entire Emfuleni area, because of the wastewater problems, has experienced a rapid economic decline. There have been massive retrenchments at large corporate companies like Cape Gate, ArcelorMittal and Sasol, all of which have impacted heavily on business in general. And undeniably, golf is an expensive game to play; it requires considerable investment in equipment and green fees.

Aside from golf, the polluted Vaal River has had a profound impact on numerous other sports associated with water, including fishing, boating, skiing, jet-skiing and rafting. The Vaal River Barrage offers different types of waters for different types of fishing. The still waters above the Barrage encourage the carp and bass fishing while the white waters below the barrage offer excellent fly-fishing waters for yellow fish. The Vaal River has historically provided an excellent getaway for fishing, golfing and boating enthusiasts looking to relax from the hustle and bustle of the metropolis of Johannesburg. However, the pollution in the Vaal River has resulted in a marked decline in the businesses associated with these sports.

Fishing and boating shops, camping and outdoor lifestyle outlets, as well as holiday property and bed and breakfast establishments have all suffered a drop in business. This in turn leads to yet more unemployment when businesses close or reduce their staff.

Marketing water health

At present there is a strong community awareness of wastewater pollution. There is also a sense of negative unity amongst the residents of Emfuleni against what they see as sewage wastewater. Emfuleni Local Municipality, in partnership with its private sector should begin a campaign to unite residents behind the local authority in cleaning up the Vaal River Barrage. One strategy would be to create a marketing campaign that is aware of the need to 'sell' the Vaal River Barrage and Emfuleni in a user-friendly manner (for example, "Environmentally healthy water saves lives"/or "Healthy water saves lives"). The organisers of a campaign such as this would have to ensure that the business sector becomes a stakeholder. It has to be driven and managed by the municipality, in collaboration with the private sector to win over the hearts and minds of the residents and encourage visitors to the (Vaal River Barrage) area.

At present there is a synthetic racial divide in Emfuleni. That needs to be overcome. The local authority can play an important role in engaging with its 'residential foes' by recommending that there be collaboration of ALL parties to work in the interest of getting Emfuleni back on its feet. Emfuleni's future is the Vaal River Barrage. Although it is an anthropogenic construct, the presence of certain natural landscape features, and a willingness to start developing a healthy non-racial community, can be a winning deal. The objective should be for Emfuleni to 'adopt' the Vaal River Barrage and seek civil society partnerships in working towards the beneficial development of the local economy and society at large. In the regional post-industrial period, the Anthropocene can play a hard hand on the residents of Emfuleni and neighbouring communities. By using the river to bring people together to work towards using and developing a desirable

waterscape in the interest of society as a whole, can be a valuable tool in working towards the restoration of trust between the Emfuleni and all its residents.

On its own, Emfuleni will not be able to do all the work. There will have to be institutional support between water sector authorities across the board, from the local to the regional and the national level, with the prime objective of cleaning up the Vaal River Barrage and then maintaining the river health consistently and purposefully in partnership with all friends and neighbours. However, it requires political will that transcend political parties and speaks instead to local patriotism and solidarity in a place people can call home. Emfuleni must sell itself as a place with the best of prospects for a sustainable environmentally-friendly future.

Wastewater stakeholder leaders' views

On 15 August 2019, at the time of a wastewater stakeholder leadership evaluation, 26 well-informed residents, officials and political role players shared their views on Emfuleni's water woes and the Vaal River Barrage with the research group. The research group set itself the objective of engaging with residents, officials and leadership representatives of civil society to determine how to move forward. What action could be taken to deal with Emfuleni's wastewater crisis?

At the start of proceedings those present were asked what expectations they had in respect of the deliberations. The group was requested to provide their views on anticipated outcomes. In many respects their expectations resonated very well. They wanted to:

- Come up with solutions
- Meet other role players involved in improving the quality of water in the Vaal River
- Get some form of feedback (albeit from the research team) on the state of the wastewater problems
- Come to a common understanding of the issues affecting Emfuleni
- Align the other stakeholders' efforts aimed at improving Emfuleni for the benefit of all its residents

- Be part of a team willing to address and ultimately contribute to resolving the crisis
- Establish co-operative relationships
- Identify the challenges
- Form an impression of how academic research can be used to improve the current situation ("science in the service of society")
- Seek a clearer understanding of how to achieve an appropriate change in behaviour on the part of all stakeholders and target audiences
- Develop some alternate thinking to an existing problem

For the purposes of an interpretive assessment by the research team, participants were asked to write down their answers to the question: *What is the major problem affecting the environmental health of the Vaal River Barrage in Emfuleni Local Municipality?*

The stakeholders saw the challenges as:

- There was still no defined action plan on the part of the municipality to resolve the wastewater problem
- A well-defined action plan had the potential to win the trust of Emfuleni's residents but this was absent
- All stakeholders had to work together.
- There was a need to secure the involvement of all people, with the support of councillors, officials, political organisations and civil society.
- There had to be more transparency on the side of the municipality in terms of how money was spent
- The municipality had to secure the services of technical experts (potentially in the private sector) to assist in in resolving the problem (SMPA/TPA 20190815).

The second question requiring a written response from participants was: *In your opinion, what does the Emfuleni Local Municipality need to do to resolve the environmental health problem(s) affecting the river?*

Respondents cited the following needs related to resolving the wastewater crisis:

- Need to fix the wastewater infrastructure
- Explicit plans, firstly, to repair the wastewater treatment plants, followed by the pump stations and pipe networks
- R5bn is needed; this should be made available with a detailed action plan and the plan of action must be communicated to stakeholders
- There has to be regular feedback to the public on progress made
- There has to be complete transparency on an action plan, finances and relevant contracts. Linked to this was the stipulation that
- The process has to be transparent.
- A strong plea was made for short and long-term planning and the need for proper maintenance plans. Security arrangement had to be made to protect the infrastructure during and after the repairs to the wastewater system.

A number of statements were made related to the current status quo at Emfuleni Local Municipality. These included that the municipality had to:

  - Embark on a turnaround strategy to regain the trust of the public
  - Secure the services of technical and leadership skills necessary to embark on the comprehensive project
  - Address the matter of general staff competencies
  - Address the issues of corruption and maladministration in a transparent manner to win the trust of the public and other stakeholders
  - Train current staff or recruit appropriately qualified individuals
  - Solicit the help of the community in the form of retired engineers from private companies
  - Maintain close cooperation with local businesses and consultants who have technical expertise
  - Do away with BEE/AA policy and privatise the wastewater treatment facility
  - Educate the public on water issues to ensure that this precious resource is used sparingly

- Clean up the municipality's act and help solve the problem for the greater good of Emfuleni and its residents (SMPA JT 20190815)

An interpretation of the views of the stakeholder leadership group suggests that they did not see the importance or the relevance of the Vaal River Barrage in the bigger picture of Emfuleni's current crisis. It could be that they were of the view that it was most important to clean up the sewer systems as a first step so that everything else would then fall into place.

There was considerable cynicism expressed by the stakeholders to contemplate a clean-up of the Vaal River Barrage for an extensive period of time. Therefore, it can be assumed that they are critical and readily accept that there would still be wastewater spills in the future. No apparent consideration was given to the permanence of a well-managed river catchment system. This, in turn suggests that there may also be some hesitation on the capacity of the central governmental department responsible for water and sanitation, to take charge of a regional entity such as a water catchment management agency and make effective, far-reaching changes.

There is evidence that the stakeholder leadership group was cynical and focused on a 'wait-and-see what happens' view of the future. This means that in the stakeholder leaders' view the local authority must take charge and start setting things right. In the opinion of the meeting, the first responsibility for action lay with the Emfuleni Local Municipality as a local governance authority. The second step was the primary issue of addressing the wastewater crisis. In the research team's assessment, based on their findings, the latter step enjoyed priority. However, it is very evident that there is significant distrust in the current capacity of the local authority to deal effectively with the crisis at hand.

The solution does not lie in greater local autonomy for nuclear self-styled local governance in smaller entities. At the time of research in the field discussion group members refrained from choosing singular entities of local government (JTPA 20190713 2019). There was a desire on the part of residents, e.g. at Loch Vaal, to remain part of a larger municipal entity. However a prerequisite was for responsible and considerate governance of local residents.

Whilst the stakeholder leadership group was not necessarily representative of the whole of Emfuleni's multi-racial population, there was an acknowledgement of the fact that the poor lived under intolerable circumstances and had a right to a better life. However, the interpretation of the views of the stakeholder leadership group, saw black economic empowerment and affirmative action as stumbling blocks in the development of a more normalised society. The policy, according to the stakeholder group, although well intentioned and morally justifiable, actually seems to prevent the development of the necessary management and governance skills required; lack of the appropriate skills in the system remains a problem.

There is no doubt that the wastewater leadership stakeholder group is aware of the magnitude of work that needs to be undertaken if Emfuleni's wastewater infrastructure system is to be made fully operational. In fact, spontaneous estimates (for exmple of R5bn) suggests that they are far too optimistic that the problems can be resolved in the wink of an eye.

The group obviously knows what is wrong. The system needs to be fixed. It is a physical issue, but for it to happen, people and money are needed. Planning and the prevention of corruption, along with a concerted political will to set things right are primary requirements. On the positive side, the stakeholder group is willing to participate. A number of caveats have to be considered for sound governance to materialise. Local residents are willing to help, but it may lead to strong differences of opinion on how things need to be done. With this in mind, caution must be exercised before opening the floodgates to let partners into what is going to be a comprehensive reconstruction process. It will require strong leadership, representative of all residents of Emfuleni, to show the way forward.

Analysis: Identifying dominant themes to inform scenario analysis (Word analysis)

Word Clouds (also referred to as tag clouds) is a simple to use method for visualising text (Heimerl). For this project, word clouds were generated from a list of words created. The compilation of the word list featured a review of relevant newspaper articles and facilitated discussions in the research group (informed by grassroots views of individuals in Emfuleni Local Municipality). Apart from focus group discussions and 1:1 interviews with people, there were also a number of views of individual private sector operators in Emfuleni that informed the research group when they were subjected to assessments for Word Cloud analysis on two occasions. Although the focus was on the topic of Emfuleni Local Municipality's wastewater crisis, the exploration was more comprehensively focused on ways and means of seeing the present in the past, as well as, potentially, seeing it in the future. The Word Cloud assessment in the final instance informed what is also a set of different scenarios, depending on the way in which the local authority and its residential and private sector stakeholders get to play a role in future.

Words and in some instances, phrases were first categorised applying the De Bono (2006) "six hats methodology" to categorise the words into the following:

- Macro Facts – i.e. words associated with issues or themes that are outside of the direct control of the Emfuleni municipality and can be regarded as country-level challenges. Blue was associated with this list.
- Facts – i.e. verified information about the Emfuleni water and sewage situation, notably information reported in the media, but not including subjective opinions. White (neutral) was associated with this list.
- Shortcomings – i.e. typically these are problems (shortcomings) associated with the Emfuleni water and sanitation situation; they can be perceived shortcomings irrespective of the truth. Black (negative) was associated with this list.

- Emotions – i.e. words that describe an emotion (feeling/ sentiment/ reaction) with regard to the Emfuleni situation. Red was associated with this list.
- Actions – i.e. current actions or interventions, regardless of the success or failure of the outcome, which are relevant to addressing the Emfuleni situation. Yellow was associated with this list.
- Ideas – i.e. future solutions, regardless of the success or outcome, which are relevant to addressing the Emfuleni situation. Green was associated with this list.

A total of 256 words or phrases were identified; 159 came from a newspaper article review and a further 97 words from a facilitated discussion held on 13 July 2019 with researchers who are affiliated to the project. Once duplications and words that could not readily be associated with the topic were removed from the list, a total of 189 words remained. These were then categorised into the groupings described above. While this was a subjective analysis it was undertaken by two researchers to minimise bias. Tabulated lists were then prepared of the categorised word lists in alphabetical order. During a research meeting held 20 July, nine researchers were invited to review each list and indicate (vote) by placing stickers on the word which they felt could best be associated with the Emfuleni situation. The following criteria were applied:

- Researchers were provided with stickers equivalent to a total of 25% of the total word list count. For example, if 20 words/phrases were assessed for a specific theme then each researcher received five stickers, or votes;
- At most two stickers could be applied to a single word;
- The topic was kept wide and included referencing to anything associated with Emfuleni Local Municipality's water and sanitation crisis in the context of the Vaal River.

Word clouds were generated for each of the six world lists (macro-factors, facts, shortcomings, emotions, actions and ideas) using WordArt. Words identified as

most important through the sticker placing (i.e. voting) exercise were weighted according to the number of hits.

In summary, the following questions were posed:

- Macro Factors (blue)

  What do you think are most important **macro factors** relevant to the Emfuleni water and sewage crisis in the context of the Vaal River?

- **Facts** (white)

  What words/phrases do you most associate with /are the most important with regard to describing the **facts** about the Emfuleni water and sewage crisis in the context of the Vaal River? Words or phrases must be: i) Verified facts/information about the situation (what have you seen or read about the situation or; ii) What the river supports; what it experiences; what it undergoes, what you read about it in the newspaper, reports, media etc.

- Shortcomings (black)

  What do you see as the biggest **shortcomings**/problems (perceived, irrespective of the truth) relevant to the Emfuleni water and sewage crisis in the context of the Vaal River?

- Emotions (red)

  What is the **emotion** you best associate with the Emfuleni water and sewage crisis in the context of the Vaal River?

- **Actions** (yellow)

What current **actions** (and interventions) regardless of the outcome, are in your view of most relevance to the Emfuleni water and sewage crisis in the context of the Vaal River?

- **Ideas** (green)

What future solutions (**ideas**) regardless of their outcome are in your view of most relevance to the Emfuleni water and sewage crisis in the context of the Vaal River?

An identical exercise was undertaken at the stakeholder workshop held on 15 August with a multi-stakeholder group of people affected by the Emfuleni situation. The stakeholders were asked to indicate whether they represented government, civil society or the private sector. Some participants chose not to disclose their affiliation and in this case their results are grouped under a separate category "no affiliation".

Table 2: Number of respondents who participated in the word voting at the 15 August stakeholder workshop

Category	Civil society	Government	Private sector	No affiliation	Total
Macro Factors	8	1	8	0	17
Facts	10	3	7	5	25
Shortcomings	10	4	7	4	25
Emotions	8	6	7	7	28
Actions	10	8	6	4	28
Ideas	11	8	7	2	28

On the day of the workshop many of the government representatives arrived late with the result that they did not vote for the relevance of the first few categories, specifically the macro factors and facts. However, they did vote on the other categories. A breakdown of the voting is provided in Table 2 which illustrates this trend as well as a few other observed deviations.

Furthermore, on reflection the researchers came to the conclusion that the group of civil society members participating in the workshop was not sufficiently representative and for this reason only an analysis of the private sector results was undertaken to compare their responses against those of all the workshop participants. In addition it was decided not to pursue an analysis of the government representatives since the sample size was too small.

Macro Factors

A word cloud of the macro-factors is presented in Figure 15 a. = Researchers b.= All workshop participants and c. = Private sector responses from workshop. Of the 12 words categorised as macro-factors relevant to the Emfuleni situation "Corruption" (with 25% of the votes) was viewed by the researchers, (Figure 1a) as being the most relevant. Other words identified by the researchers (where a higher consensus was measured) included "declining economy" (14% of the vote); "poverty" (11%); "unemployment" (11%); "inequality" (8%) and "urbanisation" (8%).

As a collective the stakeholders participating in the consultative workshops concurred that "corruption" was the single most relevant macro-factor but differed from the researchers in ranking "criminality" (22% of the vote) and "investment" (13% of the vote). The private sector representatives at the workshop also ranked "corruption" as the largest factor, also receiving 23% of the vote with "criminality" (23%) and "investment" (13%) receiving votes.

In summary the results confirm that there is consensus that "corruption" is a relevant macro factor with all three groupings identifying it as the most relevant. Workshop participants identified "criminality" as another highly relevant macro-factor which did not feature as predominantly. For this set of data the word clouds is demonstrated as a useful tool to analyse the contrasting stakeholder views across the groupings.

a. Researchers

b. All workshop participants

c. Workshop participants - private sector only

Figure 15: Word cloud of a word list of identified macro factors relevant to the Emfuleni water and sewage crisis in the context of the Vaal River

The words identified by the researchers can readily be associated with a narrative associated with the situation experienced in Emfuleni. As an example, the following narrative is a plausible description of the situation at Emfuleni Local Municipality:

> *The region serviced by Emfuleni Local Municipality continues to experience rapid urbanisation and persistent unemployment. The unemployment rate is significantly higher than the national average. The regional economy continues to decline. A high degree of inequality persists between the social classes (namely between rich and poor) and across race (specifically rich whites and poor blacks).*
>
> *As a consequence of high unemployment and a culture of non-payment for municipal services, coupled with the rapidly growing demand for services, the municipality does not have the financial means to meet all its obligations. This means that inadequate maintenance, refurbishment and upgrading of infrastructure has occurred. In addition, financial mismanagement, lack of the necessary skills and capacity shortages have added to the delivery challenges experienced by the municipality and have created an environment highly conducive to corrupt practices.*

The Emfuleni situation (water and sanitation crisis) is as a result of complex, multi-faceted factors. The researchers confirmed independently that the narrative presented above is plausible and is clearly part of the discourse.

Facts

The word cloud depicting a representation of the words characterised as facts were ranked in order of relevance by the researchers, workshop participants (all and private sector only) to the Emfuleni situation. This is presented in Figure 16. A total of 108 words were evaluated.

a. Researchers

b. All workshop participants

c. Workshop participants - private sector only

Figure 16: Word cloud of a word list of identified facts relevant to the Emfuleni water and sewage crisis in the context of the Vaal River

In all cases no one word or phrase received more than 8% of the vote. Words which received the highest votes by the researchers (Figure 16a.) are all associated with sewage with 9 votes each (8% of total) for the phrases "raw sewage spillages" and "sewage running into the Vaal river". A further 7 votes (6% of total) was allocated to "Sewage crisis". In hindsight all words and phrases associated with spillage and specifically sewage pollution could have been clustered together. The focus on sewage is supported by the extensive media coverage on raw sewage spillages into the Vaal River.

For the workshop participants the largest number of votes was given to "pollution" (8%); "sewage running into the Vaal River" (7%); "Raw sewage spillages" (6%) and "degraded infrastructure" (6%). The private sector participants also identified "pollution" as being of the greatest relevance with 7% of the votes with an identical number of votes being given to the phrase "Sewage running into the Vaal River" and "sewage crisis".

Other words or phrases identified as relevant include "Human Rights violation", "degraded infrastructure" and "stench". The words/ phrases "downstream impacts"; "failure of Emfuleni to pay Rand Water"; "Health risks", "pollution" and "Vaal River" all received above average votes.

A plausible narrative deducted from the word cloud is suggested as the following:

> *The evidence of continuous sewage spillage and uncontrolled releases of sewage is overwhelming. The stench associated with sewage pollution is real and in no way a perception in the minds of a few, making this matter a contender as a confirmed human rights violation. The situation poses health risks. There is no one solution to Emfuleni's wastewater crisis.*

Shortcomings

"Political will" (8% of the vote); "Corruption" (7% of the vote) and economic factors described as "debt and cash flow" (5%) were identified as the most relevant shortcomings facing the Emfuleni situation, as depicted below in Figure 17.

a. Researchers

b. All workshop participants

c. Workshop participants - private sector only

Figure 17: Word cloud of identified shortcomings relevant to the Emfuleni water and sewage crisis in the context of the Vaal River

Workshop participants ranked “Corruption” and “Municipal maintenance Programme” high with 8% and 7% of the vote respectively, as did the private sector only participants who gave 8% to each of the words/phrases. Words or phrases which received larger amounts of votes each by the researchers were:

“Competence”, “DWS interventions”, “Emfuleni municipality”, “Fraud prevention”, “Funding”, “Infrastructure”, “Payment of utility charges”, “Sebokeng WWTW”, “sewage infrastructure” and “water and sewage management”.

The workshop participants generally concurred with the researchers that “DWS interventions”, “Competence” and “water and sewage management” were the most relevant phrases. The emphasis on economic, political and specifically corruption confirms the multi-faceted nature of the shortcomings (problems) facing the municipality and suggests the analysis of the problem and identification of solutions needs to consider the sequencing of events. For example, the following sequence is relevant to this situation: Declining revenue means that the municipality is unable to provide adequate services. Due to infighting between political parties in the council, the will / or ability to “do the right thing” is lacking resulting in the emergence of corrupt practices. In such a case it would be unwise to tackle corruption without addressing the underlying causes.

Emotions

A word cloud of the words categorised as emotions is presented in Figure 17. In analysing this word cloud, few dominant emotions are identified which shows a relatively even spread of votes across the list for all three groupings. The most relevant words the researchers identified were “hopelessness” and “negligence” at 5% of the total vote while “accountability”, “collapse”, “failure”, “unhealthy” and “vulnerability” each received 4%.

a. Researchers

b. Workshop participants - all

c. Workshop participants - private sector only

Figure 18: Word cloud of a word list of emotions relevant to the Emfuleni water and sewage crisis in the context of the Vaal River

Actions

Collectively the researchers identified certain actions as being more relevant than others, notably actions to "fix sewage infrastructure" receiving 13% of the total vote; "declare Vaal a disaster area" (11%); and "Refurbish infrastructure (9%). The phrase "implement emergency plan", "OUTA actions" and "Stop pollution of the Vaal River" each received 7% of the vote.

The stakeholder participants voted on similar issues notably "declare Vaal a disaster area" (13% of the vote); and "fix sewage infrastructure" (13%), but were of the collective view that "high court judgement" (9%) was more relevant. Overall a wide spread of issues was voted as being relevant. The private sector participants at the workshop articulated greatest support for the statement "Declare Vaal a disaster area" with 17% of the vote; while "Implement emergency plan" came second followed by "declare Vaal a disaster area". The general spread of votes was wider compared to some of the other categories. The word cloud identifies both similar and contrasting responses.

Notwithstanding the more relevant themes identified, the overall spread of votes was more equal with only 5 words not receiving any votes at all, namely: "Forensic investigations"; "HAWKS intervention"; "High Court judgements"; "New Vanderbijlpark High Level Reservoir"; and "SANDF protecting equipment". On reflection it is unclear why any of these phrases did not receive a single vote and it may just be that the researches came to the conclusion that there were more relevant matters that were prioritised. A similar conclusion is drawn for the workshop participants.

a. Researchers

b. All workshop participants

c. Workshop participants - private sector only

Figure 19: Word cloud of a word list of identified actions relevant to the Emfuleni water and sewage crisis in the context of the Vaal River

Ideas

The last word cloud, presented in Figure 18 below shows a view of the most relevant ideas or solutions the researchers and stakeholders identified. From the researchers the word “education” received 7% of the vote, while “Financial rescue plan” and “participatory governance” both received 6%. The words “sanitation service improvements”, “Vaal River Rehabilitation” and “Wastewater re-use” received 5% of the vote. The emphasis on education suggests that the researchers attribute the water and sanitation crisis affecting Emfuleni to a lack of skills.

The workshop participants had a different view with a wider spread of votes with “Education” only receiving 4% of the vote. There was consensus by the collective workshop participants and private sector group that “wastewater reuse” was a priority. The collective stakeholders added “Accountability” (5% of the vote) while the private sector group emphasised “Rectify the problem at the source” as the most important issue with 6% of the votes.

(Please turn to next page)

a. Researchers

b. All workshop participants

c. Workshop participants - private sector only

Figure 20: Word cloud of identified ideas relevant to the Emfuleni water and sewage crisis in the context of the Vaal River

Discussion:

Word clouds provide a simple way of representing a large amount of information and can be used to present and provide the basis for analysing a large amount of information. Furthermore, in undertaking a voting exercise a collective view of the most relevant issues can be identified.

However, there are limitations to this approach. The small group (in this case 9 researchers) and the limited stakeholder engagement undertaken in identifying and then finalising the word list and the subsequent categorisation of words into the six categories create shortcomings. Nevertheless, the exercise yielded useful information on what the researchers viewed collectively as being the most relevant to the study topic. It is recommended that a similar exercise be conducted during the stakeholder sessions and at the end of the project to compare priorities across stakeholders and identify any shifts in trends.

Scenario development – a preliminary assessment of the future

Scenarios are plausible stories of the future that can be used to test the robustness of a strategy. Furthermore, scenarios provide the outer limits of possible futures. An attempt was made to develop a set of future scenarios to create a better understanding of plausible futures facing the region.

Methodology

Four stories were developed, anchored around the key driving forces of 'Corruption' and 'Socio-economic equality' within the boundaries of the four quadrants as shown below in Figure 19.

The key driving forces can be justified since the most relevant issues identified in the macro-factor word cloud (Figure 15) were "corruption", "declining economy" and the social factors of inequality, unemployment, poverty and urbanisation. From these prioritised words the key driving forces were identified from which the following scenario axes were defined:

- Corruption; with a range from chaos to controlled
- Socio-economic (cohesion); with a range from inequality to equality

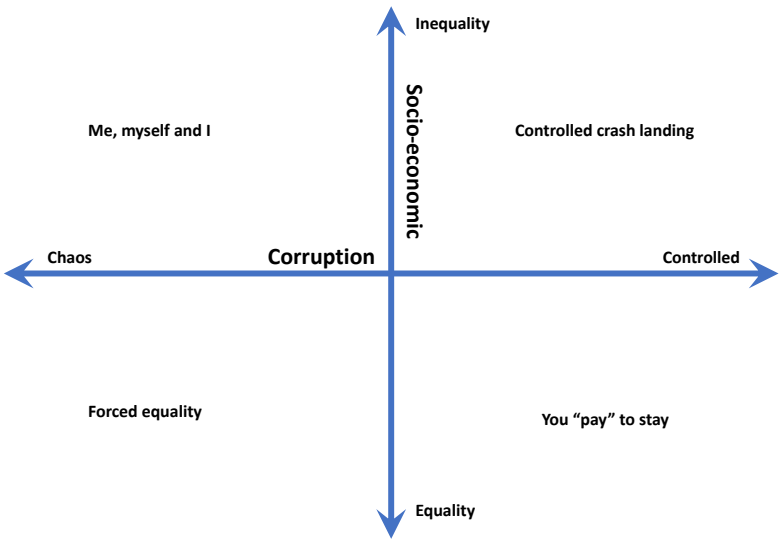


Figure 19: Scenario axes applied to develop the four future scenarios

As shown in Figure 19 the extremes of corruption can be viewed as controlled (horizontal right axis) and uncontrolled (horizontal left axis). The key driving force of socio-economic (cohesion) revolves around the degree of equality ranging from unequal (inequality at the vertical top axis) and equality (vertical bottom axis).

Additional driving forces identified from the word clouds and given in Table 3 below was used to help construct the four future scenarios. In building the scenarios the following must be kept in mind: Equality does not imply that everyone is rich; it's a measure of the disparity between the highest income earners and the lowest income earners.

Table 3: Driving forces and trends incorporated into the different scenarios

Driving Force	Me, myself and I	Controlled crash landing	You "pay" to stay	Forced equality
Unemployment	Increases drastically	Remains unchanged	Decreases a lot	decreases
Poverty	Big gap (super rich and very poor, middle class evaporates); big income gap	Income gap continues	Expanding middle class	Those with power get richer
Criminality	Extremely high	Sporadic	Low ("police state")	high
Human rights	Little	Unequal	High on agenda	Poor (money buys you)
Corruption	off the charts	Controlled	Under control (severely punished)	Prevalent
Urbanisation	Medium (land grabbing)	High	High (smart cities)	Uncontrolled (informal settlements)
Economy	Rock bottom	Trying but going nowhere	Economy booming	Slow growth
Climate change	Reality	Worse case (extreme)	More resilience	Reality
Political will	none	Trying, but cannot cope with disasters	Strong (big brother)	Low

In the development of scenarios an attempt is made to create plausible futures within which the robustness of strategies can be tested. For the purpose of this exercise the scenarios are used to understand plausible futures so that

appropriate solutions can be identified and implemented. A short write-up on each of the four scenarios follows.

Me, myself and I

Emfuleni becomes a very unstable and unequal society where people fight for land, services and their survival. Everybody is in it for him/herself with the rich getting richer and the poor becoming extremely poor.

Unplanned urbanisation continues. As the unemployment numbers rise (from an already high level), so does the level of poverty. Crime is rife due to the poor state of police services including enforcement action. Human rights take a back seat and levels of corruption are higher than ever. Land grabbing is a daily occurrence and gangsters rule the townships and suburbs. Education standards drop at schools and tertiary institutions. State support for education is low due to mismanagement, debt and other government priorities.

The Vaal River is just a continuous stream of sewage with a growing backlog of sewage infrastructure maintenance and upgrading due largely as a result of financial mismanagement, corruption and debt. Health risks associated with sewage persists and economic impact is felt downstream up to Parys and beyond. Cholera outbreaks are frequent as the degraded infrastructure and skills shortage cannot cope. Political will to address the challenges facing the municipality is low. Water security becomes a big issue.

Money talks and the super-rich pay for lifestyle and “services”. Political power buys you “comforts”; the rich live nicely behind high surrounding walls and security guards, the poor live miserable lives. Inequality increases.

Political instability is the order of the day with continuous leadership changes. There is no political will to solve the most basic of problems. The economy declines rapidly. Given the significant under-investment in infrastructure the impact of climate change is harsh, resulting in flood damage (absence of early warning and effective emergency response), water security (non-adherence to water restrictions and failure to introduce water conservation measures) and heat

stress (failure to provide shelters and adequate potable drinking water supplies during extremely hot days).

Summary:

The scenario of "me, myself and I", depicts a future of poor government control resulting in chaos and lawlessness in which inequality is high and where everybody fends for themselves against a background of infrastructure failure, high levels of corruption. The "haves" (rich, employed and predominantly white) are able to find ways to create an existence and somehow prosper; while the have-nots (poor, unemployed, uneducated and predominately black) become increasingly poorer, unhealthy and vulnerable to the impacts of climate change since provisions needed to adapt to climate change are inadequate.

Forced Equality

Land and wealth distribution are high on the agenda of the government (including municipalities) because "reverse apartheid" policies are put in place, thereby achieving a higher degree of equality and somewhat forcing the closure of the gap between the rich and the poor. Government funding on all levels is utilised to upgrade the poorer communities to the detriment of the middle-class suburbs.

Crime, corruption and fraud are at their highest levels ever, and tender processes are totally geared towards those in power. Land redistribution is a daily occurrence and industry, mining and banks are nationalised one by one. In the workplace, schools and in public services a "reversed apartheid" approach is in place, in the hope of increasing social and economic equality.

Political will is for "own benefit" only, and leads to incompetence, bad decision making, continued cadre employment (without considering competence) and uneven land distribution. Fraud and corruption levels are high resulting in spending of funds and and wasteful expenditure. Money allocations are distorted to certain schools and other education institutions including universities. Who you know and not what you know will get you the job, contract or service.

The environment takes a back seat and the infrastructure degradation and incompetence cannot handle the unregulated pollution levels which are widely

prevalent. Uncontrolled urbanisation adds to the problem. The New Vaal River City is more a power move of the politicians than a way to solve the systemic crises the area faces.

Unemployment drops slightly while equality improves (at least in numbers) but coming from a significantly unequal base it fails to create stability. With political factions causing a lack of political will, the ability to govern and control criminality is lost. Human rights violations are high ("money buys you…") and corruption remains prevalent. Slow economic growth coupled with failing and poorly maintained infrastructure reduces the resilience of residents to adapt to the vagaries of climate change.

Summary

In the scenario "Forced equality", government introduces significant measures to achieve a greater degree of equality but lacks the political will and control to govern. The result is lawlessness and chaos.

Controlled crash landing

Climate plays havoc, and extreme rainfall results in two flood events in a single year. The number of days with extreme heat increases significantly. Weather is unpredictable, can swing from severe drought to flooding in a single season.

Ageing infrastructure cannot cope with the sudden changes in weather patterns and the unavailability of funding, although the political will is there to change and fix. The increase in bureaucracy makes changes on every level of government slow and inefficient. The lack of foreign investment due to problems elsewhere, such as Brexit; war in the middle east, and a brewing war between China and Japan are cause for concern. Government must spend money at home to cope with natural disasters and combat economic turmoil due to climate change, failing crops, drowning cities, etc.

Urbanisation is on the increase because people have to move due to the unavailability of water or the flooding of coastal cities. Skill shortages increase due to the rich getting the education, but they soon leave the region to secure

better employment elsewhere. The school system remains divided (unequal) and the poverty cycle is not broken. Everybody is slowly getting poorer.

Poverty, unemployment and sporadic criminality stays about the same as it was in 2019. Although municipalities and government act and own up to accountability they cannot cope due to a lack of funds and one disaster follows after the other, natural disaters, failing infrastructure, disease outbreaks, etc. Occasional sewage spills, load shedding and an unreliable water supply are the order of the day. Fraud prevention is in place but takes long to prosecute.

Summary

In the scenario, controlled crash landing, government has greater political will and control but is unable to address the social and economic inequalities meaningfully due to bureaucracy and legal challenges. Extreme climate change impacts occur placing a greater burden on communities and the government.

You “pay” to stay

The government has put in place massive measures to alleviate poverty, decrease the income gap and improve equality. The higher income taxpayers are required to help drive focused education, new industrial development and job creation. At first there is a huge brain drain of people who cannot live under the new laws and the increase in taxes. They leave for greener pastures.

Education is focused on meeting the needs of the new industrial revolution and quotas on required skills are strictly controlled by government. Competition for places at top schools and universities is high. Transdisciplinary studies are the order of the day in technical fields, but the humanities suffer because funding for these disciplines declines rapidly. Training is also highly specialised.

Slowly the poverty and unemployment level falls and the gap between the poor and rich becomes smaller. Smart cities (Vaal City) are built to accommodate the up and coming middle class, with all the facilities at close range: free education, national health service etc. In this society people recycle and minimise waste. The economy begins to grow and international investors show interest in investing in

the region, especially China. A nuclear power station is built to help with meeting the energy demands of the new industrial South Africa.

The government is fast to introduce measures to improve resilience against climate change and the municipality becomes more capable to respond as infrastructure is upgraded and maintained. Fraud and corruption are at the lowest ever because the government takes a Big Brother approach and any wrongdoing is severely punished. For example, polluters pay extremely high penalties or are forced to shut down, all controlled by Big Brother. Laws are enforced with heavy fines and taxes. The community of Parys has success in suing both the Emfuleni Municipality and the Municipal Manger in his personal capacity, forcing them once and for all to address the sewage pollution into the Vaal River.

Summary

In the scenario, you “pay” to stay, the degree of inequality reduces but higher taxes, environmental fines and penalties create both winners and losers. Big Brother is in control.

Conclusion

Emfuleni Local Municipality's wastewater crisis that began in 2018 should be contemplated from a comprehensive view of factors. The physical breakdown of wastewater infrastructure, in this study, is symptomatic of a number of more comprehensive factors such as climate change in the Anthropocene and taking note of the Integrated Vaal River System (IVRS) as a prime component that forms part of the motions of the natural water cycle in times of change.

A number of descriptor issues are singled out, such as the WEF nexus of critical resources that are subject to collapse should any single one, or two, components of the nexus collapse. From the assessment it is evident that Emfuleni Local Municipality is frail and that resilience, the ability to find solutions robustly to a social ecological crisis of substantial proportions, is not an easy way out. The interpretation of descriptors, as well as views of stakeholders at grassroots level, suggests that the process of adaptation to circumstances of change are varied and could lead to a variety of consequences.

What is evident is that corruption and political will, along with sufficient human resource skills, as well as the financial support for setting things right, requires considerable time and effort. Wastewater stakeholder leaders and members of the research team were of the view that it would take time to move into a phase of restoring the social ecology of Emfuleni Local Municipality.

It is recommended that attention be given to contemplating Emfuleni's wastewater problem as a wicked problem that needs to be addressed in a proactive manner. This implies the use of existing legislation, the introduction of bylaws if and where considered necessary and the drive to put plans in place to either terminate or mitigate a problem in a constructive manner. In a later phase more detailed assessments can be made of new infrastructure technologies for dealing with wastewater issues.

Local government in Emfuleni requires rejuvenation. There is the need for leadership with visionary plans and the willingness to take on challenges in an era of economic scarcity. This should preferably take place in comprehensive

systems of partnership with all stakeholder groupings within Emfuleni. At the local, regional (provincial) and national level, cooperative governance needs to be revisited. There appears to be disjuncture in the system. Not all governance stakeholders are precisely aware of their responsibilities. Commitment is required to resolve disaster conditions and there is no convincing evidence of the necessary communication between departments or indeed with the local residents. There is a need for people to once again engage in the *agora* of the village marketplace, where matters can be discussed, debated and resolved in an equitable environment. This will require the revival of a sense of belonging in a local community where there is a social solidarity and a sense of local patriotism.

It is of great importance for local government to seek opportunities for revitalising Emfuleni's local residential, industrial and commercial communities. Legacy issues of post-industrialisation, the transition to a new South Africa and the inability of people to work together in the pursuit of common interests across racial divides, appear to be major obstacles at present. However, these can be overcome if there is sufficient willpower to face challenges head-on.

Making assessments of word clouds, based on the views of the researchers, the stakeholder leadership group and the private sector, provides insight on the problems, potential alternatives, and views of the future. The Word Cloud formations feed into assessments of four potential development routes in Emfuleni, from various perspectives on the state of the wastewater infrastructure currently and the most appropriate ways in which to address the issue.

Of particular importance are the identification of four potential routes of future local development, based on the analysis of different stakeholder participating as respondents in the research project.

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