MANAGEMENT OF WETLANDS WHITHIN COAL MINING TOWNS: CASE STUDY OF VICTOR KHANYE LOCAL MUNICIPALITY MPUMALANGA PROVINCE

BY

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DECLARATION

I, Jeffrey Chuene Kgare, hereby declare that the mini dissertation titled "Management of wetlands within coal mining towns: case study of Victor Khanye Local Municipality Mpumalanga Province" is my work in design and execution, and that all sources or quoted have been referenced and acknowledged as prescribed by research ethics code

Signature: _____ Date: 04/05/2022

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DEDICATIONS

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ABSTRACT

Mining is one of the most destructive practices on earth around the world mining is threatening peoples' homes and destroying ecosystems. Wetlands management in coal mining environment is major challenge, especially when it contributes to destruction of the environment. The purpose of this study was to investigate the impact of coal mining on wetlands. The recent calls around the world for protecting the environment have ignited the calls for sustainable management of wetlands especially in coal mining areas. A mixed methods approach which entails both quantitative and qualitative methods was used to collect data from human and physical environments of two mining areas around Victor Khanye Local Municipality. The population of this study were the municipal officials, farmers and residents residing within Victor Khanye Local Municipality. Convenience and snowball sampling were used to select participants for questionnaires, interviews and focus groups. The research adopted mixed research methods to assess the management of wetlands within coal mining towns case study of victor Khanye local municipality. Data gathered through questionnaires and interviews, was thematically analysed. Majority of respondents showed that they were aware of lack of monitoring and management of wetland within Victor Khanye Local Municipality and detrimental environmental impact of coal mining on wetlands within Victor Khanye Local Municipality. Some respondents were skeptical about some of the environmental benefits of wetlands. Respondents were also aware of negative changes of wetland properties (soil, water, vegetation, birds and animals) due to different land uses on wetlands. Low percentages of organic carbon content in sediments from utilized parts of both wetlands reflected deterioration in soil fertility.

There is uncoordinated dissemination of information about wetlands to the general public, and existing wetland legislation is not effectively implemented. The study recommends that the Mpumalanga department of environmental affairs and other stakeholders should implement wetland management strategies. All stakeholders should be involved in developing programs of wetland conservations. The Mpumalanga Department of Environmental Affairs should monitor institutions that facilitate wetland laws implementation, and change strategies used and people involved in educating and disseminating information about wetlands within coal mining areas.

Keywords: Management, Control, Wetlands, Coal Mining, Victor Khanye Local Municipality

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LIST OF ABBREVIATIONS AND ACRONYMS

BSAP: BIODIVERSITY STRATEGY AND ACTION PLAN

CBC: CITIES BIODIVERSITY CENTRE

UNCBD: UNITED NATIONS CONVENTION ON BIOLOGICAL DIVERSITY

CEPA: COMMUNICATION, EDUCATION AND PUBLIC AWARENESS

DWS: DEPARTMENT OF WATER AND SANITATION

EIA: ENVIRONMENTAL IMPACT ASSESSMENT

FEPA: FRESHWATER ECOSYSTEM PRIORITY AREAS

IDP: INTEGRATED DEVELOPMENT PLAN

IUCN: INTERNATIONAL UNION FOR CONSERVATION OF NATURE

LAB: LOCAL ACTION FOR BIODIVERSITY

LBSAP: LOCAL BIODIVERSITY STRATEGY AND ACTION PLAN

NBF: NATIONAL BIODIVERSITY FRAMEWORK

NBSAP: NATIONAL BIODIVERSITY STRATEGIES AND ACTION PLANS

NEMA: NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 36 OF 1998

NGO: NON-GOVERNMENTAL ORGANIZATION

NWA: NATIONAL WATER ACT, 36 OF 1998

NSSD: NATIONAL STRATEGY FOR SUSTAINABLE DEVELOPMENT

PBSAP: PROVINCIAL BIODIVERSITY STRATEGY AND ACTION PLAN

SANBI: SOUTH AFRICA NATIONAL BIODIVERSITY INSTITUTE

SDBIP: SERVICE DELIVERY AND BUDGET IMPLEMENTATION PLAN

SDF: SPATIAL DEVELOPMENT FRAMEWORK

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CHAPTER 1

INTRODUCTION AND BACKGROUND OF THE STUDY

1.1 INTRODUCTION

According to Barbier (2014) public policy is a process about selecting strategies and making choices. Public policy making include some steps getting of agenda, policy formulation, policy adoptions, policy implementation (Ashton, 2010). It must be also evaluated to see the intended results, to revise existing and future public programs and projects (Barbier, 2014). Public administration is the set of processes, structures, functions, methods, and procedures. Public administration is the formulation and particularly implementation of public policy and the examination of the strategies and choices associated with that process (Ashton and Dabrowski, 2011). Public administration also can be defined as public programs and projects, profession, and as academic field of study (Cameron and Stone, 1995; Cloete and Thornhill, 2005). There is no clear separation between administration and politics in the development of government policy and public administration. Administrators engage in political acts by recommending legislation as much as by making policy decisions in carrying out the laws (Raipa, 2002; Cameron and Stone, 1995; Cloete and Thornhill, 2005). The administrators understanding of managerial issues and policies places them in a position of substantial expertise, while their knowledge of administrative and legal procedures helps them by suggesting ways of managing and enforcing the laws (Raipa, 2002). Public administration is the formulation and particularly implementation of public policy and the examination of the strategies and choices associated with that process. Administrators engage in political acts by recommending legislation as much as by making policy decisions in carrying out the laws (Cameron and Stone, 1995; Cloete and Thornhill, 2005).

The administrators understanding of managerial issues and policies places them in a position of substantial expertise, while their knowledge of administrative and legal procedures helps them by suggesting ways of managing and enforcing the laws (Raipa, 2002). The public needs to understand exactly what environmental policy is and how it affects them (Cloete and Thornhill, 2005). According to McCormick (2001) environmental policy is defined as "any action deliberately taken to manage human activities with a view to prevent, reduce, or mitigate harmful effects on nature and natural resources, and ensuring that man-made changes to the environment do not have harmful effects on humans or the environment".

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Environmental policy generally covers air and water pollution, waste management, ecosystem management, biodiversity protection, and the protection of natural resources, wildlife, and endangered species. Issues like these, affect everyone across the globe and cannot be ignored. Sources of pollution have local and regional effects on the chemistry and quality of water flowing through wetlands. Point sources, such as municipal industrial sites, and non-point sources, such as agricultural lands and urban runoff, add materials to ground water and surface water that upset the balance of wetland water chemistry and the biogeochemical cycling of materials in wetland ecosystems. (Mitsch and Gosselink, 1993)

The study focuses on the management of wetlands within coal mining towns in Victor Khanye Local Municipality, Mpumalanga Province, South Africa. The introduction highlights the problem statement, aim of the study as well as objectives of the study. It further highlights critical research questions, significance of the study, delimitation of the study and limitations. It ends with research design and methodology, delimitation of the study and definition of operational concepts. The study is organised in the above outlined pattern. In 2016 the world wetlands day was celebrated in Mpumalanga and this event was surely significant in that Mpumalanga has been assumed to become the world's hot spot of pollution in the whole world with both air and wetlands pollution. It generally covers air and water pollution, waste management, ecosystem management, biodiversity protection, and the protection of natural resources, wildlife, and endangered species. Issues like these, affect everyone across the globe and cannot be ignored. There are many pieces of legislations in south Africa that seeks to protect the environment from human activities however the impact of environmental damage still continues within coal mining towns (Cameron and Stone, 1995). The study will assess the impact of coal mining towns on wetlands case study of Victor Khanye Local Municipality.

1.2 BACKGROUND OF THE STUDY

In Mpumalanga Province, coal mining areas are associated with certain geological features that are intrinsically linked to the occurrence of wetlands (Rucker and Trah, 2017). Not only is the need to protect or conserve wetlands to secure water resources as mining could also result in impeding and diverting water into the wetland through precipitating water ingress from the undermined wetland into the underground workings (Rucker and Trah, 2017). Subsequent to the removal of the over lay body, the weight of the overlying strata could weaken the support provided during the mining operations, resulting in strata movement and

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the formation of cracks in the overlying strata (Kotze, Breen and Quinn, 1995). In 2016, Conservation experts in the Mpumalanga Province indicated that wetlands and their prime ecosystems are at risk due to the growing human impact of farming and urbanization, and this exposes the country to higher risk of climate related hazards and natural disasters (Bell, Bullock, Halbich and Lindsay, 2001). Wetlands are prime aquatic ecosystems which contribute to biodiversity sources of pristine water but human interference in urban growth have left many wetlands under threat troubles and some of the wetlands have been misused to the extent that they like they are dying away (Bell, Bullock, Halbich and Lindsay, 2001).

Opencast mining through wetlands will result in the permanent destruction of the wetlands and the total loss of biodiversity and habitat (Sebola and Fourie, 2007). Wetland destruction is common phenomenon in the world. Wetlands are the link between the land and water. Hoage (2013) defines the wetland as transition zones where the flow of water, the cycling of nutrients, and the energy of the sun meet to produce a unique ecosystem characterized by hydrology, soils, and vegetation making these areas very important features of a watershed. Using a watershed-based approach to wetland protection ensures that the whole system, including land, air, and water resources, is protected (Van Der Waldt and Knipe, 2001).

Wetland is defined as a land area that is saturated with water, either permanently or seasonally, such that it takes on the characteristics of a distinct ecosystem (Sebola and Fourie, 2007). The primary factor that distinguishes wetlands from other landforms or water bodies is the characteristic vegetation of aquatic plants, adapted to the unique hydric soil (Bell, Bullock, Halbich and Lindsay, 2001). There are number of factors that contributes towards the destruction of wetlands one maybe lacks environmental monitoring mechanisms and strategies within particular environment (Van Der Waldt and Knipe, 2001). Economic activities such as mining and agriculture contributes extensively towards wetland degradation furthermore there is change of water quality, reduction of underground quantity, and diversion of water flow, increase in pollutant inputs on the environment and changing species composition as a result of disturbance of the environment (Sebola and Fourie, 2007).

Opencast mining operations in close proximity to wetlands can result in the following impacts: erosion of the catchment area adjacent to the wetland, deterioration of the wetland water quality, and a decrease in the wetland area downstream of the opencast pit due to decreased runoff (Bergh, 2013). Wetlands overlaying the mined area could start to drain into the underground workings for our own future and well-being, but we are also bound by national

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and international commitments to do so (Bester and Vermeulen, 2010). A body of international, regional and national policies and treaties exists that relates to the conservation of water ecosystems (Broadhurst, Amaral Filho, Moyo, Nwaila, Sampa N'Gandu, Shongwe and Sibanda, 2016). South Africa also has policies and acts protecting our wetlands, but overlaps and gaps regarding wetland legislation exist, and shared responsibilities between different government departments lead to ineffective implementation.

The need for clear guidelines regarding the sustainable use of wetlands in agriculture is vital for their conservation in South Africa (Chadwick, Highton, and Lindman, 2013). Chadwick *et al.,* (2013) further indicate that most of the mining areas are therefore located within the above-mentioned buffer zones, leaving few areas that can be mined without obtaining onerous authorisations that do not necessarily result in the protection of the wetlands. According to Dlamini (2007) wetlands were not regulated when the planning of several mines in Mpumalanga commenced and advanced, as this was done prior to the introduction of the National Water Act 36 of 1998 and the Mineral and Petroleum Resources Development Act 28 of 2002. At the time, the only environmental requirement for mining rights activities to commence is an approved Environmental Management Programme under the Minerals Act 50 of 1991 (Eberhard, 2011).

Post-1998, the requirement to obtain an authorisation for mining in or near wetlands has therefore impacted on mine and financial planning, as areas that could previously be mined now require authorisation (Eberhard, 2011). The current legislation is still unclear on how the impacts on wetlands should be regulated. It is of great concern that legislation defines buffer zones for regulation but suggests no scientific basis on how these buffer zones should be delineated and whether the defined buffer zones are indeed effective in the protection of wetlands (Eberhard, 2011). Filtered streams flow out of wetlands and join with streams and rivers and these wetlands also detain water allowing for replenishing of ground water and boreholes downstream (Feris and Kotze, 2014). However, the Victor Khanye Municipality does not keep a mandatory record of wetlands and thus, the impact of mining on them is not monitored. All these water resources are lost to coal mining in Delmas, making it well positioned to illustrate cumulative impacts combined with a weak regulatory system. Wetlands cannot be rehabilitated after coal has been extracted and fires ignited downstream and usually it becomes a wasteland or may possibly be remediated for livestock farming but not agricultural activity (Feris and Kotze, 2014).

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Wetlands are sensitive and vital systems in our environment, and yet they are decreasing and degrading at an alarming rate downstream (Feris and Kotze, 2014). Loss of wetlands continues today, with direct and measurable negative impacts on nature and people downstream (Feris and Kotze, 2014). Wetlands are one of the world's most important environmental assets, containing a disproportionately high number of plant and animal species compared with other areas of the world and furthermore do provide a range of products, functions and services, free of charge (Retief, 2017). Wetland dependent species such as fish, water birds and turtles are in serious decline, with one-quarter threatened with extinction particularly in the tropics downstream (Feris and Kotze, 2014).

The wetland acts as a sponge as much of the flood water is then stored in the wetland and is slowly released to the downstream areas, instead of it all rushing to the sea within a few days (Reddick, Von Blottnitz and Kothuis, 2008). Water flowing into these pans loses speed and spreads out and this greatly reduces flood damage, particularly erosion, and ensures a steadier supply of water throughout the year (Reddick, 2006). Wetlands improve water quality as they are very good natural filters, trapping sediment, nutrients (for example, nitrogen and phosphorus), and even pathogenic (disease-causing) bacteria (Reddick, Von Blottnitz and Kothuis, 2008). In addition, pollutants such as heavy metals (for example, mercury, lead) and pesticides may be trapped by chemical and biological processes. In other words, the water leaving the wetland is cleaner than the water entering it. Wetlands are filters where sediments and nutrients accumulate; so many plants grow there, e.g., bulrushes, grasses, reeds, waterlilies, sedges and trees. The plants, in turn, provide food and a place for attachment and shelter for many creatures (Reddick, 2006). There is more life, hectare for hectare, in a healthy wetland than in almost any other habitat. These productive places support huge numbers of insects, fish, birds and other animals. Some animals are completely dependent on wetlands.

Ramsar Global Wetland Outlook (2018) estimate that of global inland and coastal wetland area is in excess of 12.1 million square kilometers, an area almost as large as Greenland. Of this, 54% is permanently inundated and 46% seasonally inundated. An estimated further 5.2 million km2 are intermittently or occasionally inundated, but this is believed to include areas of former converted wetlands affected by extreme storm events. Around 93% of wetlands are inland systems, with 7% being marine and coastal although this coastal estimate does not include several wetland classes such as nearshore subtidal wetlands, which also fall into the Ramsar definition.

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Global areas of human-made wetlands are small in comparison: reservoirs cover an estimated 0.3 million square kilometres and rice paddy 1.3 million square kilometres (Davidson *et al.,* 2018; Davidson and Finlayson, 2018). Estimates of global wetland extent have increased considerably since the 1980s, due largely to recent improvements in remote sensing and mapping methods; this is not a reflection of any real increase in the area of wetlands (Davidson et al., 2018). Wetlands decreased in area; the status of wetlands has deteriorated despite recognition of their importance for many decades. In 2011, the first wetland inventory for South Africa confirmed that wetlands are the most threatened ecosystem. The World Day pamphlet (2018) indicates that remaining 300 000 wetlands in South Africa constitute 2.9 million hectares or 2.4% of South Africa's surface area. Sixty-five percent (65%) of wetland ecosystem types are threatened and forty-eight percent (48%) of threatened wetlands were found to be critically endangered. The percentage of wetland coverage in South Africa at 2.4% is low when compared with the world coverage of approximately 6%. This potentially reduces the ability of South Africa's natural systems to minimise the impact of normal and extreme weather events such as floods. This trend can however be reversed by changing practices and through the restoration of wetlands.

Ramsar Global wetland outlook (2018) highlights that the largest areas of wetlands are in Asia (32% of the global area), North America (27%) and Latin America and the Caribbean (16%). Wetland areas in Europe (13%), Africa (10%) and Oceania (3%) are smaller (Davidson et al., 2018). The 2011 National Biodiversity Assessment report reveals that 65% of our wetland types are under threat (48% critically endangered, 12% endangered and 5% vulnerable). Only 11% of wetland ecosystem types are well protected, with 71% not protected at all in south Africa.

1.3 PROBLEM STATEMENT

Wetlands play an important role in ensuring a clean supply of water for the country, so it is critical that these areas are protected. The Department of Environment Forestry and Fisheries has invested over 83 million Rand to maintain South Africa's wetlands in 2021. According to the 2018 National Biodiversity Assessment, in South Africa, it is indicated that wetlands are the most threatened of all South Africa's ecosystems. Therefore, the main question to pose in this instance is: Why are wetlands so threatened? The answer to this question is obviously the reason that South Africa as a country with a significant population,

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and all of the citizens would be relying on natural water resources for domestic purposes, mining industry and other economic activities that rely on these wetlands.

In recent times there has been release of toxins, particularly sanitation into South Africa's water systems we also find that that on occasion we have suggestions industry or mining releasing influence that they are not supposed to release into the water system and obviously all of this does damage, but we also know that we are now facing this phenomenon called climate change (Sonter, Moran, Barret and Soares-Filho, 2014; Schutte, 2014). South Africa is amongst the 30 driest countries in the world and under normal circumstances we are a water-scarce country, so it is obviously increasingly important that the country looks after its river systems (Simate & Ndlovu, 2014). Wetlands play a very valuable role in the ecosystem services so when there is plentiful water like at the moment wetlands absorb flooding, they prevent rapid movement of water, but they also store this water for situations where there is drought and then gradually release the water into the entire river systems of course also with these factors, wetlands are also filtration systems, and they clean up toxins so that water that is released is purified naturally males (Simate & Ndlovu, 2014).

Overlaps and gaps regarding wetland legislation exist, and shared responsibilities between the different departments lead to ineffective implementation and monitoring of the implementation of the policy (Schutte, 2014). It is of great concern that legislation defines buffer zones for regulation as stipulated in National Water Act 36 of 1998 and Mineral and Petroleum Resources Development Act 28 of 2004 however it does not suggest no scientific basis on how these buffer zones should be delineated and whether the defined buffer zones are indeed effective in the protection of wetlands (Schutte, 2014; Muir, 2017).

Victor Khanye local municipality has not delineated the wetlands despite increasing in number of open cast coal mining activities meaning that the municipality and other stakeholders has no monitoring tool on conditions of wetlands males (Simate and Ndlovu, 2014). Currently, there is inadequate baseline information on existing wetland resources, including the bio-physical characteristics as well as the socioeconomic and cultural values of the resources together with the threats that affect them males (Simate and Ndlovu, 2014). No comprehensive inventories have been conducted for any wetlands within the area and lack of management plans has exacerbated wetland destruction and degradation in many areas around the country (Schutte, 2014).

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Dewatering has cumulative impacts on wetlands, which are complex, interlinked systems in this region. South Africa holds extensive coal reserves and coal accounts for approximately 92% of South Africa's energy generation (World-Wide Fund for Nature WWFN, 2011). Coal mining is one of the core industries that contribute to the economic development, but deteriorates the environment (Tiwary, 2001). Statistics South Africa, 2016 Community Survey, the total population of Victor Khanye Local Municipality is approximately 84 151 persons, which amounts to 5.8% of the total Nkangala District Municipality population 1 445 624 and 1.9% of the Mpumalanga province population 4 335 964 the population growth may be due to increase in coal mining activities that attract skilled and unskilled labour force. Over the years unemployment rate for females has been more than males and in 2019 it was at 38.3% for females and 26.1% for males (Simate and Ndlovu, 2014). (Statistics South Africa, 2016). Unemployment can be expressed as a percentage of the Economically Active Population (EAP). The EAP refers to all the people aged between 15 and 64 years that are able and willing to partake in economic activities (excluded in this figure are those individuals not actively looking for work, students, pensioners, housewives) (Simate and Ndlovu, 2014).

The unemployment and employment levels within Victor Khanye Local Municipal area are important to investigate, as it is indicative of the ability of local residents to earn household income (generated from economic activities and which are employed to purchase goods and services) (Rout, Masto, Padhy, George, Ram and Maity, 2014). In addition, high level of unemployment is generally associated with poor socio-economic conditions and poverty (Schneider, 2016). In Victor Khanye Local Municipality, it was approximated that 8 573 of its people are unemployed (Simate and Ndlovu, 2014). It is evident that the unemployment rate for Victor Khanye Local Municipality is 28.2%, it is significantly lower than the Mpumalanga province (43.1%) (Simate & Ndlovu, 2014).

Ngubane (2016) denotes that lack of and poor enforcement of policies on wetland management is one of the major challenges facing community-based conservation of wetland ecosystems. Whereas there are appropriate regulations, poor institutional structures have made it very difficult to enforce the relevant policies (Morrice and Colagiuri, 2013). Currently, there is inadequate baseline information on existing wetland resources, including the bio-physical characteristics as well as the socioeconomic and cultural values of the resources together with the threats that affect them (Ngubane, 2016). No comprehensive inventories have been conducted for many wetlands and similarly, there is inadequate technical and skilled human resources to undertake specialized conservation and management

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programmes i.e., research, monitoring, integrated coastal zone planning, extension work to monitor and manage the existing wetlands and their resources (Munnick, 2010). Lack of management plans has exacerbated wetland destruction and degradation in many areas around the country. Victor Khanye Local municipality is experiencing an increase of coal mines, and this has an impact on non-delineated wetlands within the ecosystems of Victor Khanye local municipality. Without any control mechanism in place to control the impact, all wetlands will get destroyed with all species and coal mining is one such activity (Oelofse, 2008).

1.4 AIM OF THE STUDY

The main aim of the study is to investigate implications of lack of mechanism to manage wetlands within coal mining towns with specific to reference to Victor Khanye Local municipality, Mpumalanga province, South Africa.

1.5 SPECIFIC OBJECTIVES OF THE STUDY

The specific objectives of the study are:

- To describe the status of wetlands within Victor Khanye local municipality
- To determine the impact of coal mining operations on wetlands within Victor Khanye local municipality
- To devise proper mechanisms to manage wetlands within coal mining towns with specific to reference to Victor Khanye Local Municipality.

1.6 RESEARCH QUESTIONS

The research questions of the study are:

- What is the status of wetlands within Victor Khanye local municipality?
- What is the impact of coal mining on wetlands within Victor Khanye local Municipality?
- What are wetland management control systems within Victor Khanye local municipality?

1.7 SIGNIFICANCE OF THE STUDY

The study is important to researchers as it stimulates the development of new theories or ideas on how municipalities can control and preserve wetlands within coal mining towns. The

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sustainable preservation of wetlands within mining environment is for the benefit future generations. The research highlighted the impact of the destructions of wetlands within coal mining towns. The study will benefit the whole academic sector of South Africa because there is gap of research pertaining wetland management within coal mining towns. The study highlighted new wetland management plans and programs within coal mining localities around South Africa and it has enhanced the researcher's abilities to perform research and grow academically. The findings of the research will assist the institution in question to resolve wetland management challenges and improve the environment within coal mining towns.

1.8 DELIMITATION OF THE STUDY

The study focuses on management of wetland within coal mining towns in the Victor Khanye Local Municipality in Mpumalanga province, South Africa. Victor Khanye Local municipality is within Nkangala district municipality. Victor Khanye Local Municipality is situated on the western Highveld of Mpumalanga Province, covering a geographic area of approximately 1,567 square kilometers (Simate and Ndlovu, 2014). The prominent towns and settlements in the Municipality include Abor, Argent, Delmas, and Brakfontein (Simate and Ndlovu, 2014). The municipality is strategically located in close proximity to the metropolitan areas of Tshwane municipality and Ekurhuleni municipality to the west. The headquarters of the municipality are in Delmas (a French word meaning small farm) (Simate and Ndlovu, 2014). Victor Khanye Local municipality is currently characterized by an increase in coal mining and related activities in the Leandra area. The participants in this study comprised administrative officials, senior managers, middle managers, and officials from department of water affairs and Department of mineral affairs within Victor Khanye local municipality.

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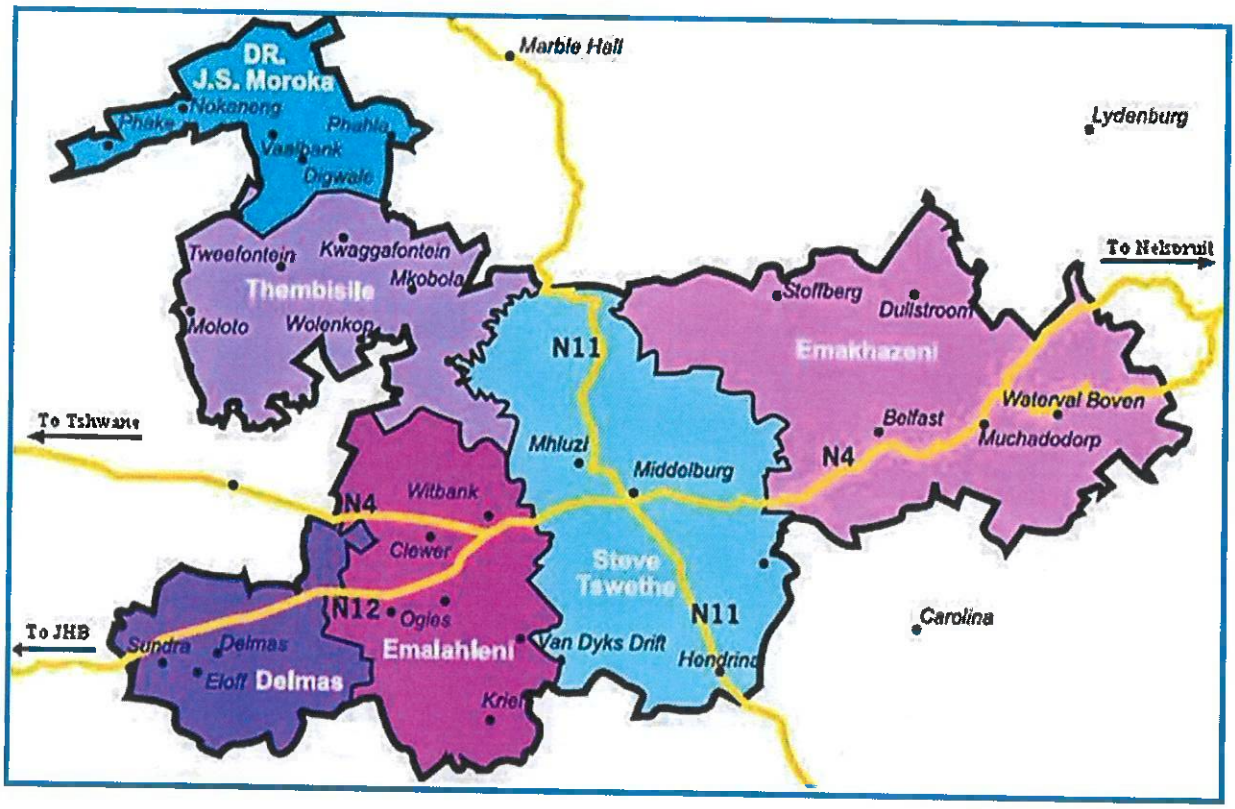
Figure 1.1: Location Map of Delmas (Victor Khanye spatial development framework)



Source: Google Maps

1.9 LIMITATION OF THE STUDY

Restricted access to sensitive information which was regarded as privy to only senior public officials to safeguard for security reasons limited the availability of information for the research (Schutte, 2014). Lack of access to the latest data and records such as environmental management plans and annual reports also proved to be limitation to the scope of research, however, this was resolved by gathering of the latest information.

1.10 DEFINITION OF OPERATIONAL CONCEPTS

This section focuses on the definition of operational concepts.

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Wetland: The generic term 'wetland' is used worldwide and includes specific ecosystems such as bogs, coastal lakes, estuaries, fens, floodplains, mangroves, marshes, mires, moors, pans, peatlands, seeps, sloughs, springs, swamps, vlei and wet meadows (Mays, 1996; DWAF, 2005). Whatever the local name given to wetlands, the driving force of all wetlands is the interplay between land and water, and the consequent characteristics that reflect both (Cowan, 1999). Any part of the landscape where water accumulates for long enough and often enough to influence the plants, animals and soils occurring in that area, is a wetland (DWAF, 2005).

Management: Management, in relation to a wetland, includes control, protection, maintenance and rehabilitation of the wetland with due regard to the use and extraction of biological resources, community-based practices and benefit-sharing activities in the area in a manner consistent with the National Environmental Management: Biodiversity Act, (10 of 2004) (Mangena and Brent, 2006). Management is regarded as a comprehensive generic function covering the entire process of planning, organizing, directing and controlling (Pooe and Mathu, 2011). According to Pooe and Mathu (2011:336). "management is the function in industry concerned with the execution of policy within the limits setup by the administration and the employment of the organization for the particular objects set before it".

Coal Mining: Coal mining is the process of extracting coal from the ground. Open cut mining is the most common used in South Africa's coal mining industry because coal seams are close to the surface. Such mining is cheaper than underground mining and enables up to 90% recovery of the resource. Many brown coal beds lie close to the surface and can be hundreds of metres thick, so can be extracted easily and cheaply. Firstly, the topsoil is removed and stored for use later in restoring the disturbed land. The surface rock (called overburden) covering the coal is then blasted with explosives and removed by excavators. The uncovered coal is in turn then blasted to break up the layers and loaded into large trucks which can hold up to 300 tonnes of material. The coal is transported to the processing plant where impurities are removed.

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Towns: A town is a compactly settled area usually larger than a village but smaller than a city, a compactly settled area as distinguished from surrounding rural territory, a large densely populated urban area (Van Der Waldt & Knipe, 2001). Cities are convenient places for people to live, work, and play. Convenience has economic consequences, as well. Reduced costs associated with transportation, and the ability to share expenses for infrastructure creates what is known as economies of agglomeration, which is the fundamental reason for cities.

Victor Khanye Local Municipality: The Victor Khanye Local Municipality (previously Delmas Local Municipality) is a Category B municipality strategically located within the Nkangala District in the Highveld of the Mpumalanga Province. It is situated on the border of the Gauteng Province, less than 100km from Pretoria, Johannesburg and EMalahleni. It is one of the smallest of six municipalities in the district. The municipality is linked by a major freeway, the N12, which was declared a Maputo Corridor. There is a railway line running through to the inner part of Mpumalanga and to Mozambique.

Mpumalanga Province: Mpumalanga means "Place where the Sun Rises" and people are drawn to the province by its magnificent scenery, fauna and flora, and the fascinating remnants of the 1870 gold-rush era (Simate and Ndlovu, 2014). With a surface area of only 76 495 km2, it is the second-smallest province after Gauteng, yet has the fourth-largest economy in South Africa.

Mpumalanga is defined as the province contains several distinct physiographic regions: the Highveld, a plateau ranging in elevation from 4,000 to 6,000 feet (1,200 to 1,800 metres), in the west; the forested Drakensberg mountains rising to more than 7,500 feet (2,300 metres) in the east; and the Lowveld, a bush-clad plain that slopes gently upward toward the Lebombo Mountains on the Mozambique boundary to the northeast. Much of Mpumalanga is drained by eastward-flowing tributaries of the Limpopo River (Simate and Ndlovu, 2014).

1.11 STRUCTURE OF THE STUDY

This study consists of five chapters which are as follows:

CHAPTER 1: Introduction and Background of the Study

This chapter provides introduction and background of the study. It addresses why the study is important in the field and answers the question and the extent of the problem. This section provides the status quo of the relevant work field and identifies a gap in knowledge or

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activities that must be filled to move the field forward. Sufficient details are given in this discussion to make clear what the research problem is and exactly what has been accomplished. It also provides critical research questions and the hypothesis of the study.

CHAPTER 2: Literature Review

The objective of this chapter is to highlight a critical summary of published research literature relevant to strategies and programs on land fill site management. Its purpose is to create familiarity with current thinking and research. This study will first review various types of constraints in landfill site management. Based on this understanding, a classification method will be developed to categorize constraint factors for the purpose of constraint identification and modelling. In the second stage of this study, existing constraint modelling methods will be identified based on a comprehensive review of current industry practices and academic research. Finally, once the constraint classification and modelling techniques are identified, a conceptual framework for total constraint management will be outlined.

CHAPTER 3: Research Methodology

This chapter provides research design methodology used when conducting the study. It outlines the population of the study, sampling method used, sampling size, data collection and pilot study as well as the data analysis method used, namely, thematic analysis and statistical analysis. It also highlights the ethical considerations that were adhered to.

CHAPTER 4: Data Presentation, Analysis and Presentation

This chapter covers the presentation, analysis and interpretation of data gathered by the researcher. A statistician analysed the data using the Statistical Package for Social Sciences. Descriptive and inferential statistics such as frequencies, tables, percentages, and correlation tests were used in the data analysis and summaries.

CHAPTER 5: Findings, Conclusion and Recommendations

The aim of the summary was to provide an overview of the study and to indicate the line and progression of reasoning of this research. Findings are stated according to the research aims, final conclusions are drawn, and recommendations are made. The limitations of this study and possible avenues for future research are discussed. The chapter concludes with a summary of the value of this research study, by proposing directions for wetlands management.

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The results of this study are presented and discussed at length in the previous chapter in an effort to either answer or reject the stated research questions. Possible explanations were also offered for the results that were reported. In this chapter, the results are summarised, and conclusions drawn. Lastly this study offers specific recommendations in an effort to further improve the conditions and management of landfill sites. The chapter concludes with a summary of the value of this research study

1.12 CONCLUSION

The chapter demonstrates the strategic location of the area, aims and objectives and research questions which are essential to determine the outcome of the study. Building blocks of research problem development which begins with the explanation of the concept of research, research cycle, sources of research problem, statement of research problem, questions, objectives. The following Chapter 2 presents the literature review and theoretical framework that provides the context to this study.

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CHAPTER 2

LITERATURE REVIEW AND THERORETICAL FRAMEWORK

2.1 INTRODUCTION

In this chapter the researcher reviewed literature on wetlands in South Africa and around the globe with the purpose of gathering extensive information on threats to wetlands and the mitigation measures to be applied. South Africa is recognised as a water-scarce country and one where access to water resources is inequitably spread across different sectors of the population (Mangena and Brent, 2006). According to McCarthy (2011) domestic water scarcity is exacerbated by the pollution of the water resources and the destruction of natural infrastructure, such as river systems and wetlands.

2.2 DISTRIBUTION OF WETLANDS IN SOUTH AFRICA

South Africa's wetlands are considered the most threatened of all the country's ecosystems (Simate and Ndlovu, 2014). Wetlands traverse terrestrial systems, form buffers along rivers and are influenced by water flow across catchments. Mpumalanga wetlands are classified by the national classification system as palustrine wetlands (seepage and floodplain wetlands), which include vegetated and unvegetated endorheic pans (isolated wetlands). The most common wetland types in Mpumalanga are "seepage and non-floodplain riparian wetlands," which make up at least 34% of the total wetland coverage of the Upper Olifants River Catchment (hereafter UORC). Seepage wetlands are located on noticeable slopes, including sloping valley bottoms, and are associated with perched water tables and saturated conditions close to the surface. Floodplain wetlands are found on a broad, generally flat topography dominated by alluvial processes and can occur next to well-defined river channels. Wetlands provide indirect benefits to people and the natural environment such as water purification, sustained stream flow, flood reduction, reducing the impacts of sea surges, groundwater recharge or discharge, erosion control and supporting species.

Wetland loss and degradation has been a persistent problem in many parts around the world because of population growth, which imposes great pressure on water resources and undeveloped land areas for settlements, higher agricultural and industrial production and infrastructure expansion (IUCN, 1999). Wetland habitat in South Africa is under pressure due to expanding mining development, particularly in the Mpumalanga Province.

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Education not only satisfies the human needs for knowledge and development; it provides a means to an end (Simate and Ndlovu, 2014). Education and training provide the person with the needed skills to enter the labour market or to become self-employed, leading to accelerated and sustainable development.

Table 2.1: (Census 2011, Community Survey, 2016)

Education Indicators	Trend 2001	Latest figure 2011	Latest figure 2016	Better (+) or worse (-) than Nkangala	Better (+) or worse (-) than province	Ranking: best (1) – worst (17)
Number of people 20+ with no schooling	8 361	5 529	5 712			4
Population 20+ with no schooling (%)	25.9%	11.8%	11.1%	(-) (9.3%)	(+) (11.5%)	9
Population 20+ with matric & higher (%)	18.7%	34.5%	32.6%	(-) (44.9%)	(-) (43.1%)	17
Functional literacy rate (%)	56.0%	76.9%	78.1%	(-) (82.6%)	(-) (79.1%)	9

The baseline information employed to portray the educational profile of Victor Khanye Local Municipality is indicative of those individuals in the area aged above 20 years of age (Simate and Ndlovu, 2014). These figures show that only 5.6% of residents in the municipality are educated on a level higher than Grade 12 (Simate and Ndlovu, 2014). Moreover, it also has to be mentioned that 11.1% of residents in Victor Khanye indicated that they had no formal form of schooling, this figure is relatively low in comparison to the 2001 and 2011 census.

Table2.2: (IHS and SERO, 2019)

Industry	Victor Khanye
Agriculture	21.6%

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Mining	3.8%
Manufacturing	4.3%
Utilities	1.5%
Construction	7.7%
Trade	8.5%
Transport	12.3%
Finance	5.8%
Community services	6.9%
Total	**5.5%**

It is approximated that 35-50% of the original natural wetlands in South Africa have been destroyed due to human influence (Mavis, 2013). Wetlands are sensitive ecosystems that perform many complex functions including the maintenance of water quality, carbon storage, stream-flow regulation, flood attenuation, various social benefits as well as the maintenance of biodiversity (Mavis, 2013). Wetlands are lost or degraded because their products, functions and attributes are not adequately appreciated or valued by human institutions and policies. South Africa holds extensive coal reserves and coal accounts for approximately 92% of South Africa's energy generation (WWFN, 2011).

People have not appreciated the value of wetland resources except for the limited consumptive use of some of the wetland resources (Simate & Ndlovu, 2014). Wetlands in South Africa, however, are poorly conserved owing primarily to a general underestimation of the ecological and economic importance of these systems (Simate & Ndlovu, 2014). Some of the major contributing factors to the decline of wetlands in South Africa include mining, industrial and agricultural activities as well as poor treatment of waste water from industry and mining (Oberholster *et al.*, 2011). Little, if any, of the ecological values are considered important by the local inhabitants while in fact their livelihoods depend entirely on sustenance of these values. This lack of awareness among community members often generates negative tendencies that put the well-being of the wetland at risk; for instance, dumping of

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wastes, draining and land clearing for grazing and agriculture, burning and overexploitation of wetland resources (Mavis, 2013).

Governments across the world spend money to stimulate growth, fight unemployment and reduce under-development of its populace (Koster *et al.,* 2016). This is precisely because economic growth, and by extension economic prosperity, does not happen naturally, that is without the active role of local institutions (Yang *et al.,* 2008). There is a need for the local institution to learn about the enabling factors (Turner and Berube, 2009). The outcome of learning may include the introduction of a policy, programme or incentive that is responsive in addressing challenges and responding to opportunities in a particular space (Kline and Moretti, 2014). These learnings are not confined to one layer of government, thus, should be embraced by all players including the state-owned enterprises and private sector institutions (Pugalis and Gray, 2016). Over the past ten years, the government of South Africa has made many changes regarding national policies and acts (such as the National Water Act 36 of 1998) in an effort to reduce the inequalities and underdevelopment.

2.3 CLASSIFICATION OF WETLANDS

A wetland is a land area that is saturated with water either permanently or seasonally such that it takes on the characteristics of a distinct ecosystem (McCarthy and Pretorius, 2009). The primary factor that distinguishes wetlands from other landforms or water bodies is the characteristic vegetation of aquatic plants adapted to the unique historic soil (Mavis, 2013). Wetlands play a number of roles in the environment principally water purification flood control carbon sink in shoreline stability wetlands are also considered the most biologically diverse of all ecosystems serving as home to a wide range of plant and animal life wetlands occur naturally on every continent except Antarctica the largest including the Amazon River basin the West Siberian plain and the Pantanal in South America the water found in wetlands can be freshwater, brackish or saltwater (Mavis, 2013). The main wetland types include swamps marshes bogs and fens, and subtypes include mangrove, car-polka sign and Varzi (McCarthy, 2011).

Wetlands comprise approximately 6% (8.5 km^2 x 103) of the world's land surface and are found in every climate from the tropics to the frozen tundra (Mays, 1996). Several definitions for wetland exist, but two of the most common wetland definitions used in South Africa are the National Water Act (NWA) and the Ramsar definition: Discussion Paper: Wetlands in Agriculture National Water Act, Act No 36 of 1998: "Land which is transitional between

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terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil".

South Africa, being a contracting party to Ramsar, also uses the definition accepted by the convention. Article 1.1 of the convention defines wetlands as (Cowan, 1999; Koester, 1989): "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters."

Internationally, the Ramsar definition of wetlands is the most widely quoted. Probably the second most-quoted definition of wetland is that of the US Fish and Wildlife Services (USFWS) (Adam, 2001): "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purpose of this classification, wetlands must have one or more of the following attributes:

i) at least periodically, the land supports predominantly hydrophytes;

ii) the substrate is predominantly undrained hydric soil; and

iii) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year. For the purpose of this document, the definition of the NWA (Act No 36 of 1998) will be used.

A wetland is defined in the National Water Act (No. 36 of 1998) as 'land which is transitional between terrestrial and aquatic systems, where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil. (National Water Act, Act 36 of 1998; Chapter 1; Clause xxix). The definition used by the Ramsar Convention is much broader and reads as follows: For the purpose of this convention wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh or salt, including areas of marine water the depth of which at low tide does not exceed six meters (Ramsar Convention, Article 1.1, 2009) South African National Wetland Classification System follows the Ramsar definition with minor changes, and is as follows; wetland is an area of marsh, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh,

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brackish or salt, including areas of marine water the depth of which at low tide does not exceed ten metres (SANBI, 2012).

Management is the act of getting people together to accomplish desired goals and objectives using available resources efficiently and effectively (Jeffrey, 2005b). Since organizations can be viewed as systems, management can also be defined as human action, including design, to facilitate the production of useful outcomes from a system (Jolly, 2014). This view opens the opportunity to manage oneself, a pre-requisite to attempting to manage others. Management functions include planning, organizing, staffing, leading or directing, and controlling an organization or effort for the purpose of accomplishing a goal (Jolly, 2014).

Management is a very popular term and has been used extensively for all types of activities and mainly for taking charge of different activities in any enterprise (Jeffrey, 2005b). People in organisations are performing diverse tasks but they are all working towards the same goal, therefore, management aims at guiding their efforts towards achieving a common objective a goal (Jeffrey, 2005b). Thus, management has to see that tasks are completed, and goals are achieved (i.e., effectiveness) with the least number of resources defined as a process of getting things done with the aim of achieving goals effectively and efficiently. There are certain terms which require elaboration, and these are (a) process, (b) effectively, and (c) efficiently. Process in the definition means the primary functions or activities that management performs to get things done. Effectiveness in management is concerned with doing the right task, completing activities, and achieving goals and in other words, it is concerned with the end result, but it is not enough to just complete the tasks (Jolly, 2014).

The term 'management' today has several different connotations that highlight the different aspects of its nature (Jennings, Neuman and Blicker, 2018). The study of management has evolved over a period of time along with the modern organisations; based both on the experience and practice of managers and a set of theoretical relationships. Over a period of time, it has grown into a dynamic subject with its own special characteristics.

The UN Millennium Ecosystem Assessment (2019) determined that environmental degradation is more prominent within wetland systems than any other ecosystem on earth international conservation efforts is being used in conjunction with the development of rapid assessment tools to inform people about wetland issues constructed wetlands can be used to treat municipal and industrial wastewater as well as stormwater runoff.

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The idea of classifying wetland systems is to group similar types of wetlands (with homogenous natural attributes) into categories and subcategories, typically for the purposes of wetland inventory. Each wetland type in a classification system represents a broad set of natural hydrological, geomorphological, and ecological characteristics. The aim of classification is to aid identification and understanding of the main wetland types occurring in an area or at a site and provide a broad-level characterisation of the system.

The famous Cowardin wetland classification system (Cowardin *et al.*, 1979) was successfully used by the US National Wetland Inventory for almost 20 years (Dini et al. 1998). In South Africa, the classification system of Dini, Cowan and Goodman (1998), which is based on the Cowardin system, recognises six broad types of wetland systems: marine, estuarine, riverine, lacustrine, palustrine and endorheic. This classification was used as the early basis of mapping and inventorying wetlands in South Africa, and is the system included in the current Wetland Reserve Determination Process (DWAF 1999). Here, 'riverine' wetlands are defined as those contained within a channel (that is, rivers, rather than wetlands associated with rivers), and are excluded from the wetland Reserve Determination method.

The hydrogeomorphic classification (HGM) system developed for the US Army Corps of Engineers by Brinson (1993) is now the system most commonly applied in the US. This is based on the concept that while each wetland may be unique, each can be placed into categories in which similar wetlands share similar functional properties. The focus is on hydrological and geomorphic controls which maintain many of the functional aspects of wetland systems. By emphasizing the abiotic features of wetlands, HGM was kept relatively independent of the biogeographic distribution of biota (Brinson 1993). The HGM method was adapted for South African conditions by Marneweck and Batchelor (2002) and more recently again by Kotze, Marneweck, Batchelor, Lindley and Collins (2004).

The wetland classification system developed for the National Wetland Inventory of SANBI (Ewart Smith *et al.*, 2006) emphasises the influence of ecoregions on wetlands. The ecoregions will to some extent dictate the nature of wetlands occurring within the particular ecoregion. There are 31 Level 1 ecoregions in South Africa (including Lesotho and Swaziland) and each delineation needs to locate the wetland within the appropriate ecoregion, especially for the development of EIAs, EMPs, etc. Level 2 and Level 3 ecoregions provide greater detail and insight into the expected nature of the areas (Kleynhans *et al.*,

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2005). The following hierarchical classification system is proposed for wetlands (SANBI, 2012):

- Level 1 Connectivity to open ocean
- Level 2 Level 1 Ecoregion (from Kleynhans *et al.*, 2005)
- Level 3 Landscape unit
- Level 4 Hydrogeomorphic (HGM) unit (Level 4 is divided into a number of categories which vary depending on the landscape unit and the HGM unit.

The second adaptation is a simple system designed for use in wetland assessment and inventory and is appropriate for application in the wetland Reserve Determination method. Seven wetland types are recognized. The system focuses on the hydrogeomorphic determinants of wetlands and incorporates geomorphology, water movement into, through and out of the wetland, and landscape/topographic setting. Volume 13 of the Ramsar (2010) gives detail on the monitoring requirements for designated wetlands. Recognising that monitoring can be expensive, programmes should be cost-effective and adequate for management purposes. Rapid assessment techniques are suitable for broad-scale implementation and may provide adequate data for broad-scale management. However, detailed quantitative monitoring is often required for specific sites.

Day *et al.*, (2010) and Bird (2010) propose indicators for the identification of temporary wetlands using invertebrates and plants as indicators and provide methods for using these indicators. Th indicators should be used when the assessor is faced with the wetlands in sandy soils as covered in procedure of the DWAF (2008) field procedure. Job (2008) also tested the DWAF (2008) field procedure widely in the Western Cape where wetlands may be difficult to identify. It was found that 65% of wetlands could be identified using the indicators described in the DWAF (2008) field procedure, and the remaining 35% fell into the 'special cases' category. These were mostly sandy and low chroma soils. For these, the recommendation that she made are:

- Record the presence of a dark, high carbon content layer on the soil surface, and/or
- Thoroughly document landscape conditions and any remnant vegetation, soil, hydrology indicators, and then develop the rationale for considering the area to be wetland.

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- Maintaining basic aquatic processes, that is maintaining channel stability, groundwater recharge, control of microclimate and water temperature, flood attenuation and maintenance of general wildlife habitat
- Reducing impacts on water resources from upstream activities and adjoining land uses, storm water attenuation, sediment trapping, removal of toxics, nutrient removal, and removal of pathogens.
- Providing habitat for aquatic and semi-aquatic species, provision of habitat for aquatic species, that is, screening of adjacent disturbances and habitat connectivity
- Providing habitat for terrestrial species, which is the provision of habitat for terrestrial species and habitat connectivity

The Ramsar (2010) framework for the design of a monitoring framework is discussed under the section titled 'The identification, and development where necessary, of a suite of indicators for monitoring the health of the ecosystem services identified as important in the area to be conserved'. Ramsar (2010) provides a framework for planning a wetland inventory. In order to complete the task to the standard required by the Ramsar (2010) Convention, the requirement is that all steps to be followed. They do, however, suggest that the emphasis may be placed on ecosystem services if this is desirable.

Considerable work has been carried out in the last few years on classifying or typing the wetlands found in this country (Ewart-Smith *et al.*, 2006; SANBI 2009), where "classification" in this sense refers to assigning wetlands to a type based on position in the landscape, hydrological functioning, and other features. It is important to note that this use of the term "classification" is different to the sense used by Department of Water Affairs DWA which means categorising a particular aquatic system (for example, a river reach, wetland, or estuary) for management purposes (Jay, 2012).

Wetland Classification System (SANBI 2009) defines wetlands as areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tides does not exceed ten meters." The National Wetland Classification system first splits wetlands into three groups (at Level 1) according to connectivity to the sea. These three groups are; Marine Systems (connected to the open ocean), Estuarine Systems (partially enclosed systems connected to the ocean) and Inland Systems (unconnected to the sea). In this report, only the water quality of "Inland Systems" is considered and only the classification

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of these is described here. "Inland Systems" are defined as ecosystems that have no existing connection to the ocean (are characterized by the complete absence of marine exchange and/or tidal influence) but which are inundated or saturated with water, either permanently or periodically Inland wetlands can be sub-divided according to the ecoregion (Kleynhans *et al.*, 2005) in which they are located.

2.3 SIGNIFICANCE OF WETLANDS

Kayranli *et al.*, (2010) suggests that wetlands only cover approximately 2-6% of global surface area (depending on the definition of wetland) but contain a large proportion of the world's carbon (approximately 15×1014 kg). Mitsch and Gosselink (2007) suggest that wetlands cover 6-8% of the global surface area and are responsible for approximately one-third (approximately 450 petagrams) of the total SOC pool (estimated to be 1550 Pg). Water and wetlands are crucial for sustaining many man-made infrastructures; for example, in the case of irrigation systems, municipal water supply, electricity generation and sewage run-off/sanitation. Not only does hydropower depend on water availability, but also thermoelectric power plants (fossil fueled and nuclear) are strongly dependent on water availability for cooling (van Vliet et al., 2012).

According to Lal (2003) soil provides an estimated 2300 Pg (2.3×1018 g) of the total C pool. A 1982 study by Post *et al.*, (1982) reported that wetlands cover 280 million ha globally, and the average carbon density in wetland is 723 t/ha. This amounts to a total of 202.44 billion tons of carbon in wetlands. According to Bernal and Mitch (2008), more research is needed to quantify more accurately the extent of wetlands' soil carbon pool worldwide and the importance of wetland type, hydrological fluctuations, and climate. Nevertheless, there is no doubt that by unit surface areas wetland ecosystems store more carbon than any other ecosystem in the world (Ramsa, 2010).

Wetlands are generally regarded as a sink for atmospheric carbon, a definitive element to consider when accounting for the earth's carbon pool. If not managed properly however, they become a source of greenhouse gases (GHGs) (such as carbon dioxide and methane) (Adhikari *et al.*, 2009; Bernal and Mitch, 2008). Conserving wetlands is therefore a practical way of maintaining existing carbon reserves and avoiding GHG emissions. However, recent literature reviews on the topic suggest that there is no commonly accepted agreement as to whether wetlands are actually carbon sources or sinks, and there exists disagreement in the interpretation of variables, reactions, and the impact of environmental conditions on carbon

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storage and release. Therefore, recommendations on how to adapt policies and planning processes to enhance carbon storage vary considerably (Kayranli *et al.,* 2010). Despite the recent disagreements on whether wetlands are a carbon source or sink, all types of wetland systems including natural-, constructed-, and treatment wetlands have at least the potential to sequester carbon (Kayranli *et al.,* 2010). Estimates of greenhouse gas fluxes from constructed and natural wetlands indicate that fluxes from constructed wetlands are higher than those from natural wetlands (Bernal and Mitch, 2008).

Natural wetlands also have more carbon sequestration capacity than the constructed wetlands (Howard, 2016). Wetland protection and restoration measures can improve the carbon sequestration potential of wetlands (Hota and Behera, 2015). However, it takes several decades for the carbon sequestration ability of restored wetlands to reach levels comparable to those of natural wetlands.

There are several Natural Resource Management Programmes in South Africa that work with wetlands, but their impact on wetland management or rehabilitation has not been evaluated (Hota and Behera, 2015). Nor have the management of individual wetlands and the cooperation of organisations managing these been evaluated. Kotze *et al.,* (2009) in their review of the impact of the Natural Resource Management. Specific ecosystem service functions of wetlands contributing to their importance in the social-ecological landscape are examined below. When evaluating South Africa's water resources, it is necessary to recognize that the unity and interaction of the water cycle: evaporation, clouds and rainfall are linked to groundwater, rivers, lakes, wetlands, and the sea (Thompson, 2006).

Wetlands are therefore an integral part of the water cycle, and their functions, attributes and values cannot be overestimated (Finkelman, 2004). Wetlands are among the most productive ecosystems in the world, sustaining habitats containing high diversity and large numbers of endemic and threatened species. They perform valuable ecological functions, they act as a water store and regulate runoff; they function as nutrient filters and/or sinks by filtering of suspended solids as well as being an effective transformer (that is, primary oxidation/reduction systems on the landscape) of N, P and C (Mays, 1996, DWAF, 2005), they directly support millions of people and provide goods and services to the world outside the wetland (Cowan, 1999). Apart from these important environmental services, wetlands are also valuable in terms of recreation, scientific, educational, and cultural values (Adam, 2001).

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Understanding that wetlands are a special type of landscape, that they are widespread and that they provide both environmental and cultural benefits to society, it becomes clear that wetland conservation is essential (Finkelman, 2004). Despite the benefits provided by wetlands, South Africa lacks a planning tool for effective wetland conservation (Finkelman, 2004). With heavy losses to a small but extremely important landscape type, it is imperative that a strategy to conserve wetlands be developed (Duus, 2013).

According to Cowan (1999), a policy and its implementation strategy is a means of planning for wetland conservation that will enable South Africa to meet both its national objectives and international obligations. In a study done by Schuyt (2005) on four wetlands, a total of 16 different goods and services were identified by local populations (De Klerk, 2016). These goods and services will be lost if African wetlands are lost, with a profound impact on local and subsistence farmers. Factors that put increased pressures on wetlands are population growth, rising poverty, and economic stress, which could be intensified by drought. A further complication is that benefits of wetlands are not shared by those who own the property (De Klerk, 2016). Private landowners could derive higher returns from wetland conversion, while the public benefit of the wetland and therefore the cost of the conversion is carried by the local populations (Schuyt, 2005).

Wetland losses are directly linked to biodiversity loss, in Sub-Saharan Africa, processes that are responsible for wetland and biodiversity loss include destruction and fragmentation of habitat, desertification, introduction of alien species, and harvesting and hunting of selected individual wild species (Perrings, 2000). In southern Africa, a review of wetland inventories indicated the extent of wetland resources in ten countries in the region. Loss figures are given for two areas in Natal the Tugela Basin, where over 90% of the wetland resources have been lost in parts of the basin and the Mfolozi catchment (10,000 km^2), where 58% of the original wetland area (502 km2) has been lost (Moser, Prentice and Frazier, 1996).

In southern Africa, wetlands play a significant role in the livelihoods of rural communities (Taylor *et al.*, 1995; Breen *et al.*, 1997; Frenken and Mharapara, 2002). The ability of wetlands to store water during the wet season and release it during the dry season provides farmers, who live in semi-arid areas, with opportunities to grow crops all-year round thereby improving their food security and incomes. Besides crop production, wetlands provide other services that support people's livelihoods such as: dry season livestock grazing and watering;

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domestic water supply; fishing; and natural products (Matiza and Chabwela, 1992; Mmopelwa, 2006).

Therefore, it is one of the most important and productive ecosystems. However, in past centuries, instead of attaching importance on wetlands, humans regarded wetlands as a harbour of mosquitoes, carriers of disease, and sources of death. Therefore, settlers and early governments began to reclaim wetlands in large areas and make full potential use of the wetlands. Due to the dual effects of human activities and natural factors, the wetland area in the world has been decreasing, and the wetland quality has been deteriorating.

Davidson (2009) gave an astonishing fact that wetlands around the world had degraded by about 87% since 1700 in Wetlands are still facing the threat of loss or degradation. Until recently, it has been recognized that wetlands not only contain the value of biodiversity and as habitats for plant animal and fish species, but also can bring many environmental services or functions (Chadwick, Highton and Lindman, 2013). Thus, wetland policy has begun to shift from encouraging development to protecting and rational utilization.

In the context of cognition transformation, the Ramsar Convention was signed in 1971. It is not only a global intergovernmental treaty of wetland conservation and wise use, but also the first environmental convention in the world. Ramsar Convention aims at protecting wetland ecosystem function, maintaining wetland culture, and finally realizing sustainable socio-economic development through local, regional and national action and international cooperation.

Ramsar Convention, countries all over the world have participated in the research of wetland protection and wise use. Now, the Ramsar List is the world's largest network of protected areas. By now, there are 2303 Wetlands of International Importance (Ramsar Sites) on the territories of 169 countries across the world, covering about 229 million ha, which accounts for about 19% of the global wetland area. Although there several positive news stories about the R data existing regions, and the degradation mainly occurred in the 20th and early 21st Century.

Water moves around the earth through the water cycle, and wetlands are a crucial part of it. The water cycle is influenced by both physical (for example. topography, geology) and ecological factors (for example, transpiration from plants, the effects of land cover on water flows). The water cycle also underpins and is influenced by nutrient cycling (which influences

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water quality) and carbon cycling (which influences land cover and organic carbon in soils, including in high carbon ecosystems such as peatlands, which also influence water flows).

Wetlands are a conspicuous and important part of this cycle and therefore a key determinant of the type and level of ecosystem service delivered particularly regarding surface water flows (most of which occur through wetlands). Whilst this report focuses on the role of wetlands in delivering ecosystem services, it is important to keep in mind this landscape/ecosystem setting of wetlands. Usually, but not always, wetlands receive water from the landscape and deliver it, generally through rivers, to the coast and onwards into the sea. (Elliot and Hoage, 1985) There are exceptions: some wetlands deliver water back into the landscape (through groundwater and soil moisture recharge) while other inland wetlands can be the final destination of water. In some cases, wetlands cannot be distinguished from land, for example, wetlands dominated by vegetation cover (such as forested wetlands).

Wetlands are a key factor in the global water cycle and in regulating local water availability and quality (Biyase, 2015b). Wetlands contribute to water purification, including denitrification and detoxification, as well as to nutrient cycling, sediment transfer, and nutrient retention and exports (Biyase, 2015a). Water is a provisioning ecosystem service itself, but it is also necessary to all other provisioning ecosystem services (for example, food, fibre, timber) and most regulating ecosystem services (for example, water purification, flood protection), supporting ecosystem services (for example, photosynthesis, primary production, nutrient cycling), and cultural ecosystem services (for example, recreation, aesthetic experience, spiritual enrichment) (Biyase, 2015a; Biyase, 2015b).

The role of wetlands in water-related provisioning, regulating, and supporting services is one of the fundamental factors in ensuring water security, but also in maintaining other ecosystem services (Biyase, 2015a). Other provisioning ecosystem services delivered by wetlands include food (for example, fish, rice and other agricultural products), timber, fibre and non-timber forest products, and hence often play an important role in the livelihood of many communities (Bradford and Salmon, 2007). For example, global inland capture fisheries production in 2010 was 11.2 million tonnes and inland aquaculture production was 41.7 million tonnes all of this derived from wetlands. Many people across the world have cultural value links with water and wetlands that may be overlooked when changes occur to these habitats. While these are not monetary values, it is essential to recognised that such values are important for local communities (Bradford and Salmon, 2007). It is also important to note

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that the ecosystem services that wetlands provide are not always synergistic with each other. Maximising ecosystem services for water supply or flood defence could imply trade-offs, for example, with biodiversity or cultural values.

2.4 GLOBAL PERSPECTIVES OF COAL MINING ON WETLANDS

The international status of wetlands has been deteriorating for several centuries. According to the Economics of Ecosystems and Biodiversity initiative, it is estimated that since 1900, at least 50% of the world's wetlands have been lost. Apart from the high population growth, the changes in political power led to the need for rapid development, increasing the pressure on our natural resources. These conditions often result in the destruction of the very natural resources on which our sustained development depends (Cowan, 1999).

Countries with the most sites are the United Kingdom (174 sites, accounting for 7.6% of the total sites) and Mexico (142 sites, accounting for 6.2% of the total sites), but the total area of them are 1.3 million ha (accounting for just 0.6% of the total area) and 8.7 million ha (accounting for 3.8% of the total area), respectively. Bolivia has the largest area under the Ramsar Convention 's protection, which is mainly distributed between 10◦S and 20◦S, with a total area of 14.8 million ha (accounting for 6.5% of the total area, while the amount proportion is just 0.5%); Countries with a protected area exceeding 10.0 million ha also include Congo, Canada, Chad, the Democratic Republic of Congo, and the Russian Federation, which are mainly distributed between 10◦S-20◦N and 40◦N-60◦N (Akcil and Koldas, 2006).

The single sites with the largest protection area are the Ngiri-Tumba-Maindombe (a lake wetland from the Democratic Republic of Congo, with an area of 6.6 million ha, accounting for 2.9% of the total area) and the Queen Maud Gulf (a coastal wetland from Canada, with an area of 6.3 million ha, accounting for 2.7% of the total area). Sites with a protected area exceeding 5.0 million ha also include the Grands affluents (a river wetland from Congo, with an area of 5.9 million ha), the Sudd (a marsh wetland from South Sudan, with an area of 5.7 million ha), and the Okavango Delta System (a river wetland from Botswana, with an area of 5.5 million ha). Due to different protection purposes, four wetlands with an area of only one hectare have been added into the

Ramsar List, which are the Ganghwa Maehwamareum Habitat in the Republic of Korea, the Somerset Long Bay Pond in the UK, the Ile Alcatraz in Guinea, and the Mare Aux Cochons high altitude freshwater wetlands in Seychelles it has been estimated that in South Africa,

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between 35-50% of all wetlands have been destroyed (DWAF, 2005; SANBI, 2006). The main reasons are drainage of wetlands for crops and pastures, poorly managed burning and grazing those results in Donga erosion, planting of alien trees in wetlands, mining, pollution, and urban development (DWAF, 2005).

Wetlands are a small but extremely important part of the South African landscape, and their conservation has been sorely neglected, probably due to factors such as poor knowledge on the extent of our wetlands; lack of planning tools for their conservation and; inability to meet our international commitment in terms of wetland conservation (Cowan, 1999). The loss of wetlands in the United States of America and Europe has slowed, but not stopped. In the last 20 years, the loss of wetlands in several other continents and countries has declined at a concerning rate, for example, in China, the Republic of Korea and Singapore.

It is estimated that 12.8 million square kilometres of wetland remain in the world, although this is thought to be an underestimate. Human-made wetlands are mainly reservoirs, most of which distribute in Asia (Pakistan and India) and Europe (UK and France). Marine/coastal wetlands mainly distribute in North America (Mexico) and Africa (the countries along the Atlantic coast). There are 37.0% of the inland wetland sites and 28% of the marine/coastal wetland sites have been artificially reconstructed.

The inland wetland sites containing human-made wetland sites mainly distribute in Europe (59.0%, primarily in the countries located in West and South Europe), Africa (15.0%, primarily in Congo, Burkina Faso, and Algeria), and Asia (13.3%, primarily along the Yangtze River). The marine/coastal wetland sites containing human-made wetland sites are mainly located in Europe (46.9%), North America (18.0%), Africa (15.4%), and Asia (11.0%). Noting that 414 wetland sites are distributed in high altitude areas, of which, the main types are alpine marsh wetlands (43%) and alpine lake wetlands (37%), mainly distributed in Africa (31%, the Atlas Mountains and the southern mountain region), Europe (29%, the Alps and the Iberian Peninsula), and Asia (21%, the Himalayas and the Mongolia Plateau)

2.4.1 China

The wetlands area of China accounts for about 4.2% of the global wetlands area and only 5.58% of the national area. China's wetlands are proportional lower than the global average level. Taking into account the intensive human disturbance and pollution, water resources

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and biological resources provided by wetlands ecosystem are less than 1/5 of the world average level; thus, the wetlands resources in China are in extreme shortage.

China includes 5 types in 34 variations, covering riverine wetland, lake wetland, inland marshes/swamp, coastal wetlands and artificial wetlands. In China, a national wetland resources survey has been conducted twice, during 1995e2003 and 2009e2013. According to the China's second national wetland resources report, completed in 2014, the total area of wetlands is 53.42 10 6ha, and accounts for 5.58% of China's territorial area, with a loss rate of 9.33% compared to the first survey (Wetland China, 2014).

China's wetlands have been destroyed or degraded since the 1950's. Since Reform and Opening in 1978, China has made significant achievements in economic development. At the same time, the Chinese government has strengthened the protection of wetland resources and formulated the "National Wetland Protection Plan (2002e2030)". According to the plan, 8.99 billion CNY will be invested in wetlands protection and restoration. More than 550 National Wetland Nature Reserves and 100 National Wetland Parks have been established.

The draft of the National Wetland Protection Regulations has been completed based on the absorption of the views of all aspects. At the local level, some provinces such as Heilongjiang, Gansu, Hunan and so on have implemented local wetland protection regulations. Some scholars have done research related to coastal wetland (Sunet *et al.,* 2015; Jiang *et al.,* 2015; Luo *et al.,* 2016), lakes wetland (Mei *et al.,* 2016) and riverine wetland (Zhang et al., 2016) that including wetland ecosystem assessments (Sun *et al.,* 2016), restoration, carbon cycle, wetland change and management system (*Lin et al.,* 2016). However, in the context of so much effort done, the annual wetland disappearance rate is still close to 1%.

It is very necessary to understand the general situation of wetlands in China. There are still some issues that should be discussed, as well as efforts that need to be undertaken in the conservation of China's wetlands. In the ten years of the two surveys, the wetlands resources in China showed three main changes. Wetland's area has reduced greatly. By comparing the wetlands with same type and range, wetlands area decreased by 3.39 million ha, of which the natural wetland area decreased by 3.37 million ha, up to 9.33%. Many rivers and lakes were changed into artificial wetland. The area of protected wetlands has obviously been increased. During the two surveys, the protected wetlands area increased to 5.25 million ha.

The total area of protected wetlands is up to 23.24 million ha, which is the 43.51% of the total wetlands area in China. The pressure of wetlands disturbance has been increasing. By

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contrast, we can find that the driving factors of wetlands degradation have been expanded from pollution, reclamation and illegal hunting into pollution, excessive exploitation of biological resources, reclamation, bio-invasion and occupation by infrastructure (Akcil and Koldas, 2006). The number, frequency and interference area of the affect factors are increasing. China, the most industrialized and polluted country, over the past 30 years has also experienced serious environmental pollution problems with regard to contaminated air, soil and water, which have resulted in harmful effects on public health and environmental well-being (Hu *et al.,* 2014:1).

This severe pollution in China is reported to claim the lives of huge numbers of people every year. In fact, in the year 2015 alone, about 1.8 million Chinese died as a result of environmental pollution (Yan 2017:1). Several reports have indicated that the pollution is not only affecting China but also neighbouring countries such as Japan and South Korea (Cain 2013; Galbraith 2013). This could possibly result in wars between China and these countries if care is not taken. The people of China, especially those in the most affected areas, experience critical problems from time to time with regard to their soil, water and health and this results in frequent protests against the government and the polluting industries (Xue et al., 2018; Zhang et al., 2014). In fact, Xue and others (2018:190) in their study went further to declare that environmental protest actions have come to be viewed as the most effective method of drawing government attention to environmental protection.

2.4.2 Australia

Surveys have found that, of the 317 active and abandoned mines in Australia that have the potential for the excavated material to be acid generating, 54 sites generate significant amounts of potentially acid-generating wastes (greater than 10% of their wastes), while a further 62 generate some potentially acid-generating wastes (less than 10% of the total waste) (Harries, 1997). Rehabilitation of these sites, *viz.* Mt Lyell (Tasmania), Mt Morgan (Queensland), Brukunga (South Australia) and Rum Jungle (Northern Territory) have proved to be difficulty. In most States there is an active process of identifying those that pose the most serious threat to the environment and local biodiversity. These sites are then prioritised according to the level of risk they pose, and are progressively rehabilitated, usually at public expense. In NSW alone, there are an estimated 20,000 to 30,000 derelict mines that require clean-up and rehabilitation (NSW State of the Environment Report 1997). Australia was the first Contracting Party to the Ramsar Convention.

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There are several rivers in Australia that have had significant lengths of their extent rendered biologically dead from such mining impacts. For instance, some sections of the Molonglo River, which flows into Lake Burley Griffin in Canberra, were damaged to such an extent by acid leaking from the Captains Flat mine that no aquatic biota could persist. Many parts of this river remain severely damaged. With the exception of several industry leaders, rehabilitation practices at many of Australia's current mining operations are of a relatively poor standard with respect to re-establishment of biodiversity values (Reddick, 2016).

The restoration of landscape function and partial vegetation structure is considered by many to constitute rehabilitation success, with far less regard for the restoration of species composition. As noted by Woodside and O'Neill (1995), little if anything is done to re-establish the fauna (invertebrates or vertebrates), with many mines of the opinion that within the post-mined rehabilitation, the fauna will migrate from adjacent areas. This is quite often not the case, particularly when opportunities for secondary succession are exacerbated by excessive fragmentation or lingering pollution (Lockwood and Pimm 1999). However, due to the relatively small size of the mineral operations in comparison to alternative land uses, poor rehabilitation is only likely to impact local biodiversity.

The Biodiversity Group of Environment Australia was the designated administrative authority for implementation in Australia of the Ramsar Convention, and in 1995 began the process of preparing a National Wetland Policy. Globally, and nationally, it is reported that over the past two centuries around half of the wetlands have been destroyed. Majer and Nichols (1998) examined successional changes in ant communities within rehabilitated mine pits over 14 years against a forest analogue and concluded that mine pit ant community composition converged towards the forest site as time since rehabilitation increased. However, distinct differences between the mined and unmined sites remained.

Inventory and monitoring information are intricately linked and at the heart of successful wetland management (Rountree, Batchelor & Mackenzie, 2008). Monitoring addresses the extent of change in the environment, yet, for wetlands, it is rarely based on valid scientific principles. Monitoring is also a research tool, but has not, until relatively recently, been accepted as integral to the research effort in environmental management, in part because the questions that may be answered have not been well defined or articulated (Reddick, 2016). The absence of rigorous scientific input to monitoring design has contributed to the devaluing of past long-term monitoring effort. To turn this around and to ensure that wetland

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managers receive adequate and timely data we need to enhance the scientific rigor applied to monitoring. Management is a complex process and involves many sectors of society (Sonter, Moran, Barret, and Soares, 2014). Involving these sectors in monitoring has recently received some attention, but this is not universal and is not necessarily well supported. The challenge is to correct this situation and take advantage of community interest in wetland conservation that may provide mechanisms for more cost-effective monitoring. A protocol for monitoring Australian wetlands is presented, which is a series of logical steps to assist in the development and implementation of monitoring programs that are effectively linked to management procedures (such as a formal management plan) (Sonter, Moran, Barret, and Soares, 2014). The protocol includes a review process that could result in the termination of a program that has achieved its goals, or the abandonment or revamping of one that has failed.

2.4.3 United States of America

The United States has taken an increasingly aggressive stance on wetland loss in the past three decades (Rountree, Batchelor & Mackenzie, 2008). Thirty years ago, the country was losing almost 500,000 acres of wetlands per year. It is now nearing the national goal of 'no net losses of wetlands, which was reaffirmed by President Bush in 2002. In 2004, the President announced a new national goal, to have an overall annual increase of wetlands in America, through the creation, improvement, and protection of at least three million wetland acres over the next five years (Whitehouse Press Release, 2004).

The Dade County, Florida, USA has developed its own acquisition program and has participated in, and benefitted from, acquisition efforts initiated by the federal government and by the State of Florida (Rout, Masto, Padhy, George, Ram & Maity, 2014). The County has recently approved a two year, county-wide property tax (to generate some $90 million) for the purchase of wetlands, pinelands, and tropical hammocks. Many wetlands provide habitat for other important faunal components, serving as resting and feeding stations along migratory flyways for ducks, waders and shorebirds which benefit from the diversity of food organisms (Reddick, 2016).

The seasonal influx of passage migrants serves to increase the biodiversity of many wetland sites. In their study of coastal wetland habitats in Surinam, South America, Swennen and Spaans (1985) found more than 75% of the foraging waterfowl were migrants of northern origin, with only a minority being local resident species. For the eight families studied in an

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area of just 736ha of these rich and varied coastal wetlands they found 15,678 waterfowl belonging to 40 species dependent on the wetlands during the tropical part of their life cycle. The philosophy of the County is that, even with the appropriate strict regulation and mitigation, the best way to protect the most sensitive areas is to own them EPA, 1991. The River and Harbors Act (1899), which provided the US Army Corps of Engineers with the necessary permission for any construction involving dredging, filling, or obstruction of navigable waters, but did little to protect wetlands, other than those that are navigable.

The Federal Water Pollution Control Act, more commonly known as the Clean Water Act, which gave the federal government authority over wetlands. This Act includes the Corps' 1968 revision of permit regulations, in response to increasing national concern for the state of the nation's natural resources. In this revision, all developments potentially affecting wetlands are required to be evaluated before a construction permit is issued. The effect of the proposed work on navigation, fish and wildlife, conservation, pollution, aesthetics, and the interest of the general public is assessed.

The exemptions from the wetland protection laws include farming activities including roads associated with farming and the construction or maintenance of farm ponds, irrigation or drainage ditches; maintenance of structures such as dikes, dams, levees, etc.; construction of temporary sedimentation basins on construction sites; forest roads or temporary roads for moving mining equipment (Maine State Planning Office 2001).The 1972 amendments to the Clean Water Act extended the US Army Corps' regulatory jurisdiction to cover all waters of the United States, including wetlands. This authority is listed in Section 404 of the Clean Water Act, and certain activities in wetlands are permitted under what is commonly known as "404 Permit."

The Corps "404 Regulatory Programme" undertakes the permit review process, which requires an assessment of the effect of a project on wetland functions (Mitsch & Gosselink, 2015). This was the principle driving force behind the development of wetland functional assessment methods in the US. The US Environmental Protection Agency (EPA) was made a partner in the 404 Programme, giving them veto authority and responsibility for establishing guidelines for protection of aquatic environments. Under these requirements, the agency is required to develop improved monitoring and assessment methodologies for aquatic ecosystems and their associated landscapes (Morrice & Colagiuri, 2013).

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The US EPA has a national research strategy on the Environmental Monitoring and Assessment Programme (EMAP) run by the Office of Research and Development, as well as a Biological Monitoring Programme that operates at the state level and is coordinated by the USA EPA Office of Water. The US Geological Survey (USGS) operates the North American Water Quality Assessment (NAWQA) Programme (US EPA 1998).

EMAP and NAWQA make assessments of the environment and trends in quality at both national and regional scales. EMAP has not yet selected a single approach to sampling wetlands. The most commonly used approach is the multimeric approach, as it allows for the integration of ecological information with the elements and processes of naturally functioning aquatic assemblages (Butcher 2003).

2.4.4 Asia

Although little information was accessed on wetland assessment in Asia, a framework has been developed for wetland inventorying, assessment, and monitoring (WIAMS) in Asian wetlands. According to Butcher (2003), this framework was developed in close association with the Ramsar Convention, such that it is applicable on a global to local scale. The wetland ecosystem faces a grave threat to its ecological character thereby endangering the overall sustainability of the resource recovery practices which form the base of existence of the entire Kolkata City, and of the livelihoods of 0.2 million poor who depend on wetlands resources for sustenance Progressive shift in the land use within EKW mostly by unauthorized constructions on agricultural land or wetlands, or filling in waterbodies with unmatched rapidity has been continuously reducing the overall capacity of the wetlands to recycle wastes and attenuate floods (Munnick, 2010). During 1970-2011, the area under fish farms has declined by over 18%, a large chunk of which has been converted to built-up land (Mavis, 2013).

2.4.5 Mediterranean

The degradation and loss of the rich resource of extensive wetlands of the Mediterranean region was recognised in a major wetland conference in Grado, Italy in 1991. This led to the initiation of a Mediterranean wetland initiative known as MedWet, in 1992. The intention behind the programme was to develop methods that could potentially improve wetland conservation in the Mediterranean region, with an emphasis on addressing and halting further loss and degradation and ensuring the wise use of wetlands (Costa *et al.,* 2001).

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One of the actions within MedWet was the development of methods for inventory and monitoring of wetlands. Owing to the diverse nature of the region and the resources available, it was necessary to design a method which was flexible in terms of the level of detail required, and adaptable to a range of different situations and requirements. The inventory tools developed, which include guidelines, datasheets, a habitat description system, mapping conventions and database software, have been field-tested sites in each of the five European Mediterranean countries and in Morocco and Tunisia (Costa *et al.*, 2001).

2.5 COAL MINING ACTIVITIES IN MPUMALANGA, SOUTH AFRICA

South Africa is a signatory to the Convention on Wetlands of International Importance especially as Waterfowl Habitat of 1971 (referred to as the Ramsar Convention), which is an international convention making provision for protection and wise use of wetlands. "Wise use of wetlands" is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development" (Birnie and Boyle, 2009: 674). In 2011, the first wetland inventory for South Africa confirmed that the wetlands are most threatened ecosystems. There is no single piece of South African legislation dedicated to the protection of wetlands. However, the protection of wetlands has been directly or indirectly included in the following pieces of legislation. Armstrong (2009) provides a thorough coverage of the legislation valid at the time and the reader is referred to this document for detailed discussion of each piece of legislation. Certain regulations have been promulgated since Armstrong's 2009 synthesis and important ones are mentioned below:

- National Environmental Management Act, 1998 (Act No. 107 of 1998): is the framework environmental legislation in South Africa and provides indirect protection for wetlands as an environmental resource. National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004): This Act gives effect to ratified international agreements affecting biodiversity to which South Africa is a party, and which bind the Republic. Furthermore, the Minister may list ecosystems and species that are threatened or in need of protection, and these might include wetland ecosystems and species closely associated with wetlands. The Minister may also list threatening processes and activities in listed ecosystems and related to protected species. The Act also makes provision for the rehabilitation of ecosystems, which include wetlands.

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The Minister may also promulgate a list of invasive species and the required measures associated with these.

- Regulation GN R543, 18 June 2010: Environmental Impact Assessment Regulations: provides for activities that may impact detrimentally on the environment to require prior environmental authorisation. Regulation GN R544 (Listing Notice 1): sets out a list of identified activities which may not commence without environmental authorisation from the competent authority, and which must follow the basic assessment procedure as provided for in regulations 21 to 25 of the NEMA EIA Regulations. These include activities in wetlands and estuaries.
- National Environmental Management: Protected Areas Act (57 of 2003): The intention of the Act is to protect and conserve ecologically viable areas as well as their natural landscapes. These would include wetlands designated as or within protected areas. National Environmental Management: Waste Act 2008 (Act 59 of 2008): In recognition of the adverse impact that poor waste management practices have locally and globally, the intention of this Act is to minimise pollution and so promote sustainable development.
- National Water Act, 1998 (Act 36 of 1998): activities in and within 500 m of wetlands or the saltwater mixing zone of estuaries will require a water use license. The Act also makes provision for the protection of water resources, which include all wetlands as well as the prevention of pollution and degradation of these resources. Any activity which will impact a wetland requires that the wetland be delineated.
- Regulation GNR 1352: in terms of the NWA of 12 November 1999, Regulations on Use of Water for Mining and Related Activities Aimed at the Protection of Water Resources: the regulation is specifically aimed at mining activities and prohibits water pollution and activities that may impact on the integrity of a water resource, such as the location of residue deposits and open cast or underground mining activities within 100 m or within the 1:100-year flood line of any water resource. The Regulations also makes provision for the protection of water resources during the mining of sand and alluvial minerals from watercourses and estuaries.
- Conservation of Agriculture Resources Act, 1983 (Act 43 of 1983): Sets out measures to prevent the spread of alien vegetation. Given the ideal growth opportunities afforded by wetlands for alien species, the protections of wetlands from invasive species are implied in this legislation. The legislation includes a list of alien and invasive species and the required measures to be taken in relation to these. The Act also provides for

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the regulation of control over the utilisation of agricultural resources in SA in order to promote the conservation of soil, water and vegetation (including wetlands).

In accordance with the Act, Authorisation is required to:

i. Drain or cultivate any vlei, marsh or water sponge.
ii. Cultivate any land within the flood area of a watercourse or within 10 m outside the flood area of a watercourse.
iii. Divert run-off from a water course, or
iv. Burn veld, including wetland vegetation.

CARA: Regulation GNR 1048 of 24 May 1984 (as amended): Makes provision for the protection of land and promotes the conservation of soil and water resources and natural vegetation through various measures, such as the prevention of soil erosion, the prevention of the disturbance of natural flow patterns and run-off, prevention of bush encroachment and makes provision for the restoration of land resources. Wetlands and their supporting hydrology are by definition included under the term "natural resources".

National Forests Act, 1998 (Act 84 of 1998): forestry activities that may impact on wetlands are regulated. Mountain Catchments Act (Act 62 of 1970): this Act provides for the conservation, use, management, and control of land situated in mountain catchment areas.

Wetland delineation the definitive guideline for the delineation of wetlands in the environmental cluster of South African government departments is the Practical Field Procedure for The Identification and Delineation of Wetlands and Riparian Areas (Rountree *et al.,* 2008). The DWAF field procedure uses the definition from the NWA: "wetland" means land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil (Chapter 1: NWA, 1998).

Three broad zones are identified in the DWAF field procedure for the delineation of wetlands, and these are: the permanent zone, the Seasonal zone (wet for much of the year) and the temporary zone (wet occasionally). The object of delineation is to identify the outer edge of the temporary zone. Wetlands are not always wet, particularly at the edge of the temporary zone, so four indicators have been provided for identifying the areas considered as wetlands. These four indicators are:

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- The Terrain Unit Indicator: this indicator helps to identify those parts of the landscape where wetlands are more likely to occur.
- The Soil Form Indicator: this indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
- The Soil Wetness Indicator: this indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation.
- The Vegetation Indicator: this indicator identifies hydrophilic vegetation associated with frequently saturated soils. According to the wetland definition used in the National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practice, the soil wetness and form indicators tend to be the most important, and the other indicators are used in a confirmatory role.

The reason is that vegetation responds relatively quickly to changes in soil moisture regime or management and may be transformed; whereas the morphological indicators in the soil are far more permanent and will hold the signs of frequent saturation long after a wetland has been drained (perhaps for several centuries). Despite hydrology not being one of the four indicators listed above, the delineation procedure is substantially facilitated by an understanding of the broad hydrological processes that drive the frequency of saturation, particularly in the case of river channels.

The soils of temporary wetlands in very arid areas are also often too shallow, too saline or too temporarily inundated to exhibit typical wetland features in their soils. Such wetlands are called “cryptic” and cannot reliably be identified as wetlands during the dry season on the basis of standard wetland identification and delineation tools (Day *et al.,* 2010). For instance, they cannot mitigate point source impacts such as sewage outflows or storm water drains. The remaining 300 000 wetlands in South Africa constitute 2.9 million hectares or 2.4% of South Africa’s surface area. Sixty-five percent (65%) of wetland ecosystem types are threatened and forty-eight percent (48%) of threatened wetlands was found to be critically endangered.

The percentage of wetland coverage in South Africa at 2.4% is low when compared to the world coverage of approximately 6%. This potentially reduces the ability of South Africa’s natural systems to minimize the impact of normal and extreme weather events such as floods,

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but this trend can however be reversed by changing practices and through the restoration of wetlands tools (Day *et al.,* 2010).

Roux *et al.,* (2006) note that a loss of biodiversity inevitably leads to ecosystem degradation and the subsequent loss of important ecosystem services. This loss is most detrimental to the rural poor who rely directly on the ecosystem services, particularly the provisioning services, most heavily. Taking cognisance of the above, the quantitative target for inland water biodiversity conservation in South Africa has been set at 'at least 20% of each inland water ecosystem type (determined at an appropriate scale) should be in the Natural Class in the DWAF (now DWS) water resource classification system'. Rivers-Moore (2011), however, found that the Beta-diversity turned over in less than 20% of the river length in the upper reaches, requiring a higher percentage of the river than the blanket 20% to be conserved.

2.6 THEORETICAL OVERVIEW OF WETLANDS

Systems approach is based on the fundamental principle that all aspects of a human problem should be treated together in a rational manner (Healy, 2005). Wetlands cannot be managed in isolation within the environment. Systems ideas is referring to three different types of systems, each created in a different era; general systems theory, ecosystem perspectives and complex systems theory (Healy, 2005). Healy (2005) stated, "the original proponents of general systems theory used biological terminology to explain client needs, situations and the purpose of social work practice" . The term that is applied for systems theory is for all systems in general.

All systems have boundaries within which both physical and mental energy is exchanged. Systems theory sees the system as a set of related components that work together in a particular environment to perform specific functions that are required of them to achieve the system's objective (Walker, 2012). Most people are part of a variety of systems and subsystems. For example, a family is seen as a system in itself, but each member of the family may have different subsystems, such as their peers, education, job, recreational activities, etc. and all of these subsystems play. Von Bertalanffy (1971) was the creator of the "system" concept, he developed this idea as an answer to the limitations of individual disciplines in addressing complex social issues (Mitchell, 2005).

There are two types of systems that this applies open and closed. Closed systems have no interchange across the boundaries whereas open systems have permeable boundaries or

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guidelines but there is also some room for movement, within reason. Systems theory is a theory indicates that interacting processes and the way they influence each other over time to permit the continuity of some larger whole. Systems act so as to continue. Systems change because their own balances are not optimal or because they are influenced by other systems.

Potential environment consists of the set of environmental phenomena that may enter into an environmental relation at some point in the ontogeny. Mason and Langenheim (1957) asserted that the environment of any organism is the class of those phenomena that enter a reaction system of the organism or otherwise directly impinge upon it to affect its mode of life at any time throughout its life cycle as ordered by the demands of the ontogeny of the organism or as ordered by any other condition that alters its environmental demands. Only direct factors were considered part of environment. "Indirect and historical factors both function to condition a phenomenon to which an organism then reacts. Important as this is to the ecosystem, the only [organism] reaction is to an already conditioned phenomenon. Central to this language was the concept of 'system,' defined as a group of interacting, interdependent elements that form a complex whole. It also pointed toward a new world view that emphasizes such key concepts as every system's embeddedness in other, larger systems, and the dynamic, ever-changing processes of self-organization, growth, and adaptation (Sinnott, Rabin, 2012).

Brethower (1972, 1982, 2001) and Brethower and Dams (1999) developed a systems model called the total performance system which represented a "map" of an organization defining how it received inputs, added value by processing these inputs to outputs, and how those outputs were received by the next system (for example, another individual, business function, or, ultimately, consumers). The total performance system interactions are regulated by feedback from the processing system as well as feedback from the receiving system. A similar systems model was created by Rummler (Rummler, 2004, 2001; Rummler and Branche, 1995) who described three levels within organizations where systemic relationships exist: an organizational level that incorporates the company goals or strategy; a process level such as workflow or information flow across functional departments that make up the organization; and a job/performer level focusing on the behaviour of individual employees and managers.

System changes may be further described in chaos theory and complexity theory. According to Reddick (2016), the principal environmental concerns of coal mining are physical

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disturbance of the landscape, surface subsidence and re-settlement, land stability, erosion, surface runoff, flooding, and sedimentation control, water quality and protection, spontaneous combustion or Coal mine fires, fugitive methane, public safety and disturbance issues and acid mine drainage. the pyrite in the rock gives rise to water with a low pH (Lechner *et al.,* 2016).

In the case of water, the continuous release of various chemicals from coal mines has drastically affected water quality all over the world. This has further resulted in acidification and degradation of the water, affecting the aquatic bodies and human health (Ali *et al.,* 2017; Cloete *et al.,* 2017; Mishra and Das 2017; Moschini-Carlos *et al.,* 2011; Ochieng *et al.,* 2010). For example, a study conducted in some rivers and stream sites in Australia revealed that these water resources contained different heavy metals at high concentrations that were above the water quality guidelines for freshwater streams (Ali *et al.,* 2017:1). A similar case was reported in Brazil where coal mining activities have seriously affected the water quality of three different lakes due to the presence of several metals at high concentrations which were above acceptable limits. The authors lamented that this detrimental impact has rendered the lakes unsuitable for human uses (Moschini-Carlos *et al.,* 2011:280).

All these reports agree with the United Nations Environment Programme (UNEP) reports which state that there is a global deterioration of water quality as a result of heavy metals concentration which has direct impacts on human health and environment. (Ali *et al.,* 2017:2). People exposed to water polluted with heavy metals released from coal mining such as Arsenic have suffered from a range of chronic health problems which include increase in blood cholesterol, cardiovascular diseases, cancer, and high mortality rates (Ali *et al.,* 2017).

Secondly, this acid water in turn mobilizes heavy metals from the environment, in the mine or in the river course from the sediments (in Witbank, for example, heavy metals from steel manufacture, vanadium and chrome are all present within polluted river courses). treating the water with calcium to raise the pH, makes the water more saline, a problem that requires expensive and energy intensive reverse osmosis or similar processes, (Sonter *et al.,* 2014). It is very difficult, if not impossible, to avoid acid mine drainage. Rock once broken up is open to oxygen, which reacts with the pyrite in both the coal and the surrounding rocks. Once water flows over this, acid mine drainage follows (Peyper, 2017).

Spontaneous combustion of coal discard heaps and some working mines observed by the researchers release toxic compounds including carbon monoxide, carbon dioxide, methane,

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benzenes, toluenes and xylenes, as well as sulphur, sulphur compounds, salammoniac, arsenic, mercury and lead (Hota and Behera, 2015). Emissions, particularly AMD and dust, from current and defunct workings and waste piles continue to be a source of water pollution, air pollution and land degradation (Reddick, 2016), e, for the most part, local environments remain polluted and mining communities continue to suffer, resulting in a highly politicised scenario and on-going (and possibly escalating) conflicts between communities, mining companies and local government (Mining Review Africa, 2016).

The World Health Organisation (WHO) reported that an estimated 1.3 million deaths annually can be ascribed to urban outdoor air pollution (Morakinyo *et al.,* 2016:1). Moreover, if not addressed in time, these problems foreshadow and may culminate in threats to human life from human conflict. Air pollution, with its detrimental effects on human health, could be a result of indiscriminate or uncontrolled burning or combustion of different substances such as coal. Exposure to certain pollutants that come from those substances could result in chronic health conditions such as increased respiratory problems, reduced lung function and cardiovascular diseases (Albers *et al.,* 2015; Brunekreef and Holgate 2002; Olaniyan *et al.,* 2017; Samet *et al.,* 2000; Stieb *et al.,* 2002; Thaller *et al.,* 2008). An increased number of deaths from respiratory diseases have also been reported (Laumbach and Kipen 2012; Jiang *et al.,* 2016).

The effect of coal mining is not only limited to air pollution but has further resulted in global warming all over the world. During coal mining activities, a number of greenhouse gases such as carbon dioxide, methane, nitrogen oxide and other heat-trapping gases are produced which remain in the atmosphere for several years once emitted (Lockwood *et al.,* 2009; Hertwich *et al.,* 2010). Mining activities have had many effects on South African water resources for many years. Water drainage from coal mines is highly acidic and contains high concentrations of different toxic chemical substances (Council for Scientific and Industrial Research 2009).

Acid mine water drainage in South Africa as in other countries over the years has resulted in serious degradation of the water quality. It is also regarded as one of the major causes of water pollution which has affected aquatic bodies (McCarthy and Humphries 2013). This affects the health of the people and animals that depend on the water for drinking (Bureau for Food and Agricultural Policy 2012; Ochieng *et al.,* 2010).

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As Mpumalanga is known to be a province where most of the South African coalfields are concentrated, the province is simultaneously regarded as a source for some of the country's most important rivers (Nelson, 2010). These rivers supply water to South Africa's major dams which are used for drinking, agriculture, and several other domestic purposes. Unfortunately, all these water ways have already been polluted by the increased and continuous release of different toxic substances from the various mines (Council for Scientific and Industrial Research CSIR 2010).

An example is the Olifants River, regarded to be one of the most polluted rivers in Southern Africa as a result of mining and power generation in the area (Department of Water Affairs, 2011). Aquatic organisms have also been threatened and have become critically endangered as a result (World Wide Fund for Nature 2013). Mpumalanga showed that several of the aquatic bodies were contaminated and died as a result of the presence of various heavy metals such as lead (Pb) and cadmium (Cd) (*Cloete et al.,* 2017).

The situation where these contaminated organisms such as fish are consumed, they can pose a great danger to human health (Cloete *et al.,* 2017; Ochieng *et al.,* 2010). This problem not only affects South African water resources, but also those of nearby countries such as Mozambique and Botswana (Kardas-Nelson 2010). This water pollution issue is likely to persist in South Africa for centuries to come (CSIR 2009), as a continuing environmental problem for future generations of South Africans. The early stages of these systems are disordered with regard to roles, that is, no roles are apparent. Subsystems are components of the systems. Super systems are composed of systems. Koestler's (1967) term "Holon" for a hierarchical system can be used to refer to any of these three levels of organization, according to the frame of reference. A system is closed if it does not interact with another system, and open if it receives causes from or generates effects to another system. A system boundary provides the interface with other systems and is defined by specifying its component set.

Input is any movement of energy matter or information from super system to system, and output is any similar movement across the system boundary in the opposite direction. South Africa has good soil for agricultural production, especially in Mpumalanga Province, and most of the South African coal mines are also located in this same province (Bureau for Food and Agricultural Policy 2012). The fact that this province has had good soil for agricultural production makes the province the largest producer and supplier of food in South Africa

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(Bureau for Food and Agricultural Policy 2012). Unfortunately, the activities of the coal mining industry have led to a high concentration of heavy metals in the soil, with consequent degeneration of that soil over the years (Ochieng *et al.,* 2010). Specifically, about maize, there has been contamination and death of several tonnes of this crop by the toxic elements in the past years and more tonnes are expected to be lost in the future (Bureau for Food and Agricultural Policy 2012).

It was also expressed in a report of the Bench Marks Foundation that Mpumalanga is at the heart of South Africa's maize triangle and coal mining is drastically reducing the land available for the growth of maize and it is also destroying the water required for farming (Bench Marks Foundation 2014: 1). The severe pollution from coal mining activities has not only affected food crops but also animals in various ways. Farmers in this area have complained about how it has affected their cows' drinking water, which, in turn, affects milk production and quality. There were also complaints by them about the negative effects on the fertility of their cows and their ability to reproduce (Bench Marks Foundation 2014).

The environmental relation of an organism is the sum of empirical relations between the environmental phenomena and any individual organism. The global status quo is that resource and spatial planning and policy development often occur independently in "silos" with conflicting policies being developed (Bazilian *et al.,* 2011; Leck *et al.,* 2015). The nexus approach, which has gained prominence in the twenty-first century (Pandey and Shrestha, 2017), requires that resource and spatial planning occur in an integrated manner that seeks to consider linkages, dependencies and trade-offs (Hoff, 2011). The word nexus means to "connect" and therefore points to the interdependencies within a particular nexus configuration (De Laurentiis *et al.,* 2016). A key consideration in a nexus assessment is that the attainment of the security of one resource sector should not compromise an adjacent resource sector (Simpson and Berchner, 2017).

Amongst the various nexus configurations, the water-energy-food (WEF) nexus has garnered particular interest (World Economic Forum, 2011). This is due to the finite nature of each of these resources coupled with the ever-increasing demand (and competition) for them due to population growth and changes in consumption patterns (Beddington, 2009).

The primary motivation for evaluating the WEF nexus in Mpumalanga is the ongoing tension between agriculture (that is, food security) and coal mining (that is, fossil-fuel based energy security) in terms of the competition for land. Related to this, and equally important is the

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deterioration of the quantity and quality of water in the region due largely to agricultural and mining activities (Ololade *et al.,* 2017). The deteriorating water quality together with the diminishing quantity thereof already has and will continue to have, a negative impact on water security in this province. This, in turn, impacts not only agriculture, mining, and electricity production in terms of their input water requirements, but also poses a risk to human health and the environment and places pressure on other competing water users (including transboundary water users).

A further motivation for addressing the WEF nexus, or resource trilemma (Wong, 2010; Perrone and Hornberger, 2016), within Mpumalanga is the impact that climate change is predicted to have, particularly on water resources. The majority of climate models project a decrease in mean annual precipitation for southern Africa by ~20% by the 2080s (Conway *et al.,* 2015). Reductions in annual precipitation will threaten, amongst others, the availability of water for irrigation and hydropower. Some farmers have adopted more energy-intensive irrigated agriculture due to the reduction in available rainfed water for crop and livestock production (Grafton *et al.,* 2016). An expected rise in temperature will increase evaporation volumes and decrease soil moisture and runoff.

Lower food production, coupled with the reduced availability of water, will threaten sustainable economic development. This reduction in rainfall will also affect the achievement of several Sustainable Development Goals (SDGs), principally SDG 2 "Zero Hunger", SDG 6 "Clean Water and Sanitation," and SDG 7 "Affordable and clean energy." Other SDGs that are dependent upon freshwater resources will also be impacted (Rockstrom and Sukhdev, 2016).

2.6.1 Ecological theory on Environment

Ecological systems theory uses ideas that link together four different social systems that surround an individual; these systems are known as, micro-systems, meso-systems, exo-systems and macro-systems (Healy, 2005). The environmental in relation of an organism is the sum of empirical relations between the environmental phenomena and any individual organism. The operational environment of an organism consists of those instantaneous environmental phenomena that actually enter a relationship with an organism; the concept applies to specific individual organisms. Space and time frames of the operational environment are determined by the organism.

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The life span of the organism corresponds to the existence time of its operational environment. Potential environment consists of the set of environmental phenomena that may enter into an environmental relation at some point in the ontogeny. Mason and Langenheim (1957) asserted that the environment of any organism is the class of those phenomena that enter a reaction system of the organism or otherwise directly impinge upon it to affect its mode of life at any time throughout its life cycle as ordered by the demands of the ontogeny of the organism or as ordered by any other condition that alters its environmental demands. Only direct factors were considered part of environment. Indirect and historical factors both function to condition a phenomenon to which an organism then reacts. Important as this is to the ecosystem, the only organism reaction is to an already conditioned phenomenon.

The state of the phenomenon prior to its conditioning is outside the scope of operational and potential environment. This may seem to rest upon trivial distinctions, but we are convinced that this is the precise boundary between clarity and confusion in the problems of the environment. Thus, chains and networks of historical causation, which condition direct factors, are excluded from Mason and Langenheim's (1957) concept of environment: we must reject the implication that causal chains constitute a unitary event playing a significant role in the environmental relation even though the steps are very important to the ecosystem.

There is also a philosophical reason for removing indirect factors from the concept of environment. To introduce indirect factors into causal relations within the environment is to introduce an infinite regress into the system of explanation. Every cause has in turn itself a cause which becomes an indirect cause of the most recent effect. The regress is toward the limbo of ultimate cause along an infinitely reticulating path, for this we have neither finite description nor finite explanation. To include such relations in environment is to confuse environment with its history.

While the conditioning of direct causes by indirect effects may be temporally antecedent, ecosystems and their models are persistent or recurrent organizations so that historical patterns of causation are relevant, with perhaps small corrections for evolution, to present and future patterns as well. Such a system's view of environment has precedent in an ecological work by Haskell (1940), who focused on events in the universe that may eventually influence an organism during its lifetime. Their influence is limited by how fast causality can be propagated, no faster ultimately than the speed of light. Thus, corresponding to each

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instant in the life of an organism is a light cone (Haskell, 1940) bounding the spatiotemporal extent of possible causes.

The cones diminish in time as the universe that can possibly affect the ageing organism contracts: The cones represent a steadily shrinking region within which the fastest moving process light, traveling at about 300,000 km a second can start, at any point-instant during the organism's existence, and effect (sic) it before its end., This region is equal to a geometric hyper body, denned below as habitat and constitutes part of environment. Germain (1973) and Hartman (1976) through the person-in-environment perspective developed the groundwork for the ecological approach currently being stressed in the field of social work. Even though a number of significant gains were made by these writers, their early contributions to the ecological theoretical approach had a number of limitations. In particular, they did not clearly define procedures for implementing the ecological approach in assessment and treatment of client problems.

The ecological theory that emerged from these theorists was not well conceptualized and had other notable limitations similar to those found with the social systems theory perspective. The present thinking on the ecological approach suggests that the primary premise explaining human problems is derived from the complex interplay of psychological, social, economic, political, and physical forces. Such a framework accords due recognition to the transactional relationship between environmental conditions and the human condition. This perspective allows the practitioner to effectively treat problems and needs of various systemic levels including the individual, family, the small group, and the larger community.

Ecosystem client functions in more than one ecology. The client's ecosystem is the interrelationships and conglomeration of these ecologies. For example, a client's ecosystem consists of the self, family, the neighbourhood, and the entire community. Obviously, as stressed earlier, conceptualizing the client's relationship to the environment is not a new idea in the profession of social work. What is powerful, however, about the concept of ecosystem is that the client's social functioning is clearly interrelated with the environment, and the client is an inextricable part of the ecological system (Hobbs, 1980). Consequently, the client's ecosystem is composed of numerous overlapping systems including the family, the workplace, and the community, as well as other critical subsystems unique to each client.

Ecological infrastructure refers to naturally functioning ecosystems that deliver valuable services to people, such as water and climate regulation, soil formation and disaster risk

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reduction (Ecological infrastructure fact sheet, 2014). It is the nature-based equivalent of built or hard infrastructure and is just as important for providing services and underpinning socio-economic development. Ecological infrastructure includes, for instance, healthy mountain catchments, rivers, wetlands, coastal dunes, and nodes and corridors of natural habitat, which together form a network of interconnected structural elements in the landscape.

Manuel (2012) notes that in spite of integrated planning networks and the existence of good ecological information, the environment is often seen as an obstacle to development, and if the high growth rate envisaged by the National Development Plan (NPC, 2011) is to be achieved through construction and extraction-based development, then the environment will certainly be an obstacle. Planning and managing the ecological infrastructure will provide for ecologically sustainable development while promoting economic and social development. Investing in ecological infrastructure is a low-cost high return development strategy with multiple social, economic and environmental gains.

2.7 ECOSYSTEM SERVICES

Ecological services Provided by Wetlands provide a variety of ecosystem services such as ground water recharge, flood attenuation, pollution abatement, habitat for biodiversity, recreation opportunities, and provide for the livelihood of some communities through the harvesting of resources. Barbier *et al.,* (1997) provides the following examples: Wetland systems directly support millions of people and provide goods and services to the communities outside the wetland. For example, wetland soils are used for agriculture, fish are caught to eat, trees are cut for. timber and fuel wood and wetland reeds are harvested to make mats and to thatch roofs. Direct use takes the form of recreation, such as bird watching or hiking. Communities benefit indirectly from wetland functions or services.

As flood water flows out over a floodplain wetland, the water is temporarily stored which reduces the peak river level to prevent flooding of riparian dwellers downstream. The value of wetland ecosystem services has also been emphasised by Becker (1998), who states that wetlands are considered to be a good last line of defence for water quality problems. Wetlands can retain up to 96% of nitrogen and 97% of phosphorus and thus have the potential to significantly lower the cost of sewage treatment (Bolund and Hunhammar, 1999). The destruction of the wetlands reduces the nitrogen and phosphorus gasses in the environment. The initial approach to determining the Ecological Reserve for wetlands was presented in Volume 4 of the Resource Directed Measures (RDM) manual (DWAF 1999a).

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The 11 methods for determining the water quantity Reserve for wetlands and in particular, the water quality component, were sketchy. During the period 2006-2010 the wetland methodology was developed further (Rountree *et al.,* 2012) and various versions were trialled at four test sites, namely Franklinvlei in the Eastern Cape, the Klip River wetland in Johannesburg, the Braamhoek wetland (part of the Braamhoek-Bedford pumped storage scheme) in the Free State Province, and Boovenste Oog in North West Province. As a result of these efforts, the methods for different components of the wetland Ecological Reserve were improved, including those for vegetation, geomorphology, hydrology, hydraulics, and water quality. The following description of the updated Water quality method for inland (that is, non-estuarine) wetlands is taken largely from Malan *et al.,* (2012). As will be seen, a basic protocol is presented for determining the wetland WQ component of the Ecological Reserve. Gaps in the method are highlighted and several of those gaps (for example, further testing of the land-use/contaminant spreadsheet, and refinement of WQ boundary values for key water quality variables) are addressed in the present project. During the process of updating the method, although consideration was given to requirements for higher-confidence Ecological Reserves, the primary focus was on the development of rapid methods.

The requirements for a Rapid Reserve determination presented several constraints in that the method needed to be quick (two days to produce the final report, with only one day in the field), relatively cheap, and relatively simple. There is a lack of capacity in the country for carrying out Reserve determinations and thus any methods developed needed to be pragmatic, but at the same time scientifically defensible. Thus, detailed investigations of Water quality in individual wetlands are unfeasible and assessments are based on limited WQ data. facilitate understanding of this process, explanations of a few key terms in the determination of the Ecological Reserve Kleynhans and Louw (2008) and (DWA 1999a, b):

2.8 ECOLOGICAL CATEGORY

The Ecological Category is used to define and type the ecological condition of a water resource in either the present, past, or future in terms of the deviation of biophysical components from the natural state or Reference Condition. This is done through an assessment of the system drivers (physico-chemical, geomorphology, hydrological) that provide the habitat template for biota and the response of native biotic groups (fish, 12 riparian vegetation and aquatic macro-invertebrates) to this template, as well as the response of native biota to introduced biota. The Present Ecological State (PES) The Present

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Ecological State of a water resource refers to the current ecological condition of the resource or a component of the resource, derived from, or described as a change for the worse from a described Reference Condition, which ideally relates to the historically natural condition. The degree of change is described by one of a range of ecological categories (A-F), where categories A-D are judged to be ecologically sustainable, and categories E and F indicate a current state that is ecologically unsustainable.

Recommended Ecological Category (REC) This is the Ecological Category in which it is recommended that a water resource be managed. The modus operandi followed by DWA's Directorate: Resource Directed Measures (RDM) is that, if the Ecological Importance and Sensitivity However, the causes related to a particular PES should also be considered to determine if improvement is realistic and attainable. This relates to whether the problems in the catchment which are causing an impacted PES can be addressed and mitigated for. If the Ecological Importance and Sensitivity is evaluated as moderate or low, the aim should be to maintain the river in its PES. Within the Ecological Reserve context, ecological categories A-D can be recommended as future states (the Recommended Ecological Category) depending on the EIS and PES.

Ecological Categories E and F are regarded as ecologically unacceptable, and remediation is needed. Resource Quality Objectives (RQOs) Resource Quality Objectives are numerical or descriptive statements of the conditions which should be met in the receiving water resource, in terms of resource quality, in order to ensure that the resource is protected. Resource Quality Objectives may relate to the Reserve, the instream flow; the water level; the presence and concentration of particular substances in the water (that is, WQ objectives or boundary values); the characteristics and quality of the water resource and the instream and riparian habitat; the characteristics and distribution of aquatic biota; the regulation or prohibition of instream or land-based activities which may affect the quantity of water in or quality of the water resource; and any other characteristic.

Ecological importance and sensitivity (EIS) The ecological importance of a water resource is an expression of its importance for the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and to recover from disturbance once it has occurred (resilience). Both abiotic and biotic components of the system are taken into consideration in the EIS assessment

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2.9 AQUATIC SYSTEMS

Aquatic systems in a fairly predictable manner (Showalter *et al.,* 2000). Thus, we know that wetlands in catchments that are highly developed in terms of urban infrastructure or agriculture are much more likely to have impaired WQ than wetlands in a catchment that is largely comprised of natural vegetation. Quantifying relationships between land-use and resultant WQ impacts, however, is difficult. Nevertheless, this is a useful approach to use since land-use data (in various forms, for example, from maps, from GIS covers) even for wetlands in remote areas is readily available. A land-use/WQ model was developed based on previous draft methods (DWAF 2007a; Macfarlane *et al.,* 2009a). Limited testing was undertaken on different types of wetlands during 2009 and 2010.

2.10 WETLANDS MANAGEMENT CONTROLS IN SOUTH AFRICA

Protection of wetlands is also a South African Constitutional requirement and is often applied in headwaters of streams, areas of important resource directed measures and for the requirement and delivery of ecosystem eco services, like natural water purification in severely impacted watercourses by housing development, agriculture, industry, and mining. Review of applications that will impact on a wetland must reflect the balance between conservation in perpetuity with the goods and services derived from this and socioeconomically gains in the long-term. For the environmental planning or management department, wetland rehabilitation prioritization should focus on achieving wetland ecosystem and biodiversity conservation objectives. For the water and sanitation department, wetland rehabilitation prioritization should focus on achieving water resource management objectives and enhancing municipal green infrastructure.

Wetland rehabilitation prioritization should focus on achieving disaster risk management and climate resilience objectives and enhancing municipal green infrastructure. For health and economic or rural development departments, wetland rehabilitation prioritization should focus on improving and/or sustaining the ecosystem services supporting basic needs and livelihoods and the effect on property and tourism values. In terms of mining, rehabilitation can occur during mine operation and after the decommissioning phase. During opencast mineral extraction, it is generally best practice to rehabilitate behind the open cast working front as the activities roll over. It is important to note that not all wetland ecosystem change

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is human induced and, in some circumstances, wetland change, usually erosion, is a natural process.

2.11 CONCLUSION

In this study the researcher reviewed the literature on the implications of lack of mechanism to manage wetlands within coal mining towns. Wetland management being a cross-sectoral activity, affecting and being affected by many different aspects of municipal governance, covers a broad range of issues and spheres from developing a wetland inventory to steps to incorporate wetland management concerns and objectives into municipal development and land use planning. Historically coal mining has had a significant impact on the environment and there is plenty of documented evidence to support this. These impacts can be largely associated with water quality, physical and chemical land degradation, and air pollution through emissions of particulate matter and toxic gases. The published literature also provides fairly substantive evidence that this environmental pollution may, and often does, have an adverse effect on local eco-systems as well as on community health and livelihoods, particularly though crop and livestock farming. In particular, acid mine drainage from coal mining results in significant pollution of land and water resources. Water that is contaminated by acid mine drainage is unsuitable for both human and animal consumption; the acidity and toxicity of the water disrupts metabolic functions, leading to adverse health effects and the death of aquatic life. Contamination of soils by acid mine drainage may affect fertility and in turn hinder plant growth and crop quality. Dust and gaseous emissions from coal mining and residential coal use can impact on human health, through the inhalation of particulate matter containing quartz and pyrite (dust), and volatile toxic elements (gaseous emissions) and dust from coal mining is also reported to have a significant effect on crop productivity.

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CHAPTER 3

RESEACH METHODOLOGY

3.1 INTRODUCTION

In this chapter the research methodology used in the study is mixed method that involves the utilisation of both quantitative design and qualitative designs. The geographical area where the study was conducted which is Victor Khanye Local Municipality, the study design and the population and sample are described. This chapter discusses the research design and methodology used to achieve the research objectives, by outlining the research area, research design, target population, sampling technique, data gathering instruments, data analysis procedures and ethical considerations. The instrument used to collect the data, including methods implemented to maintain validity and reliability of the instrument, are described. Questionnaires, individual interviews and focus group discussions were administered to females and males aged 18 years and above. Ethical clearance was obtained prior to data collection. Observation was also used to gather information on different land uses on the wetland and to observe the present situation of all wetlands.

3.2 RESEARCH DESIGN

The research design is applied so that suitable research methods are used to ensure the attainment of the goals and objectives set out in Chapter One. Hence the reason (rationale) for a discussion of the research design and methodology: Firstly, this is to provide the plan or blueprint for the research. Secondly, this should enable the researcher to anticipate the appropriate research design, to ensure the validity of the final results. Nevertheless, it is important that different views are analysed; thereafter, the methodology will be discussed. However, first it is important to consider a theoretical framework for the research design. Descriptive research involves gathering data that describe events and then organizes, tabulates, depicts, and describes the data collection (Glass and Hopkins, 1984).

Qualitative research focuses on an understanding of human or social phenomena from a multiple point of views and it gives a well detailed information about a problem. Qualitative research is an approach that allows the researcher to examine people's experiences by using a specific set of research instruments, such as in-depth interviews and observations (Pierce, 2008).

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Descriptive research often uses visual aids such as graphs and charts to aid the reader in understanding the data distribution. Because the human mind cannot extract the full import of a large mass of raw data, descriptive method of survey is very important in reducing the data to manageable form, in this case the method was utilised to get the perception on the challenges facing land fill site at Victor Khanye Local Municipality. When in-depth, narrative descriptions of small numbers of cases are involved, the researcher uses description as a tool to organize data into patterns that emerge during analysis. Those patterns aid the mind in comprehending a qualitative study and its implications.

3.3 RESEARCH METHODOLOGY

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Bryman (1994) notes that while quantitative research is hard and reliable, qualitative research is deep and rich as it allows further probing and flexibility in the field. In this study, quantitative methods made it possible to establish and confirm presumptions about the problem (Brannen, 2017). Quantitative approach was used to quantify the problem by generating numerical data that can be transformed into usable statistics, whilst qualitative method was used to challenges pertaining management of wetlands in coal mining towns case study of Victor Khanye local municipality.

3.3.1 Mixed Method Design

Mixed methods have also been used to evaluate information gathered from human and physical environments on the subjective estimates and objective quality of ecosystems (Moser, 1984). In France, along the Loing River, subjective views gathered from semi-structured interviews pertaining to human perceptions on water pollution levels on the river were integrated with objective physical water pollution data acquired from water tests (Moser, 1984). Water temperature, total dissolved oxygen, nitrates and phosphates were tested to

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determine the water quality and degree of pollution from various points within the river. These water parameters were analysed quantitatively. People also described perceived water quality including factors such as colour, floating debris, water plants and algae (Moser, 1984).

Pollution was seen to be less serious and responses from interviews showed that many people were tolerant of the water pollution. Mixing qualitative data from human perceptions and quantitative data from measuring the physical parameters within an ecosystem is a more informative technique of investigating and assessing natural ecosystems such as wetlands. This is because different characteristics, state, and ecological quality of the wetland can be explored from both human and physical perspectives. Most qualitative methods encourage participation, hence the data collected will be influenced by peoples' experiences and opinions, whilst quantitative methods reveal the reality of the studied phenomenon through statistically measured data. Therefore, integrating qualitative and quantitative method allows for continuous investigation of the studied phenomenon.

In light of the above discussion, this research also used both qualitative and quantitative methods (mixed methods) in assessing human utilisation and the environmental quality management of wetlands. Statistically gathered data through quantitative methods show the extent of wetland degradation due to different land uses therefore better management strategies should be implemented. This also enabled decision makers to have information about wetlands, important for wetland management and monitoring programmes (Loiselle et al, 2002).

3.4 STUDY AREA

The municipality is regarded as a gateway to the Mpumalanga Province. The prominent towns and settlements in the Municipality include Delmas, Botleng, Sundra, Eloff and Delpark. The Municipality is strategically located in that it is bordering the metropolitan areas of Tshwane and Ekurhuleni respectively to the west and which is an advantage in terms of transport of agricultural and mining products to processing facilities and markets. The main center of the Municipality is situated in Delmas.

The Municipality is currently characterized by an increase in coal mining and related activities, the mining of silica sand is also done at large scale and other important sectors in this area are agriculture, agricultural product processing, industrial and manufacturing. Natural resources make a significant and direct contribution to the Municipalities. In essence Delmas,

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Botleng, Delpark, Eloff and Sundra are the main formal urban areas which are predominantly residential areas with Delmas incorporating a residential area, central business district and industrial area. The remainder of the municipal area is characterized by small settlements, several agricultural holding areas, commercial agriculture, and mining.

The Victor Khanye Local Municipality (previously Delmas Local Municipality) is a Category B municipality strategically located within the Nkangala District in the Highveld of the Mpumalanga Province. It is situated on the border of the Gauteng Province, less than 100km from Pretoria, Johannesburg and *eMalahleni*. It is one of the smallest of six municipalities in the district of Nkangala District Municipality. The Victor Khanye Local Municipality is situated on the western Highveld of Mpumalanga Province, covering a geographic area of approximately 1,567 square kilometres. The prominent towns and settlements in the Municipality include Abor, Argent, Delmas, and Brakfontein. The municipality is strategically located close to the metropolitan areas of Tshwane and Ekurhuleni to the west. The headquarters of the municipality are in Delmas (a French word meaning small farm).

Victor Khanye is currently characterized by an increase in mining and related activities in the Leandra area. In addition to mining (concentrating on coal and silica), other important sectors in this area are agriculture (a major provider of food and an energy source maize); finance and manufacturing (capitalizing on the area's proximity to Gauteng). Delmas has good infrastructure. Natural resources make a significant and direct contribution to the Nkangala District economy, which is 'resource based' (coal, water, land capacity, geographical features, climate, and conservation areas, and ecosystems, natural features).

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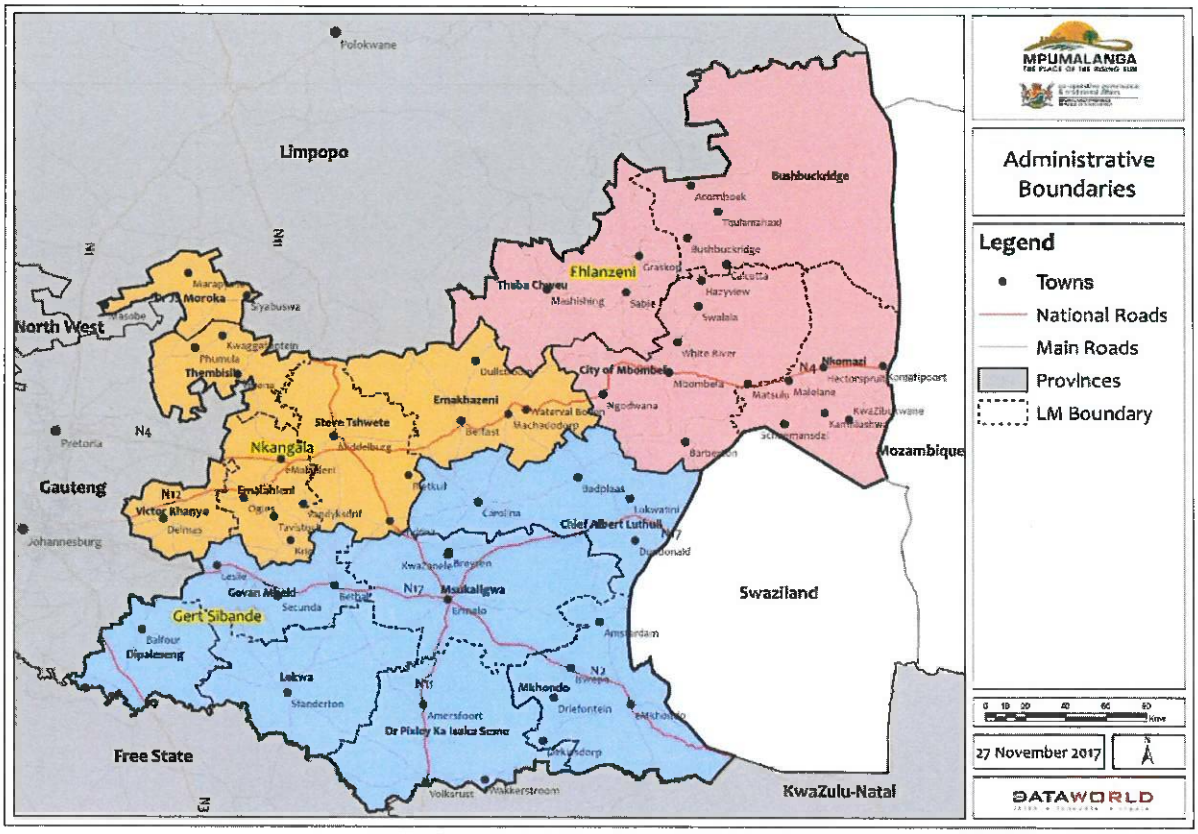
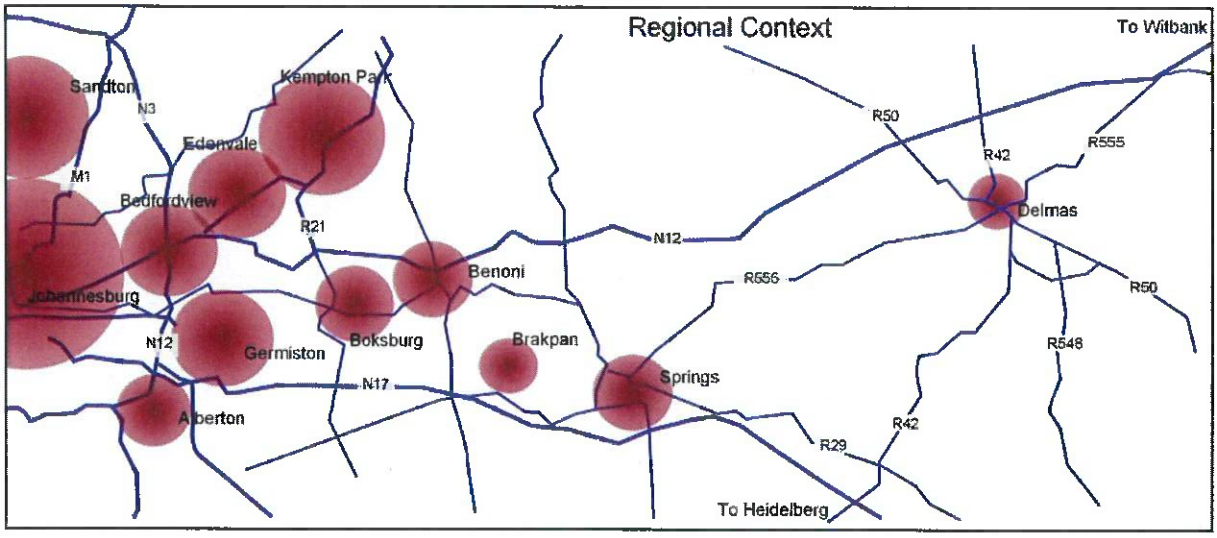
Figure 3.1: Boundaries Location District of Delmas Map



Victor Khanye Local Municipality's location on the edge of Gauteng is an advantage in terms of transport of agricultural and mining products to processing facilities and markets.

Figure 3.2: Wetlands and Rivers in Mpumalanga



(Source: Mpumalanga Tourism and Parks Agency: 2020)

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3.5 POPULATION OF THE STUDY

Polit and Hungler (1999:37) refer to the population as an aggregate or totality of all the objects, subjects or members that conform to a set of specifications. In this study the population would be senior managers, middle managers, and supervisors of the services directorate within Victor Khanye Local municipality and department of forestry.

3.6 SAMPLING

Sampling is the process of selecting units (people, organizations) from a population of interest so that by studying the sample we may fairly generalize our results back to the population from which they were chosen. Let's begin by covering some of the key terms in sampling like "population" and "sampling frame." Ideally, the sampling frame perfectly coincides with the target population. The researcher applied nonprobability sampling method by choosing population of the study to be senior administrative officials within community services at Victor Khanye Local municipality and members of community residing closer to the wetlands and coal mines within Victor Khanye local municipality.

3.6.1 Sampling Method

Since population in Victor Khanye local municipality residential areas is structured according to wards which comprises of different overlapping residential areas, it was difficult to have the actual or estimate population of Abor and Jozi du Plessis farm. In this research, convenience and snowball sampling were therefore used to select participants for questionnaires, interviews and focus groups. Convenience and snowball sampling are non-probability sampling methods in which individuals in the population are not guaranteed equal chances of selection (Heckathon, 2011). Non-probability methods of sampling were used to avoid random selection of irrelevant respondents to the phenomenon under study. Convenience sampling involves finding respondents known by the researcher or readily available, accessible, or willing to participate (Etikan *et al.*, 2016).

Questionnaires and interviews were administered to respondents as they were met accidentally on the road, working in the fields and at their homes. Thus, respondents were selected as they happen to be located spatially near where the researcher was on the wetlands. Focus group discussions usually include more than two people. Therefore,

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respondents to focus group discussions were selected through snowball sampling (through chain referral).

Snowball sampling involves personal networking or chain referral, where in some cases participants are friends or relatives (Brown, 2005). During data collection, some respondents asked their friends and relatives, especially those who were working on the wetlands, to participate in the research. This gave the researcher an opportunity of finding respondents who had experience with wetlands.

Convenience and snowball sampling were the most appropriate sampling methods for collecting data from Abor and Jozi du Plessis farm because the population in these two residential areas is hard to reach since one is a low-density area (Borrowdale) and the other is medium density area (Belvedere). Through convenience and snowball sampling, 40 questionnaire respondents were found for Abor and 39 respondents for Jozi du Plessis. For interviews, 10 respondents were interviewed at Borrowdale and 12 respondents were interviewed at Belvedere. Two focus group discussions were conducted at Borrowdale and 1 focus group at Belvedere. Few people were selected for interviews and focus group discussions because sample size for qualitative research should be small so that perception on human understanding of wetlands is discovered more easily (Ritchie *et al.,* 2003).

3.6.2 Sampling Size

Sample size determination is the act of choosing the number of observations or replicates to include in a statistical sample. The sample size is an important feature of any empirical study in which the goal is to make inferences about a population from a sample. In practice, the sample size used in a study is determined based on the expense of data collection, and the need to have sufficient statistical power. In complicated studies, there may be several different sample sizes involved in the study: for example, in a stratified survey there would be different sample sizes for each stratum. In a census, data are collected on the entire population, hence the sample size is equal to the population size.

3.7 DATA COLLECTION

Observation was also used to gather information on different land uses on the wetland and to observe the present situation of all wetlands. Therefore, methodological triangulation which entails combining different methods was used in this research to yield a comprehensive

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overview of the human environment (peoples' perceptions and views) and the physical environment (environmental quality of wetlands) as a means of evaluating sustainability. Quantitative methods which included land use mapping and soil sample analysis were combined with qualitative methods (interviews and questionnaires) to investigate wetland utilisation. Questionnaires, interviews and focus group discussions were administered to residents of Belvedere and Borrowdale whose houses are built on wetlands or those who were found working on the wetlands. Questionnaires, interviews and focus group discussions were explained to the respondents to ensure maximum response rate and for clarity of some questions, since the instruments used were written in English.

3.8 PILOT STUDY

A pilot study is a mini version of a full-scale study, or a trial run done in preparation of the complete study. The latter is also called a 'feasibility' study. It can also be a specific pre-testing of research instruments, including questionnaires or interview schedules. (Compare Polit, *et al.,* and Baker in Nursing Standard, 2002:33-44; Van Teijlingen and Hundley, 2001:1.) The pilot study follows after the researcher has a clear vision of the research topic and questions, the techniques, and methods, which will be applied, and what the research schedule will look like. It is "reassessment without tears" (Blaxter, Hughes and 257 Tight, 1996:121), trying out all research techniques and methods, which the researcher has in mind to see how well they will work in practice. If necessary, it can then still be adapted and modified accordingly. (Blaxter, Hughes and Tight, 1996:121).

3.9 DATA ANALYSIS

Data analysis is the most crucial part of any research. Data analysis summarizes collected data. It involves the interpretation of data gathered through the use of analytical and logical reasoning to determine patterns, relationships or trends.

3.9.1 Preparing data

Qualitative data analysis is a process that seeks to reduce and make sense of vast amounts of information, often from different sources, so that impressions that shed light on a research question can emerge. It is a process where you take descriptive information and offer an explanation or interpretation. The information can consist of interview transcripts, documents, blogs, surveys, pictures, videos etc. You may have been in the situation where you have

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carried out 6 focus group discussions but then are not quite sure what to do with the 30 pages of notes you collected during the process.

Qualitative data analysis typically revolves around the impressions and interpretations of key researchers. However, through facilitation, study participants can also take an active role in identifying key themes emerging from the data. Because qualitative analysis relies on researchers' impressions, it is vital that qualitative analysis is systematic and that researchers report on their impression in a structured and transparent form. This is particularly important considering the common perception that qualitative research is not as reliable and sound as quantitative research. Qualitative data analysis ought to pay attention to the 'spoken word', context, consistency and contradictions of views, frequency and intensity of comments, their specificity as well as emerging themes and trends. We now explain three key components of qualitative data analysis.

3.9.2 Defining the unit of analysis

The unit of analysis is the major entity that is being analysed in a study. It is the 'what' or 'who' that is being studied. In social science research, typical units of analysis include individuals (most common), groups, social organizations and social artefacts. The study may have a unit of observation at the individual level but may have the unit of analysis at the Municipality, drawing conclusions on the data collected from individuals.

3.9.3 Developing categories and coding schemes

A code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data. The data can consist of interview transcripts, participant observation field notes, journals, documents, literature, artefacts, photographs, video, websites, e-mail correspondence, and so on. The portion of data to be coded during the first cycle coding processes can range in magnitude from a single word to a full sentence, to an entire page of text, to a stream of moving images coding processes, the portions coded can be the exact same units, longer passages of text, and even a reconfiguration of the codes themselves developed thus far. Just as a tide represents and captures a book or film or poem's primary content and essence, so does a code represent and capture a datum's primary content and essence.

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3.9.4 Test coding scheme on a sample of text

Interviews have some specific purpose, so it is necessary to store the responses in a relevant, usable, and accessible form to fulfil this purpose. For example, after interviewing and examining a patient, a physician often dictates the results into a tape recorder. Later, a transcription is made and filed in the patient's case history so it can be reviewed the next time the patient comes in. Human services workers often store information on clients in questionnaire forms or summary notes that cover the most important findings and results of an interview. Public opinion interviewers code much of the information during the interview by simply checking the nearest appropriate answer and leaving a few open-ended responses to be coded in the office; then the codes are fed into computers to obtain quantitative results. Everyone who uses the results of interviews, whether quantitative or not, needs some way to code the results so that they can be used without listening to the whole tape or reading the whole transcript.

3.9.5 Code all the text

Much of qualitative coding can be attributed to either grounded or a priori coding. Grounded coding refers to allowing notable themes and patterns emerge from the document themselves where as a priori coding requires the researcher to apply pre-existing theoretical frameworks to analyse the documents. As coding methods are applied across various texts, the researcher is able to apply axial coding, which is the process of selecting core thematic categories present in several documents to discover common patterns and relations. Prior to constructing categories, a researcher must apply a first cycle coding method. There are a multitude of methods available, and a researcher will want to pick one that is suited for the format and nature of their document.

3.9.6 Assessing their consistency

The goal in designing a reliable instrument is for scores on similar items to be related (internally consistent), but for each to contribute some unique information as well. Note further that Cronbach's alpha is necessarily higher for tests measuring more narrow constructs, and lower when more generic, broad constructs are measured. This phenomenon, along with a number of other reasons, argue against using objective cut-off values for internal consistency measures. Alpha is also a function of the number of items, so shorter scales will often have

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lower reliability estimates yet still be preferable in many situations because they are lower burden.

An alternative way of thinking about internal consistency is that it is the extent to which all the items of a test measure the same latent variable. The advantage of this perspective over the notion of a high average correlation among the items of a test – the perspective underlying Cronbach's alpha – is that the average item correlation is affected by skewness (in the distribution of item correlations) just as any other average is. Thus, whereas the modal item correlation is zero when the items of a test measure several unrelated latent variables, the average item correlation in such cases will be greater than zero. Thus, whereas the ideal of measurement is for all items of a test to measure the same latent variable, alpha has been demonstrated many times to attain quite high values even when the set of items measures several unrelated latent variables. The hierarchical "Coefficient omega" may be a more appropriate index of the extent to which all the items in a test measure the same latent variable. Several different measures of internal consistency are reviewed by Revelle and Zinbarg (2009).

3.9.7 Drawing of conclusion from the coded data

Once you've collected your data and recorded it safely, you can start to make sense of it. At this point, data can start to become information. When looking at quantitative data, scientists typically try to compare two datasets: a control set (data collected under 'normal' conditions) and a test set (data collected where one or more independent variables have been deliberately changed). An important question is whether the two sets of data are significantly different.

3.9.8 Reporting methods and findings

The results section is where you report the findings of your study based upon the methodology you applied to gather information. The results section should state the findings of the research arranged in a logical sequence without bias or interpretation. A section describing results is particularly necessary if your paper includes data generated from your own research.

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3.10 ETHICAL CONSIDERATIONS

The researcher must respect the autonomy and protect the welfare of all participants and must therefore obtain the informed consent of the participants. This consent should be given in writing, if possible, especially if the research is of a sensitive nature. The researcher should be concerned particularly about the rights and interests of more vulnerable participants, such as children, the aged and the disabled. In general, all research must observe the international norms of avoiding harm, providing benefit wherever possible and acting justly.

3.10.1 Permission to conduct the Study

That means you need the cooperation of the 'gatekeepers' to the data you want to access, or to the people you want to talk with before you can get to the stage of asking permission from potential research participants themselves. In practice, that means you may need to secure permission or approval from different organisations or bodies before you can go ahead with your research. The researcher secured letter of approval from the municipality. As governance arrangements for research have become more common, formal permission is increasingly likely to be required in order to conduct your study. Most commonly, this concerns ethics approval.

3.10.2 Informed Consent

All the previously mentioned aspects must be provided to participants before they are entered into the study. Informed consent must be either documented by written consent or by oral consent in language that is reasonably understandable. In the case of this study, the respondents were given full information regarding the study and the objectives in their language of choice prior to the commencement of data collection.

3.10.3 Anonymity and Confidentiality

Confidentiality refers to a condition in which the researcher knows the identity of a research subject but takes steps to protect that identity from being discovered by others. Most human subjects research requires collection of a signed consent agreement from participants, and thus, researchers are aware of the identity of their subjects. In such cases, maintaining confidentiality is a key measure to ensure the protection of private information. Anonymity is a condition in which the identity of individual subjects is not known to researchers. Because

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most human subjects research requires signed documentation of consent, subject anonymity is not as common in human subjects' research. In the case of this study, the respondents won't be traced back and that they will not be revealed to any institution.

3.10.4 Right to Self Determination

The right to self-determination is an integral element of basic human rights and fundamental freedoms, the respondents were given full closure of their rights to make them to be aware of their rights.

3.11 CONCLUSION

This was the chapter in which the researcher was explaining in detail the research designs which was used in the study. The researcher explained the nature of the study, research design, population and location of the study, sampling and procedure, data collection and methods, ethical considerations, and also pilot testing.

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CHAPTER 4

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 INTRODUCTION

Victor Khanye local coal mines, while legally compliant in certain respects, all showed some avoidance of water laws. Mines had or were breaking the law whether by pumping fresh water from a river; mining through a wetland without a license; continuing to mine in the face of delayed WULs; releasing polluted water onto fields, roads, streams and rivers; stunting maize and other crops with layers of coal dust which penetrated ground water; fracturing aquifers and dolomitic rock holding clean water through blasting with resultant pollution of municipal and private boreholes; and neglecting to remediate mines with consequent AMD runoff into downstream water courses and dams. Each mine, while maybe not breaking the law in the same manner, was impacting negatively on clean water supplies and thus their cumulative damage was extensive

4.2 BIOGRAPHICAL DETAILS OF PARTICIPANTS

Table 4.1: Gender Profile

Gender	Male	Female	Total
Number of respondents	19	21	40
Percentages	47,5	52,5	100%

Table 4.1 indicates the gender profile of the respondents. It shows that of the 40 respondents who took part in the study, 19 were males and 21 females, which constitutes 47 percent males and 52.5 percent of females that adds to 100 percent of the sample collected for both wetlands at Abor and Jozi du Plessis farms. The total sample was combined and analysed for both males and females. Deep characteristics on the gender profiles displayed in Table 4.1 is as well an indication that shows that majority of personnel who work in farms are usually women, and this is explained by the simple fact that when a country is experiencing unemployment problems like what South Africa finds itself in it is usually the women children and other vulnerable people in the society who gets affected the most when the economic conditions are in a dire state.

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Table 4.2: Age Profile

Age groups	18-25	26-35	36-45	46-49	Total
Number of respondents	8	14	14	4	40
Percentages	20	35	35	10	100%

Table 4.2 indicates the age profile of the respondents. It shows that of the 40 respondents who took part in the study, 8 are between the ages of 18-25 ages which continues 20 percent of the sample, then 14 for 26-35 and 36-45 each constituting 35 percent respectively for the two age groups each and finally, 46-49 constituting 10 percent which is 4 members. The sample of the study illustrates that most communities residing closer to wetlands are young people.

Table 4. 3: Educational Level

Educational level	Primary	Secondary	Technical	University	Total
Number of respondents	1	17	3	19	40
Percentages	2.5	42,5	7,5	47.5	100%

Table 4.3 illustrates the educational level of participants. It shows that only one participant has primary school education which constitutes 2.5 percent. 17 participants have attained secondary level which constitutes 42,5 percent whereas 3 have attained technical school level constituting 7.5 percent. Finally, 19 participants have university qualifications which constitutes 47.5 percent.

Table 4.4: Employment Status

Employment status	None	Employed	Self-employed	Total
Number of respondents	12	22	6	40
Percentages	30	55	15	100%

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Table 4 indicates employment status of the participants. Of the forty participants who took part in the study, the results indicate that 12 participants are not employed which constitutes 30 percent, 22 are employed which makes it 55 percent of the total and finally, 6 participants are self-employed making 15 percent of the total sample.

Table 4.5: Employment Type

Employment type	None	Temporary	Permanent	Contract	Total
Number of respondents	12	2	18	8	40
Percentages	30	5	45	20	100%

Table 4.5 illustrates the employment type unemployment of the participants. Of the 40 participants, 12 do not have any form of employment which makes it 30 percent. On the other hand, 2 have temporary employment which constitutes 5 percent, 18 are employed permanently which makes it 45 percent, then participants who are working on contracts are 8 which makes it 20 percent of the total sample.

Table 4.6: Income Levels

Income levels	R500-R1000	R1000-R2000	R2000-R4000	R4000-R5000	R5000-R6000	Total
Number of respondents	0	4	10	8	18	40
Percentages	0	10	25	20	45	100%

From Table 4.6 above it is realized that 10% of the participants have an income level of between R1000 to R2000, and 25% have an income level of R2000 to R4000, 20% is depicted to be having an income of R4000, while the other 45% indicated to be having an income of R5000 to 6000. The income levels shown in Table 4.6 gives an indication that majority of the participants in this study are not people who earn a lot of money and their capability of utilizing wetlands might as well be limited by these income factors.

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Figure 4.1: Depiction of the location of the wetlands closer to mining operations

In Figure 4.1 researcher presented the depiction of the location of wetlands that are closer to mining operations within the Victor Khanye local municipality. And from the above image we can see that the vegetation around the wetlands it looks wilted and brownish which is not characteristic of what wetland plants should be. Wetland areas are usually wet the whole year round and therefore finding the grass turning brown this is an indication that the effects of coal mining if taking their toll on the vegetation is the biodiversity and other aquatic animals in plants have been destroyed as indicated in this figure shown above.

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Figure 4.2: Depiction of distance between mining operations and wetlands

Figure 4.2 show us the depiction of the distance between mining operation and wetlands and from this image it can clearly be seen that Delmas is an area that is surrounded by it lags number of wetlands and as such the depiction of this picture just goes to show how they need to make profits he has superseded or overtaken the stewardship for caring for the environment for sustainable use and development. When mining activities continuously gets padded outs even in around wetlands the destruction to the environment is enormous and it will ultimately have a threat on the livelihoods of the people themselves. For example, several mining operations in South Africa are assumed to be carried out by a method called fracking that involves the cracking of and large area of the underground surface which will they have impacts on the vast areas of lands and this happens in places where the naked eye cannot see and therefore, the destruction that wetland mining operations have is enormous in relation to what Figure 4.2 depicts.

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Figure 4.3: Argent Wetland

Figure 4.3 show us the argent wetlands which is the most common characteristic of the wetlands areas that I found in this study location where the investigation in this study was conducted then from the image, we can see that an argent wetland typically saturated with groundwater.

Figure 4.4: Scale of destruction on wetlands through coal mining

Figure 4.4 above shows how massive the destruction of coal mining has been in wetlands within the municipality in the picture above it actually paints a grim picture of how mining can be destructive to the environment even though it's providing people with the means to sustain

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livelihoods. From the image above we can see that the soil that is supposedly to be in its natural states of dark brown colors now tend into pink-black soil that is actually very toxic to be supporting any aquatic lives or let alone to be used by human beings for domestic purposes.

Figure 4.5: Delmas farmer showing thick black coal dust on his maize field with a Delmas Coal stockpile in the background which has broken the farm

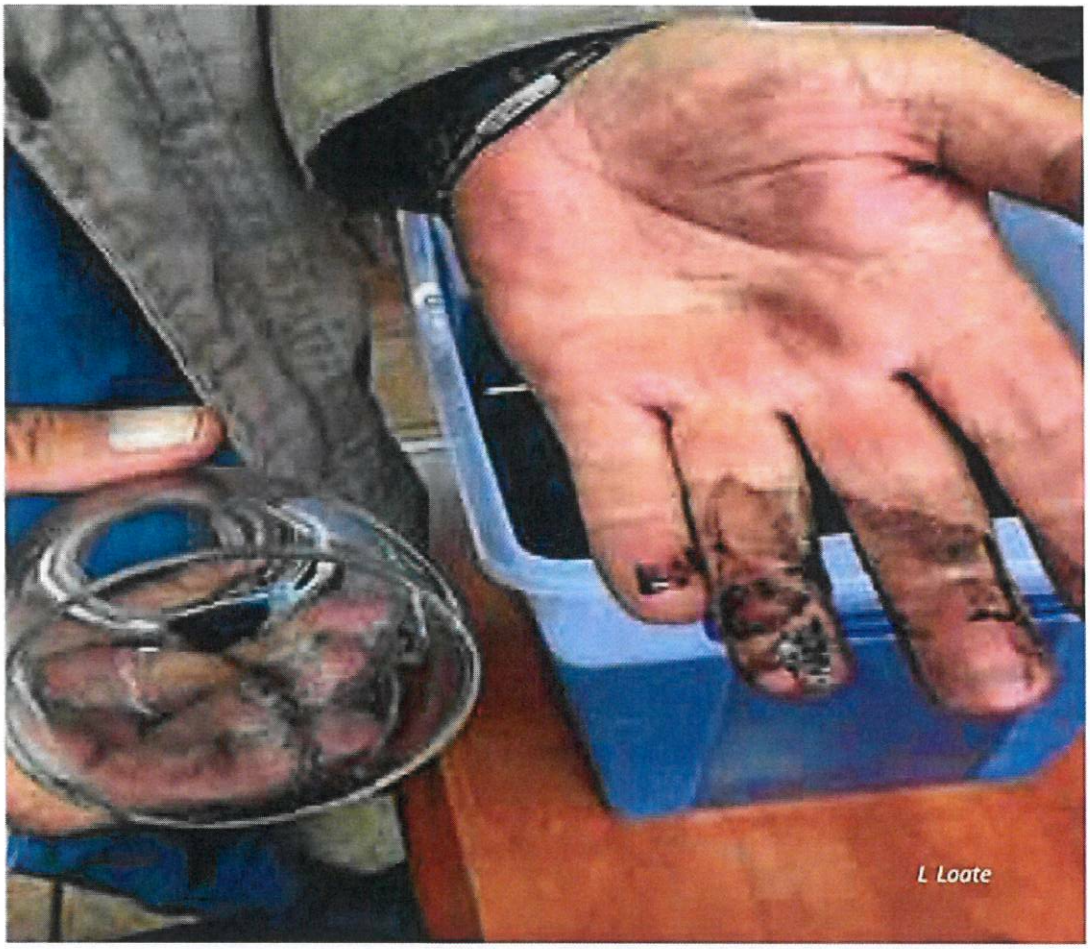

Figure 4.5 above with the Delmas farmer showing thick black coal dust on his maize field with a Delmas Coal stockpile in the background which has broken the farm Is a clear example or for how wetland mining has destroyed the soils and the environment within Victor Khanye Local Municipality. Is shown in this farmer's hands this soil is covered with a thick black coat of mining waste or mining residue and when such happens this ultimately means that the soil's capability to support plant and animal growth becomes very limited due to the contamination of wetlands because water from the wetlands is seeped into the other areas

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within the environment which will ultimately affect vast areas of land within Victor Khanye Local Municipality.

Figure 4.6: Argent Wetland destruction

The argent wetlands shown in Figure 4.6 above is depicted to be in a state where it has been exposed to valid fires first stop this image brings to the focus one of the threats to wetlands that they would fires have especially where mining activities are being carried out. Uncontrollable veld fires can be very destructive to the ecosystems and they threatened and that pollutes wetlands which would be a threat to marine life that depends on this wetlands and even human beings who use these wetlands as a source of water for domestic and other purposes, for example within Victor Khanye Local Municipality, that can be for agricultural purposes which will result in contaminated water being given to animals this will entail affect the entire ecosystem with human beings included.

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Figure 4.7: Advanced destruction of wetland by mining operation within Victor Khanye Local Municipality

In Figure 4.7 we can see the destruction caused by wetland mining operations within Victor Khanye Local Municipality. The image above is a clear indication of the disregard for the environment that mining operations have been conducted within the municipality. This therefore calls for tougher penalties to be instituted especially on the destruction of the environment in a period where climate change is threatening the livelihoods of boats plant and animal life. The needs to carry out proper rehabilitation procedures therefore becomes apparent in view of Figure 4.7 above.

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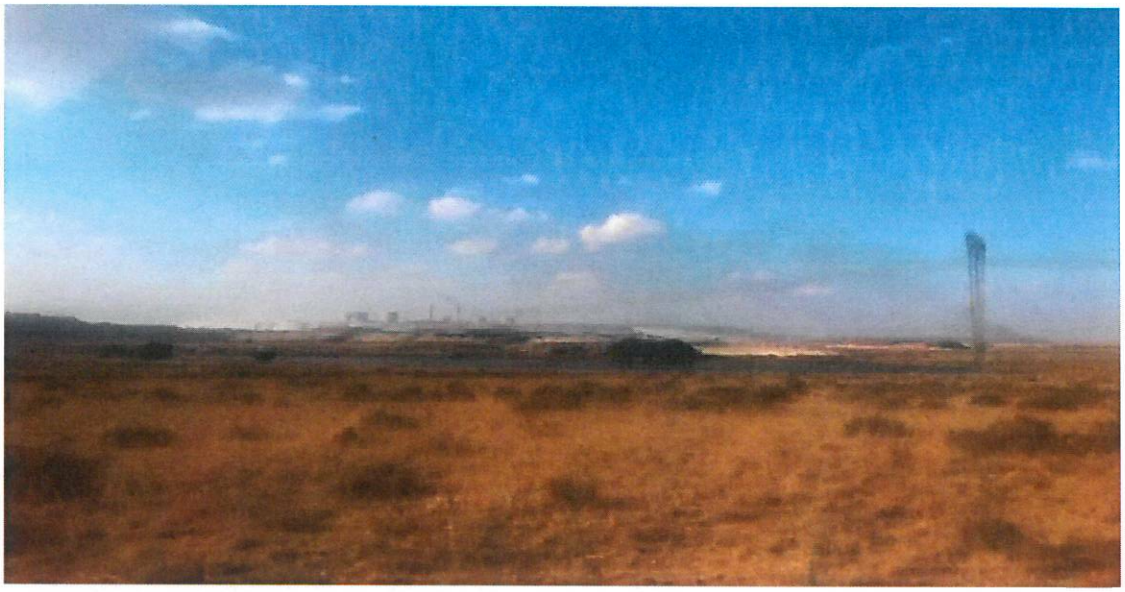
Figure 4.8: Environmental Centre Wetland



4.3 DATA ANALYSIS

The discussion and analysis of findings in this study was carried out with the view or they look back on the objectives that were set out in chapter one of this study. They need to revert back to the objectives that were set out in this study is very fundamental is it will enable the researcher to become aware of the extent or the level to which the objectives that were set in chapter one have been achieved. Therefore, the discussion of findings in this section was carried out with the view of the literary findings that were made in chapter 2 and the hands the discussion of findings and analysis in this section will be linked or connected to what the researcher discovered or found out at the literature review stage. Furthermore, linking the findings of this study to the literature will enable the researcher to figure out some patterns that might it been developing in as far as research on wetlands in South African communal areas is concerned.

Table 4.7: Should wetlands be protected or not?

Should wetlands be protected?	Yes	No
Number of respondents	35	5
Percentages	87.5	12.5

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Table 4.7 indicates that majority of respondents, 88% agree that wetlands should be protected while the minority 12.5% do not see the value in protecting wetlands. The need to realise the importance of wetlands and the biodiversity that wetlands bring is of paramount significance in maintaining biodiversity. The results gathered in table 4.7 on the minority 12.5% who see no value in the protection of wetlands, it is to be noted that their perception might as well be pushed by the fact that wetlands are assumed mostly in late layman's terms to be responsible for breeding of diseases or pathogens causing diseases like mosquitoes and other waterborne diseases, yet the fact remains that conservation of the environment supersedes or such minor threats that can be easily controlled.

Table 4.8: What are wetlands used for?

What are wetlands used for?	Respondents	Percentages
Not using	None	0
Water availability	20	50
Idle space	3	7.5
Dumping	14	35
For future generations	13	32.5

The wetland use analysis on Table 8 indicates that 20 participants use wetlands for water availability which constitutes 50 percent of the total sample while 3 indicated that wetlands are used as idling space which makes it 7.5 percent of the total sample. Only 14 indicated that wetlands can be used for dumping purposes which translates to 35 percent of the total sample whereas 13 indicated that wetlands are reserved for future generations which makes constitutes 32.5 percent. The fact that up to 35% of respondents indicated that wetlands are used for dumping shows that there is a need for educating dies people on the needs to keep waterbodies free from pollution. The recent calls by government all over the world in combatting the negative effects of climate change also requires people to refrain from such practices of damping unwanted materials in wetlands. Also, it has to be noted that this water from wetlands will also find its way into other sources of water that are used for domestic purposes and therefore jumping unwanted items in wetlands is a problem that will needs to be addressed in this community.

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Table 4.9: Should coal mining be allowed in and around wetlands?

Should coal mining be allowed in and around wetlands?	Yes	No
	5	35
Percentages	12.5	87,5

Table 4.9 indicates that 35 participants do not agree with the authorisation of coal mining operations close to the wetlands while 5 which is 12.5 percent of the population agree that coal mining should be allowed in and around wetlands. In Table 4.9 up to 87.5% of respondence do not agree that coal mining should be allowed in and around wetlands ends their perception is an indication that majority of these respondents have become aware of the dangers that coal mining has on wetlands. When coal mining is allowed to take place around wetlands this will have devastating effects on the whole ecosystem as it it will results in the pollution of vast areas of underground water which will be a threat to human and aquatic life.

The researcher's findings on this aspect relate to what has been previously noted by several scholars who indicated that principal environmental concerns of coal mining are physical disturbance of the landscape, surface subsidence and re-settlement, land stability, erosion, surface runoff, flooding, and sedimentation control, water quality and protection, spontaneous combustion or Coal mine fires, fugitive methane, public safety and disturbance issues and acid mine drainage (Reddick (2016; Lechner *et al.,* 2016).

Table 4. 10: Institution responsibility for monitoring wetland

Which institution is responsible for monitoring wetland?	Respondents	Percentages
Municipality	25	62.5
Governments	10	25
Other institution	3	7.5

Table 4.10 indicates that 25 respondents which constitutes 62.5 percent of the total number of respondents maintain that the municipality should take responsibility of monitoring the wetlands within the area while 10 respondents who constitute 25 percent of the sample

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pointed out that the government departments should take responsibility. However, only 3 respondents who constitute 7.5 percent of the total number of respondents pointed out that private institutions should be responsible for monitoring wetlands. Revelations in Table 4.10 above indicate that the people of Khanye local municipalities put the key responsibility in their municipality on the management and monitoring of wetlands as indicated by and whooping 62.5% response. Only a smaller percentage of 7.5% believed that other institutions or other non-state players also ever involved in the monitoring of wetlands in the view expressed by the minority in this study goes further to indicate that each and every resident of Khanye local municipality has a role to play in the monitoring and safekeeping of wetlands within the area.

Table 4.11: Impact that wetlands destruction has on vegetation

What impact can wetlands destruction have on vegetation?	Respondents	Percentages
Good	0	0
Bad	22	55
Fair	11	27,5
I don't know	7	17,5

Table 4.12 shows that 22 respondents, constituting 55 percent indicated that the impact of the destruction of wetlands on wetlands is bad while 11 respondents constituting 27.5 percent indicated that the impact of the destruction of wetlands on vegetation is fair whereas only 7 respondents, constituting 17.5 percent indicated that they don't know the impact of the destruction of wetlands on vegetation. Apart from those who seem not to know the benefit of wetlands on vegetation coma majority of respondents generally hold the idea that destruction of wetlands they have detrimental effects on the vegetation. For example, wetlands retain a lot of water that plans would rely on especially in terms of drought and also wetlands are a source of rich biodiversity of several plant and animal species which all work together in maintaining the ecosystems.

Table 4.13: Impact of wetlands destruction have on bird species

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What impact can wetlands destruction have on bird species?	Respondents	Percentages
Good	0	0
Bad	22	55
Fair	11	27.5
I don't know	7	17.5

Table 4.13 shows that 22 respondents who constitute 55 percent of the total number of respondents indicated that the destruction of wetlands is bad on bird species while 11 respondents constituting 27.5 percent pointed out that the destruction of wetland has a fair impact on bird species whereas only 7 respondents, constituting 17.5 percent pointed out that they don't know the impact of the destruction of wetlands on bird species.

Table 4.14: Control mechanism to be implemented to manage wetlands

What control mechanism should be implemented to manage wetlands?	Respondents	Percentages
1.By-laws	35	87.5
2.Enforcement	3	7.5
3.Community Educational programs	2	2.5

Table 4.14 indicates that 87.5 percent pointed out that by-laws should be developed and implemented for proper management of wetlands whereas 2.5 percent prefers community educational programs.

Table 4. 15: Impact that coal mining has on wetland within Victor Khanye Local Municipality

What impact does coal mining have on wetland within Victor Khanye local Municipality?	Respondents	Percentages
Good	0	0
Bad	35	87.5
Fair	0	0
I don't know	5	12.5

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Table 4.15 indicates that 87.5 percent of the respondents pointed out that coal mines will have a bad impact on wetlands whereas 12.5 percent indicated that they do not know.

Table 4.16: Impact that wetlands destruction has on fish species

What impact can wetlands destruction have on fish species?	Respondents	Percentages
Good	0	0
Bad	35	87.5
Fair	0	0
I don't know	5	12.5

Table 4.16 indicates that 35 respondents which translates to 87.5 percent pointed out that the destruction of wetlands has a bad impact on fish species while 5 which translates to 12.5 percent indicated that they do not know the impact of the destruction of wetlands on fish species. The fact that there are people in Victor Khanye Local municipality who seem to be unaware of the impact of wetlands destruction on fish species is an indication to the need for spreading the knowledge on the benefits of looking after wetlands. The results in this aspect are an indication that communities can only steer towards development and conservation if they are taught to do so and the municipalities will have to be at the fore-front in enabling this.

Table 4.17: Database of all wetlands within the area

Does Victor Khanye local municipality have database of all wetlands within the area?	Yes	No
	0	40
Percentages	0	100

Table 4.17 indicates that all 40 respondents maintain that the Victor Khanye local municipality does not have a database of the wetlands within the area.

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Table 4.18: Mapped wetlands around the municipality

Has Victor Khanye local municipality mapped all wetlands around the municipality?	Yes	No
	36	4
Percentages	90	10

Table 4.18 illustrates those 36 respondents who constitute 90 percent of the respondents indicated that the municipality has no mapped wetlands within the area the area of operations of the mines while only 4 only respondents agrees that the Victor Khanye local municipality has mapped all wetlands around the municipality.

Table 4.19: Inclusion of all wetland management plans and programs within the Integrated Development Plan

19.Has the Victor Khanye local municipality included all wetland management plans and programs within the Integrated development plan?	Yes	No
	35	5
Percentages	87.5	12.5

Table 4.19 indicates that 35 respondents constituting 87.5 percent agree that the municipality integrated all the wetland management plans and programmes within the integrated development plan whereas 5 respondents constituting 12.5 percent do not agree. The integration of wetlands management into the integrated development planning of the victor Khanye local municipality will do a great deal in spreading the much-needed knowledge that the community members must have and also by including the wetlands management plans into the integrated development plan it will automatically mean that there will be funds set aside towards the management and maintenance of wetlands within the Victor Khanye local municipality.

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Table 4.20: Funding for wetland lands management plans and programs

20. Does Victor Khanye local municipality have funding for wetland lands management plans and programs?	Yes	No
	5	35
Percentages	12.5	87.5

Table 4.20 indicates that 35 respondents constituting 87.5 percent do not agree that the municipality has funding for wetlands management programs whereas 5 respondents, constituting 12.5 percent agree that the municipality has funding for wetlands management programs. Looking at table 4.20 we realized that funding for wetlands management plans and programs is a fundamental step in ensuring that wetlands survive within the Victor Khanye local municipality. Without proper budgeting plans being put in place it will visually be impossible to manage wetlands within the municipality and even the act of letting the people know of the benefit of wetlands we will require funding so that personnel can be trained who will educate the community members one day significance or importance of wetlands within the Victor Khanye Local Municipality.

4.4 DISCUSSION OF FINDINGS

The findings as shown in the above Tables show that wetlands provide critical ecological services upon which human welfare depends. Wetlands provide the much-needed supply, storage, and purification of water. Large expanses of wetland not only regulate climate those who control flooding when used sustainably wetlands a source of resources that generate employment and contribute to human welfare through fishing supply of grass papyrus stalks and reeds used with mats and baskets as we are assigned for housing construction. The findings show that South Africa is losing critical sections of its wetland systems through encroachment.

Findings in this study show evidence that the coverage of wetland areas has reduced from 14% to as low as now about 8.4% in Victor Khanye Local Municipality. Primarily, wetlands have been a soft target especially for people who are involved in subsistence agriculture because they are not resilient the good wetlands especially during the spell or the dry spell to try to access water from the wetlands. Also, a lot of mining industries try to set up in the wetlands because the land is generally cheaper than in most of these other areas.

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The mandate of protection of wetlands is vested in the minister of water and environment districts and the national environment management authority NEMA. According to the Local Government Management Structure, in order to reverse the trend of wetland loss in the country the Minister of Environment and Wetlands set out to implement a series of auction including the occasion of wetlands eviction of encroachers and restoration. In 2018 The Auditor General's office carried out a value for money audit on the management of wetlands in South Africa to establish the extent of reduction in wetland coverage countrywide and evaluate the adequacy of measures put in place to ensure protection and restoration of wetlands.

4.4.1 Avoidance, minimization, and compensation

Compensation avoidance is exactly what it comes across as is trying to stay out of areas that are important in the aquatic system wetlands and these other parts of the aquatic systems. In some situations, completely avoiding an impact to a wetland is not possible under these circumstances the preferred step is minimization try to minimize any effects by downsizing the project where you can still maintain your objectives but impact a smaller area of wetlands or other waters. However, despite minimization efforts some activities may have substantial impacts to wetlands under these circumstances the unavoidable adverse effects on these wetland areas must be mitigated for this is the third step compensation can come in many different forms it may be enhancing an area wetland area or another water area it may be restoring an area where a well and had been previously but had been eliminated for some reason another.

Note that the Section 404 regulatory program is associated with the delineation procedure to identify specific regulated wetlands. And that is regarded as an important point because local communities are most often faced with development decisions that include more than just jurisdictional wetlands and more comprehensive in nature. This difference scale can be the source of confusion between the different agencies involved.

Although the regulatory programs are critically important, the findings in this study emphasise that these regulatory programs should always be thought of in terms of a larger planning picture a picture of what a community wants to be and the quality of life the community wants to provide its citizens. Developers in these Victor Khanye Local Municipality therefore must consider water resources as development factor.

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Just as topography or financing if the issue is postponed in the development planning process, the costs to deal with it can skyrocket in this process they cannot just ignore this issue. The penalty for blowing it off or ignorance is going to be substantial if the core comes out in the site and that permission has not been acquired. Regulations on wetlands in South Africa as highlighted in the literature review shall be strictly maintained and that those mining companies or entities who will not toll the line they are going to be penalized heavily. As one participant indicated as well that working against the system the regulatory structure that exists today is complex mainly due to the number of agencies involved and the variety of missions and purposes they have to go through.

Having said all the above, they key to remember is that any development decision impacting the local physical environment is ultimately made by the local government. Taking this study into context, the people of Victor Khanye Local Municipality can thus take advantage of the wetland resources that the different agencies provide during the planning stage of development. Before the design stage by learning how the agencies interpret conditions at a particular site ahead of time. Design elements can be shaped with these priorities in mind and costly remedial change can be minimized many creative options. Where available, as long as the overall goal of aquatic resource protection is met as long as we address those aquatic resources then the Victor Khanye Local Municipality authorities will have to look for whatever the easiest permitting mechanism is to get that applicant through the process as easy as possible in addressing the negative impacts posed by mining activities in and around wetlands.

Preserving and protecting wetlands has become a smart and effective way to restore that value. Wetlands play a key role in any biological area or ecosystem because of the tremendous benefits which they provide in terms of habitat as well as water quality. Therefore, it is not surprising that wetlands preservation and restoration should be considered as a key component of surface mining.

As a country South Africa is facing multiple environmental issues such as pollution mainly water pollution being the most pressing issue in many South African environments the quality of fresh water is extremely scarce and is rapidly decreasing as a result of the increase of pollution in river catchments caused by urbanization deforestation destruction of wetlands and energy use on Africa is widely recognized as having an admirable water law and is being a leader in granting a right to quarter in terms of quality and quantity however the water quality

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of South African water resources is deteriorating the research reported on here provides a review of changes and also quality management structures programs and approaches over the past two decades and highlights areas where these need updating completing or revision of you also quality issues in South Africa as follows each application is a major and widely recognized threat to water quality in the country each application is a consequence of nutrient enrichment that leads to ecological changes most notably blooms of algae and macrophytes you took the case in may impact ecological systems and also have an aesthetic recreational agricultural and human health impact another reason is contamination of water what's up by poorly managed switch influence may lead to high nutrient and salt levels decreased oxygen levels and an increase in the number of pathogens present in the water bodies.

South Africa has very little water available to reach all citizens and the available water has a bad quality. The bone of contention as indicated in the findings in this study is that activities such as mining which pollute the water and add chemicals to them making it extremely hard for people to survive as it is quite toxic to our human bodies. Also, people need a regular and reliable supply of fresh water to survive and therefore, with the wetlands being contaminated, mining in wetlands becomes a prime threat to the lives of many people. It is estimated that nearly about 5 million people die due to contaminated water because polluted water causes diseases such as cholera and typhoid. This makes it which make it hard for Victor Khanye Local Municipality residents to survive. Not only are polluted wetlands a hotspot for pathogen causing disease, but these sources will also as well harm the individuals who drink the water.

A study conducted by the BCG Boston Consulting Group (20210 took an in-depth look into how the economic wellbeing of a country is tied to the wellbeing of the people of the country cedar sustainable economic development assessment examined 152 countries using data from 2007 to 2016 the conclusion was that the economic wellbeing of a country ultimately determines the people's wellbeing PCG took over 140 indicators into consideration and gave a CEDAR Score from 1 to 100 in order to gauge the countries out of the 152 countries South Africa placed 75th even though South Africa is considered a global powers the country fails to use the resources it has in a meaningful manner has business practices improved or worsened water pollution although some businesses have attempted to improve water pollution through spreading awareness and offering solutions such as water purification and building water centers. The overall negative impact done by businesses have the source of industrial toxins released from a wide range of sources this includes vehicles machinery cleaning products garbage and toxic waste products the toxins released from industrial waste

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flow into our tourists and end up in our drinking water this takes a significant toll on the South Africa's water supply.

4.5 THREATS TO WETLANDS IN VICTOR KHANYE LOCAL MUNICIPALITY

Some initiatives to the development of commercial properties like mining sites, restaurants malls airports businesses can all be damaging to wetlands. Development in wetlands to build access roads parking lots and utilities like power lines construction increases sedimentation that destroys habitats and redirect water flow. In South Africa, development and industry activities on wetlands is highly regulated through the Wetlands Protection and Restoration Act. Many Municipalities, including Victor Khanye Local Municipality have regulations for protection of wetlands. An additional threat to wetlands is dam construction because it restricts and reduces water flowing into wetlands by disconnecting the rivers from their floodplains and wetland areas the natural downstream flow of sediments that create deltas and build up estuaries along coasts is reduced with migration of fish and other species being impacted.

4.6 CONCLUSION

The outcomes of the research outlines that there is no awareness of the impact on the wetlands within Victor Khanye local municipality furthermore there is no monitoring of the wetlands by Department of Environmental Affairs and Victor Khanye local Municipality resulting in damage to the wetlands within the area. The municipality has not delineated the wetlands within the area meaning it does not know the number of wetlands and the location of the wetlands. Published literature, along with the lived experiences of communities, and the work experience of other experts, bears testimony to the adverse effect of coal mining on the surrounding environment and the health and well-being of local communities. The lack of site-specific data and source-response or cause-effect case studies to support reported incidents of pollution and related impacts from coal mining in the Mpumalanga area makes it difficult to justify and prioritise interventions to effectively mitigate these impacts. Whilst some of the existing coal mining companies have implemented a number of interventions to reduce the impacts of their operations, abandoned mines and discard dumps, as well as some of the current operations, continue to pollute the environment and impact on local communities.

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CHAPTER 5

FINDINGS, RECOMMENDATIONS AND CONCLUSION

5.1 INTRODUCTION

Wetlands and pans are characteristic of Delmas sustaining abundant natural activity and filtering out pollutants. Filtered streams flow out of wetlands and join with streams and rivers downstream. Wetlands also detain water allowing for replenishing of ground water and boreholes. However, the Victor Khanye Municipality does not keep a mandatory record of wetlands and thus mining 's impact on them is not monitored. All these water resources are in different ways vulnerable to coal mining in Delmas, making it well positioned to illustrate cumulative impacts combined with a weak regulatory system.

5.2 MAJOR FINDINGS

5.2.1 Data base of wetlands

In other words, the environmental condition was derived based on recent land-use data even though database for some wetlands might have been measured some years previously. It may be possible using historical land-use data to link environmental condition with historical, but this needs to be investigated. Doing this would enable a more accurate link between number of wetlands and the environmental condition that they represent. Alternatively, new measurements of wetland can be collected (with the associated environmental condition of the wetland at the time of sampling) and if the number of measurements, and range of wetland types, regions and variables is sufficiently extensive, the historical data can be omitted from calculations of summary statistics and hence from the derivation of boundary values.

Wetlands are characterized by hydric/hydromorphic soils and slow flowing water and tall emergent vegetation and provide habitat for many faunal species including African Grass Owl. All remaining wetlands (permanent and seasonal) and their associated indigenous grassland and sedge dominated vegetation must be considered as sensitive habitats and of high conservation value. Several mammal species including Vlei Rats, Cape Clawless Otter and Marsh Mongoose may possibly occur along the valley bottom and artificially created dams. The high levels of human disturbances as well as hunting with dogs and snares will heavily impact on remaining mammal species along the valley bottom. Waterbirds, which

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were formerly restricted to high rainfall areas with natural wetland habitat, make use of man-made dams, and surrounding areas, for feeding, roosting and breeding. Certain amphibian species will utilize the shallow margins of the dam for breeding purposes including Guttural Toad, Common River Frog, Common Caco, Bubbling Kassina. Common Platanna will be found in permanent waterbodies along the alignment. Reptile species such as the Brown water Snake, Water Monitor are associated with wetland habitats including permanent dams. Low amphibian diversity is expected due to the continual deterioration of water quality due to raw sewerage constantly entering into the system.so it is important to collect all required information to document all information required. n situations where no assessment based on site observations had been carried out, land-use in the area surrounding the wetland was used to infer environmental condition. A similar approach was also used in the previous version of the database (Malan and Day 2005).

5.2.2 Declination of wetlands within coal mining areas

The local wetlands are not delineated therefore coal mining companies don't have official number of registered wetlands within victor Khanye local municipality resulting in destruction during extraction of the coal.

5.2.3 Community awareness program on the significant of wetlands

The communities residing in close proximity to coal mines and wetlands are not aware of the importance of wetlands. community groups also play an important role in collecting and analysing data relevant to wetland condition, such as bird counts, fauna tagging, fish monitoring and vegetation surveys, and taking remedial action to manage the impacts of pest species, erosion control, fencing, etc. 'Citizen involvement is a way of encouraging volunteers to make a direct contribution to scientific research at the same time as experiencing a location and learning about its environmental challenges. Citizens contribute to research by observing, taking readings, collecting and analysing data and monitoring conditions. Protocols and methodologies are developed by professional scientists and access to the internet, mobile phone apps, GIS technology and satellite imagery enable greater participation of volunteers. The result is a reliable source of large, easily-analysed data sets which would, without the support of volunteers, be difficult and costly to obtain.

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5.2.4 Lack or Constrained capacity for Wetlands Management

South Africa also lacks the skills and capacity to manage proclaimed sites (Driver et al., 2012). Many wetland site managers are either from generic nature conservation backgrounds, or from the environmental sciences, both of which are limited in terms of the depth of knowledge required to manage a wetland. There are many wetlands that could have been proclaimed as protected areas if the government or responsible authorities had the necessary skills (Cadman, Petersen, Driver, Sekhran, Maze and Munzhedzi, 2010).

5.2.5 Lack of Technical Skills on Monitoring of Wetlands

There is a lack of technical skills to make critical assessments of the wetlands before they are declared as protected areas. This includes constrained or lack of skilled personnel to handle the negotiation process of entering into contract with landowners through biodiversity stewardship. In some instances, non-government organisations are assisting authorities with financial resources and with personnel to ensure that wetlands and their ecosystems are protected (Government of South Africa, 2010).

5.2.6 Uncoordinated Functions within the Department's Causes Confusion

South Africa also lacks the skills and capacity to manage proclaimed sites (Driver et al., 2012). Many wetland site managers are either from generic nature conservation backgrounds, or from the environmental sciences, both of which are limited in terms of the depth of knowledge required to manage a wetland. There are many wetlands that could have been proclaimed as protected areas if the government or responsible authorities had the necessary skills (Cadman, Petersen, Driver, Sekhran, Maze and Munzhedzi, 2010). There is a lack of technical skills to make critical assessments of the wetlands before they are declared as protected areas.

5.3 RECOMMENDATIONS

Wetland rehabilitation prioritization should focus on improving and/or sustaining the ecosystem services supporting basic needs and livelihoods and the effect on property and tourism values. Wetland rehabilitation should focus on the improvement of recreational values. Such a prioritization process should be a single, integrated and co-operative process between all relevant departments, guided by or integrated in the IDP's Spatial Development

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Framework. Private sector, citizens and learning institutions can participate and collaborate, and it is important to coordinate how this will be done.

5.3.1 Development of wetlands management programs

Each country has a unique community structure, and most have a high percentage of endemic species due to the habitat isolation that epitomizes this island region (Ellison, 2009).it is important to develop each wetland management plans for each unique characteristic.

5.4 CONCLUSION

Victor Khanye local municipality in partnership with department of environmental affairs has responsibility to protect all wetlands within Victor Khanye local municipality and make awareness to the mining houses about the long-term impact of the damage of this natural asset. The findings gathered by the researcher in this study and the review of the published literature, including academic literature, media articles and civil society organisation reports, bears testimony to the adverse impacts of coal mining on the local environment (air, water and land) and the adverse effects of such on eco-systems and the health and livelihoods of local communities, particularly in terms of livestock farming and agriculture. Although South Africa has advanced policies and regulations, designed to protect the environment and people living in mining communities, governance and implementation remains problematic and highly contentious. This, coupled with inadequate consultation and communication with communities, has led to a situation which is dominated by highly politicised agendas with little factual basis or stakeholder co-operation. As a mitigation to the above named problems, the researcher recommends a strict adherence to the recommendations proposed in this study.

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LIST OF APPENDICES

APPENDIX I: MANAGEMENT OF WETLANDS WHITHIN COAL MINING TOWN: CASE STUDY OF VICTOR KHANYE LOCAL MUNICIPALITY

Prepared by Jeffrey Kgare

QUESTIONNAIRES ON WETLANDS MANAGEMENT IN COAL MINING TOWNS: CASE STUDY OF VICTOR KHANYE LOCAL MUNICIPALITY

A: DEMOGRAPHIC INFORMATION OF THE RESPONDENTS

1.General instruction

These participants have been randomly selected to participate in this study. There is no risk associated with participation to the study, the selection is voluntary, participants will suffer no penalty or loss of benefits. The participants may discontinue with the interview at any moment. Participation to the process will not result in any remuneration.

1.Indicate your gender:

Male	
Female	
Other	

2.You are kindly requested to tick on the appropriate age group:

Between 15 and 20 years	
Between 20 and 25 years	
Between 30 and 35 years	
Between 35 and 40 years	
Between 40 and 45 years	
Above 50 years	

3.Indicate educational level:

Primary	
Secondary	

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Technical	
Tertiary	

4. Indicate employment status:

Employed	
Self-employment	
Unemployed	

5.Type of employment:

Temporary	
Permanent	
Contract	

6.Income level:

R500- R1000	
R1000-R2000	
R2000-R4000	
R4000-R5000	
R5000-R6000	
Above R6000	

B: INFORMATION ON WETLANDS

7.Should wetlands be protected or not?

Yes	
No	

8.What are wetlands used for?

Not used	
Water availability	
Idle space	

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Dumping	
For future generation	

9.Should coal mining be allowed in and around wetlands?

Yes	
No	
I don't know	

10. Which institution is responsible for monitoring wetland around?

Municipality	
Governments departments	
Other institutions	

11. What are wetlands used for?

Fishing	
Grazing	
Dumping	
Other use	

12. What impact can wetlands destruction have on vegetation?

1.Good	
2.Bad	
3.Fair	
4.I don't know	

13. What impact can wetlands destruction have on bird species?

1.Good	
2.Bad	
3.Fair	
4.I don't know	

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14. **What control mechanism should be implemented to manage wetlands?**

1.by-laws	
2.Enforcement	
3.Community educational programs	

15. **What impact does coal mining have on wetlands within Victor Khanye local Municipality?**

1.Good	
2.Bad	
3.Either good or bad	
4. I don't know	

16. **What impact can wetlands destruction have on fish species?**

1.Good	
2.Bad	
3.Either good or bad	
4. I don't know	

17.**Does Victor Khanye local municipality have a database of all wetlands within the area?**

1.Yes	
2.No	

18.**Has Victor Khanye local municipality mapped all wetlands around the municipality?**

1.Yes	
2.No	

19.Has Victor Khanye local municipality included all wetland management plans and programs in the Integrated development plan?

1.Yes	
2.No	

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20.Does Victor Khanye local municipality have funding for wetlands management plans and programs?

1.Yes	
2.No	

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APPENDIX II: MANAGEMENT OF WETLANDS WHITHIN COAL MINING TOWN: CASE STUDY OF VICTOR KHANYE LOCAL MUNICIPALITY (FOCUS GROUP MEMBERS ABOR AND JOZI DUPLISIS FARM)

Prepared by Jeffrey Kgare

A: INFORMATION ON WETLANDS

1.Why are wetlands so important?

For grazing	
For water	
Any other use	

2. What do you think government should do to protect wetlands?

Fencing	
Close them	
Leave them	

3. What do you think mines should do to safeguard the wetlands?

Leave them	
Fencing	
Any other use	

4. Would you be involved if the there is need to rehabilitate the wetlands?

Yes

No

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APPENDIX III: LETTER FOR PERMISSION TO CONDUCT THE STUDY

Victor Khanye Local Municipality
Po Box 6
2210
07/10/2019
Sir,
RE: PERMISSION TO CONDUCT RESEARCH STUDY
I am writing to request permission to conduct a research study at Victor Khanye Local municipality. I am currently enrolled for master's in Public Management at University of Venda and am in the process of writing my master's Thesis. The study is entitled management of wetlands in coal mining towns case: study of Victor Khanye local Municipality.

I hope the municipality will allow me to get officials from the social services to anonymously fill the questionnaires. Due to the nature of the study, I hope to will be given a consent forms to be completed and returned to the primary researcher at the beginning of the research consultation process. If approval is granted, participants will complete questionnaires at municipality.

The research process should take no longer than three months. The research results will be pooled for thesis project and individual results of this study will remain absolutely confidential and anonymous. Should this study be published, only pooled results will be documented? No costs will be incurred by either by municipality or the individual participants.

Your approval to conduct this study will be greatly appreciated.
Yours Sincerely,

.....
Jeffrey Kgare
0732661437

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APPENDIX IV: MUNICIPAL AUTHORISATION TO CONDUCT THE STUDY

VICTOR KHAN LOCALMUNICIPALITY - PLAASLIKE

MUNISIPALITEIT

6 DELMAS 2210

013 665 6005
013 665 2913

Email: palesam@victorkhanyelm.gov.za
Website: www.victorkhanyelm.gov.za

OFFICE OF THE MUNICIPAL MANAGER

Enquiries: Mr J.Kgare Ref•.10110/2019

10 September 2019

MR J. KGARE
248 Market Street
Eloff
2211

VICTOR KHANYE LOCAL MUNICIPALITY
2019 -10- 14
OFFICE OF THE MUNICIPAL MANAGER

Madam,

RE: REQUEST FOR AUTHORISATION TO CONDUCT STUDY ON MANAGEMENT OF WETLANDS WITHIN COAL MINING TOWNS CASE STUDY OF VICTOR KHANYE LOCAL MUNICIPALITY.

The institution authorises the researcher to conduct above mentioned study within our area. The outcomes of the study will assist in management of wetlands within Victor Khanye Local Municipality. Increasing number of coal mines within Victor Khanye local Municipality has environmental impact on water bodies within the area, so the study outcomes will determine the type of impact either negative or positive and recommend best mitigations on negative aspects. The outcomes of the study will assist the institution to close policy gaps on wetlands control within Victor Khanye Local Municipality.

The institution wishes best regards to the researcher on his studies.

YOURS FAITHFULLY,

APPENDIX V: ENGLISH LANGUAGE EDITOR REMARKS

No. 06

Department of English

University of Venda

P/Bag X 5050

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Thohoyandou

0950

17 June 2021

To Whom It May Concern

This serves to confirm that I proof-read and edited the dissertation titled "Management of Wetlands Within Coal Mining Towns: Case Study of Victor Khanye Local Municipality, Mpumalanga Province, South Africa" by Jeffrey Chuene Kgare, Student Number: 11541095. I have made several suggestions which I hope the student will consider and effect.

Regards

NV Demana

Vincent N. Demana

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University of Venda
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E-mail: Vincent.demana@univen.ac.za
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APPENDIX VI: TURNITIN DIGITAL RECEIPT

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