Sand mining challenges in the Western Cape: The case of the Tormin Mineral Sands and Maccsand Mining and Quarrying Mines

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ABSTRACT

SAND MINING CHALLENGES IN THE WESTERN CAPE: THE CASE OF THE TORMIN MINERAL SANDS AND MACCSAND MINING AND QUARRYING MINES

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Mining, as a primary extractive activity, is characterised by arguably the most environmentally destructive operations worldwide. South Africa's mining industry, which is an important economic driver, and its environmental footprints bear testimony of such direct and indirect destruction. In the biodiversity-rich Western Cape province, which is generally far less endowed with economically mineable minerals and metal deposits compared to other provinces, mining is even more problematic.

This study addressed, in a comparative way, the polemics associated with two mining operations in the Western Cape, revisiting their environmental and socio-economic desirability as well as their varying impacts. A Socio-ecological Systems (SES) approach was used to document the processes associated with environmental applications, authorisation and operations pertaining to the MaccSand Mining and Quarrying and Tormin Mineral Sands Mines that are clouded in a myriad of environmental problems. Methodologically, the study drew on a mixed methods approach, which incorporated data derived from questionnaire surveys, interviews, stakeholder engagement meetings and geographic information systems (GIS) applications. One case study focuses on the Tormin Mineral Sands Mine owned by Mineral Sand Resources (Pty) Ltd., located near Lutzville on the West Coast. The other case study focuses on MaccSand Mining and Quarrying operated by MaccSand CC, on Cape Town's False Bay Coast.

Although the extrapolation value of findings of the study cannot not necessarily be applied to all sand mining operations in the Western Cape, it provides insights into the challenges associated with sand mining in sensitive coastal areas. The findings of the study provide testimony of the following challenges: legislative contestations associated with decisions of competent authorities and organs of state; an apparent lack of adherence to on-site operational environmental management plans and post-mining rehabilitation; varying opinions on the biophysical-environmental impacts of sand mines; varying opinions on the socio-economic impacts as well as social and labour plans (SLPs) of mines; to fully appreciate the role that civil society organisations, specifically anti-mining lobbyist play; to fully appreciate the opinions of disenfranchised communities in proximity to sand mines; and to value the corroborating role that spatial-interpretation techniques such as Geographic Information Systems and Remote Sensing can play in assessing the desirability or undesirability of mining operations and associated polemics.

This study found that there is a disconnect between the competent and commenting authorities, which have resulted in conflict and a lack of regulatory enforcements, which was exhibited during interviews. The overall viewpoint on sand mining is exceptionally negative with participants from both the Macassar and the West Coast questionnaire surveys believing there is no socio-economic or socio-ecological benefit from the sand mining operations located in these areas. Furthermore, satellite imagery illustrates that rehabilitation is occurring at MaccSand Mining and Quarrying, with under 10% of vegetation loss since MaccSand CC began operations in 2000. No visible evidence of rehabilitation can be seen at the Tormin Mineral Sands mine, while further investigations demonstrated that there has been over 60% of vegetation degradation along the West Coast since 2013 when mining operations began.

(Information/data gathering was sensitive and responsive to Covid-19 and other research protocols and ethics).

Keywords: polemics; sand mining; bio-geophysical conditions; conservation; contestations; development; environmental and socio-economic desirability; expansion; impacts; rehabilitation; Western Cape

July 2023

LIST OF ABBREVIATIONS

BID: Background Information Document

CBAs: Critical Biodiversity Areas

CCM: Commission for Conciliation, Mediation and Arbitration

CFR: Cape Floristic Region

DEADP: Department of Environmental Affairs and Development Planning

DMRE: Department of Mineral Resources

DWS: Department of Water and Sanitation

ECO: Environmental Compliance Officer

EIA: Environmental Impact Assessment

EIR: Environmental Impact Report

EMP: Environmental Management Plan

GIS: Geographic Information Systems

I&APs: Interested and Affected Parties

IDP: Integrated Development Plan

IUCN: International Union for Conservation of Nature

LUPO: The Land Use and Planning Ordinance

MPRDA: Mineral and Petroleum Resources Development Act

MSR: Mineral Sands Resources (Mining company)

NDVI: Normalised Difference Vegetation Index

NEMA: National Environmental Management Act

NGI: National Geo-spatial Information (Part of the Department of Agriculture, Land Reform and Rural Development)

NIR: Near-infrared

PAs: Protected Areas

RS: Remote Sensing

SANBI: South African National Biodiversity Institute

SAVI: Soil-Adjusted Vegetation Index

SAWS: South African Weather Service

SDGs: Sustainable Development Goals

SEMA: Specific Environmental Management Acts

SES: Socio-ecological Systems

SLAPP: Strategic Lawsuit Against Public Participation

SLP: Social and Labour Plan

UNEP: United Nations Environment Programme

UNESCO: United Nations Educational, Scientific and Cultural Organization

USGS: United States Geological Survey

VegMaps: Vegetation Coverage Maps

CHAPTER 1: INTRODUCTION

1.1 Introduction

Sand is always needed; it is a sought-after commodity due to the widespread uses it has, specifically in construction. Owing to this demand for sand, it is mined extensively in coastal and inland areas globally. The mining of sand normally goes hand in hand with environmental degradation and economic exploitation (Haney and Shkaratan, 2003). Sand is a non-renewable resource; therefore, overexploitation of this resource has led to it being depleted. This is largely because of poor enforcement of environmental legislation and poor mining practices within the province (Haney and Shkaratan, 2003). This study sought to address the environmental and societal polemics associated with the continuation of sand and mineral mining in environmentally sensitive coastal areas of the Western Cape province.

1.1.1 Mining

According to Bondarenko et al. (2014), mining is the process in which minerals are extracted from the surface of the earth, and it includes extraction from the sea. The term "mining" also includes the removal of soil to reach the material desired. The methods to remove these minerals include digging, excavation, explosions, shafting, and stripping of earth layers (Cambridge Dictionary, 2021). Mining is a process of obtaining any material that cannot be grown through agricultural means or created in a laboratory or factory; thus, mining can be thought of as the extraction of any non-renewable resource (Bondarenko et al., 2014). According to the American Geosciences Institute (n.d.), there are four core methods of mining, namely underground mining, surface mining, placer mining, and in-situ mining. Underground mining refers to mines reaching deeper deposits which are more valuable; surface mining is used to obtain materials which are less valuable, while placer mining is used to mine sediment, and in-situ mining is used to mine uranium from the surface without moving the ground. The method used thus depends on the resource being mined, its location beneath the surface, and whether extraction is worth the funds needed to obtain the resource or mineral.

In South Africa, there are different types of mineral resources mined, and the mining sector is pivotal to the economic growth of the country (Hamann, 2004). However, when mining is done irresponsibly, it has negative impacts on the environment, causing irreversible harm (Bolong, 2016), and destroying a major asset and resource, which is the environment (Downing, 2002). Environmental degradation occurs when mining companies do not adhere, or only partly adhere, to the environmental laws and regulations set in place to ensure that environmental harm and degradation do not occur and if they do, it is on as miniscule a scale as possible (White, 2013). Irresponsible mining operations can cause several negative impacts on nearby communities by devastating local ecosystems due to toxic environments created by mining companies (Duri, 2016). There are occurrences when the environmental devastation caused by mining companies is so severe that communities are abandoned, and these become known as "ghost towns" (Haney and Shkaratan, 2003). This shows the importance of the environment and how it links with ecological and human wellbeing and health (Cullen-Unsworth et al., 2014). Mining not only impacts biodiversity, but also, to a considerable extent, ecosystem services. These impacts may be direct, indirect, cumulative, or induced, and may be short-term, or long-term, lasting for decades or centuries after mining occurs. Long-term impacts may even be permanent and irreversible, which is why an Environmental Impact Assessment (EIA) is necessary for developments. This ensures the mitigation of impacts, because without mitigation, there would be risks to other economic activities, livelihoods of nearby settlements and cities, and ecological infrastructure. These impacts, of course, strongly affect poor and vulnerable communities who are dependent on the biodiversity and ecosystem services within or near their communities (DEA et al., 2013).

1.1.2 Sand Mining

Sand mining is the extraction of sand through either an open pit or from beaches and inland dunes, and sometimes dredged from oceans and riverbeds (Hernandez et al., 2021), which is also known as mega-mining, open-cast, or open cut mining (Serafini, 2018). Sand mining is economically attractive as it presents opportunities to extract other minerals from it such as rutile, ilmenite, zircon, and it is sometimes possible to extract minerals such as garnet, leucoxene, sillimanite, and monazite (UNEP, 2014). To extract the minerals, elutriation is used. Elutriation is the removal of substances from a mixture by means of washing and decanting. The Merriam-Webster Dictionary (n.d.-a) states that in sand mining, elutriation involves use of flowing water to separate the grains of sand based on their shape, size, and density. Drivers of sand mining included infrastructural development and business. Sand remains a big business both for small-scale sand miners and for huge corporations worldwide. Table 1.1 shows some sand exporting players worldwide.

Table 1. 1: Global sand export statistics of the top 14 countries. (Source: Adapted from Atlas of Economic Complexity, 2022)

Global Sand Exports 2020		
Ranking	**Country**	**Percentage**
1	United States	24
2	Netherlands	13.3
3	Germany	9.6
4	Belgium	7.8
5	Malaysia	4.7
6	Australia	3.9
7	France	3.6
8	Taiwan	2.5
9	Egypt	2.2
10	China	2.2
11	Saudi Arabia	2.1
12	Vietnam	2.1
13	Canada	1.8
14	Portugal	1.5
15	Rest of World	16.4

Table 1.1 was adapted from the Atlas of Economic Complexity (2020), in which they compiled the top exporters of sand globally. This table indicates that South Africa is not one of the top 14 countries which exports sand worldwide and would thus fall into the "Rest of the World" category, which accumulates to a 16.4% contribution to the global sand exports. Of this 16.4%, South Africa contributes 0.18% to the global percentage of sand exports (Atlas of Economic Complexity, 2020b). According to a report by the Observatory of Economic Complexity (2020b), the top exporters of sand are the United States, Australia, Netherlands, Germany, and Belgium, and South Africa only contributed 0.23% to the global percentage of sand exported in the last reporting period. Both reports are for 2020, but there is a 0.5% difference between the weighting of how much sand had been exported from South Africa. Although this may not seem like a large difference, on a global scale, it is. This shows that there is uncertainty associated with sand mining as it suggests that different institutions rank things differently, and thus either have different ranking systems or use different sources when compiling their information. The difference within ranking systems within different institutions can negatively affect a country by impacting collaboration and partnerships, as higher ranked institutions

could result in more imports from other countries, and lower ranked countries may be overlooked (Chun and Larrick, 2021). South Africa already ranks quite low, and different institutions having different statistics could thus also lead to the country being overlooked, as accurate statistics may be difficult to acquire. It has been shown that ranking systems do, in fact, affect one's decision of who to employ/appoint, and decision makers prefer top-ranked options (Chun and Larrick, 2021).

1.1.3 Impacts of sand mining

The issue with sand mining is that it is being mined at a far greater rate than the renewal rate (Lawal, 2011; UNEP, 2014). There are deserts of sand globally, which would give the implication that it is in abundance, but a particular sand is needed depending on its use and on industry. Sand is thus categorised by its size, density, composition, etc., and desert sand for instance, does not meet the requirements for multiple industries, such as that of the construction industry (Gavriletea, 2017). This is mainly because desert sand is too smooth and/or fine to bind the materials used in building, and thus cannot be used by the construction industry (Filho et al., 2021). Sand and gravel are known as "aggregates", and they account for the largest share of materials mined yearly (Krausmann et al., 2009), pegged at 68 to 85 per cent of the total materials mined yearly and which is between 47 and 59 billion tonnes globally (Steinberger et al., 2010). Some of the consequences of aggregate extraction are listed in Table 1.2.

Table 1. 2: Main consequences of extraction of aggregates. (Source: Adapted from UNEP, 2014)

MAIN CONSEQUENCES OF AGGREGATE EXTRACTION

Impact on	**Description**
Biodiversity	Impacts on related ecosystems such as fisheries
Land Loss	Refers to both inland and coastal erosion
Hydrological Function	Change in water flows, flood regulation and marine currents
Water Supply	Lowering of the water table; pollution
Infrastructure	Damage to bridges, river embankments and coastal infrastructure
Climate	Directly related to transport emission, and indirectly related to cement production
Landscape	Coastal erosion; changes in deltaic structures; quarries; pollution of rivers
Extreme Events	Decline in protection against extreme events such as floods, droughts, or storm surges

Table 1.2 shows that UNEP (2014) found that mining of aggregates (sand and gravel) has impacts on biodiversity, water turbidity, water table levels, on the landscape, and even on climate through carbon dioxide emissions which can be from transportation of vehicles at, to and from the sand mines. This shows that sand mining is and can cause significant environmental problems. Sand is used in a variety of industries such as building construction, electronics, plastics, and water filtration industries (Filho et al., 2021), but the greatest consumer of sand and gravel is the cement industry (Edwards, 2015). The large volumes of sand extraction are impacting rivers, deltas, as well as coastal and marine ecosystems. These impacts include loss of land through river coastal erosion, lowering the water table, and decreasing the amount of sediment supply (UNEP, 2014). Sand is also found on mountain and river valleys which are known as environmentally valuable areas (Kowalska and Sobczyk, 2014), corroborating the notion that sand mining can negatively affect the environment by reducing rare and significant flora and fauna found at the sand mining locations.

1.2 Study areas

1.2.1 Background on sand mining in the Western Cape

The study sites of this study consisted of beaches and coastal areas, with the mined sand being primarily used for fill and building (Clark, 2019). Figure 1.1 illustrates the materials mined in the Western Cape.

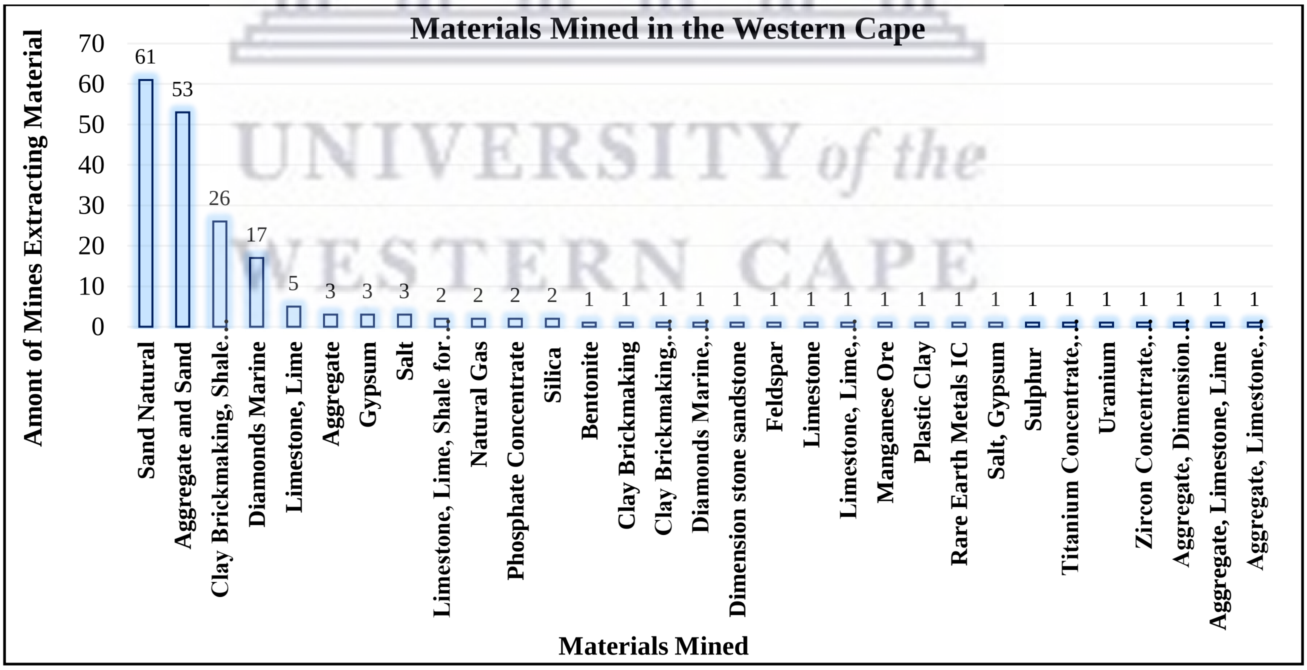

Figure 1. 1: *Material mined in the Western Cape. (**Source:** Adapted from DMRE, 2021)*

Of the 198 active mines in the Western Cape, 61 solely mine sand, shown in Figure 1.1 as 'Sand Natural'. This accumulates to 30.8% of all mines in the Western Cape mining sand (DMRE, 2021). This is largely because the Western Cape does not have significant economically harvestable minerals, but it has a large amount of industrial minerals (Ngcofe and Cole, 2014). In the Western Cape, the main mining practice which occurs is sand mining (Cole et al., 2014; DMRE, 2021), which is a form of surface mining (Serafini, 2018). In the Western Cape, there are 198 active mines in total, from which 118 mine sand solely or in conjunction with other minerals, correlating to 59.6% of all mines in the Western Cape extracting sand. The locations of these sand mines can be seen in Figure 1.2.

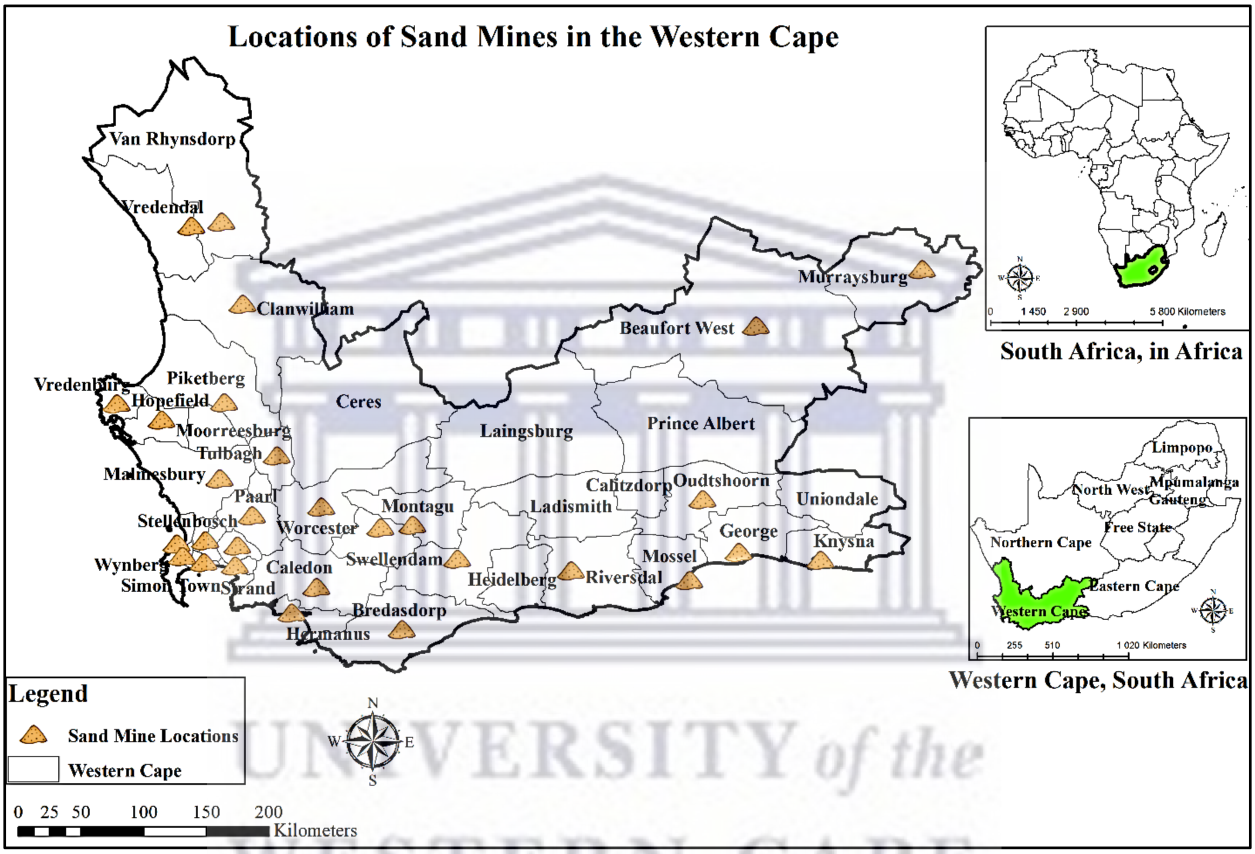

Figure 1. 2: *Location of major sand mining operations in the Western Cape. (**Source**: ArcMap V. 10.8.2 and Latitude.to, 2023)*

Figure 1.2 illustrates that there is a combination of inland and shoreline mining in the Western Cape province, with predominant locations along the coastline. This map does not give exact coordinates, as the DMRE (2021) website lists the districts in which the mines fall and not the specific suburbs. The coordinates of the districts were thus used to generate the locations of the sand mines, and these coordinates were accessed via Latitude.to (2023). This means that there may be more locations of sand mines along the coastline, as the districts' coordinates are not specifically on the coastlines, but inland in places such as Vredendal, Clanwilliam, Piketberg, Riversdal, Wynberg, Simons Town, Bellville, Malmesbury, and Hopefield. Figure 1.3 illustrates the number of mines in each suburb of the Western Cape.

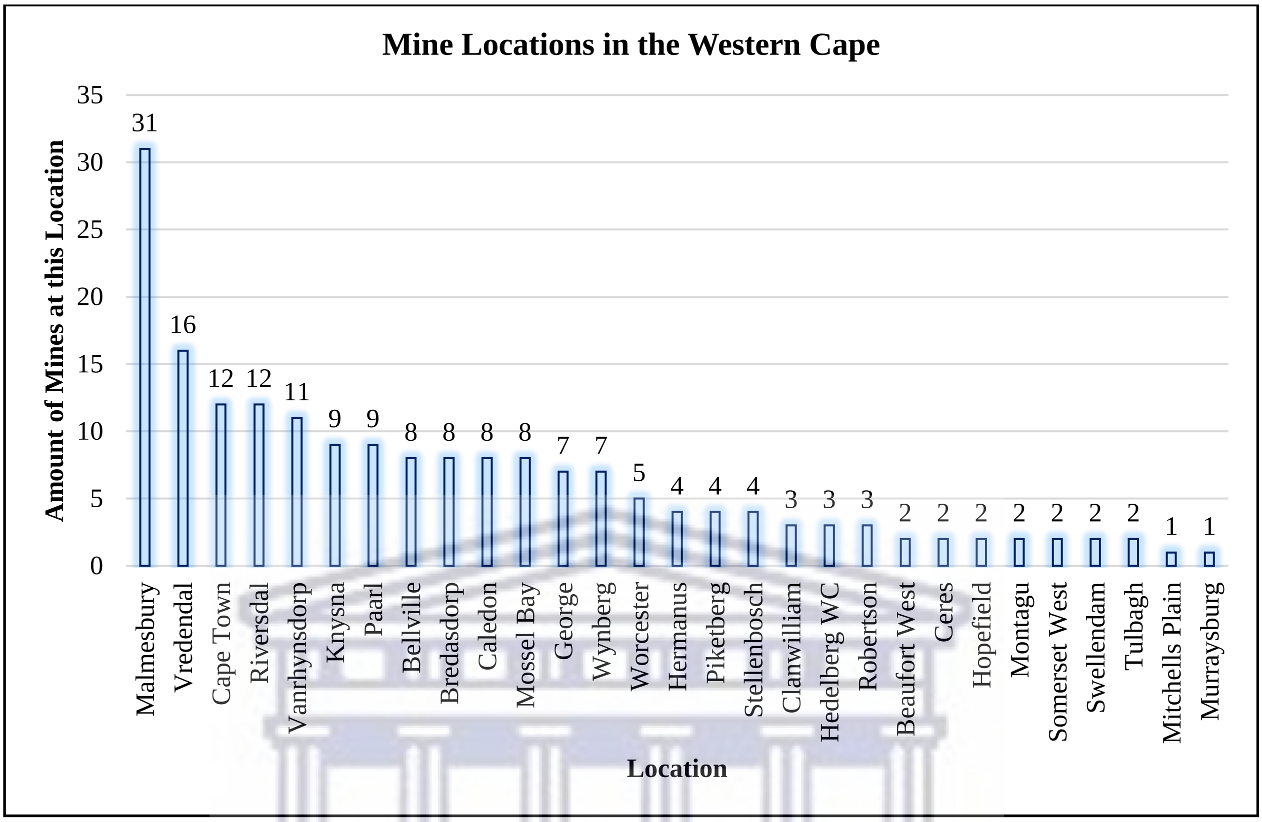

Figure 1. 3: *All mine locations in the Western Cape. (**Source:** Adapted from DMRE, 2021)*

Figure 1.3 shows that the areas with the most mines are Malmesbury with 31 mines, followed by Vredendal with 16 mines, and then Cape Town and Riversdal each with 12 active mines located there. According to the graph, Murraysburg and Mitchells Plain have the least number of mines, both having one mine at each location. This is however questionable because in 2020 alone, MaccSand CC closed 17 mines (according to an interview with a mine representative from MaccSand Mining and Quarrying), which were located in places between Eersteriver to Khayelitsha, suggesting that there are many more mines located in these areas than what are publicly listed on the DMRE (2021) website. Watson and Olalde (2018) state that special permission and access is needed to gain full access to information pertaining to mining by the DMRE, and this suggests that all the current mining companies may not be listed on the DMRE website.

For this study, two sand mines were investigated, namely the Tormin Mineral Sands Mine along the West Coast owned by Mineral Sand Resources (Pty) Ltd, and the Maccsand Mining and Quarrying Mine on the False Bay Coast in Cape Town owned by Maccsand CC. The locations of these mines can be seen in Figure 1.4.

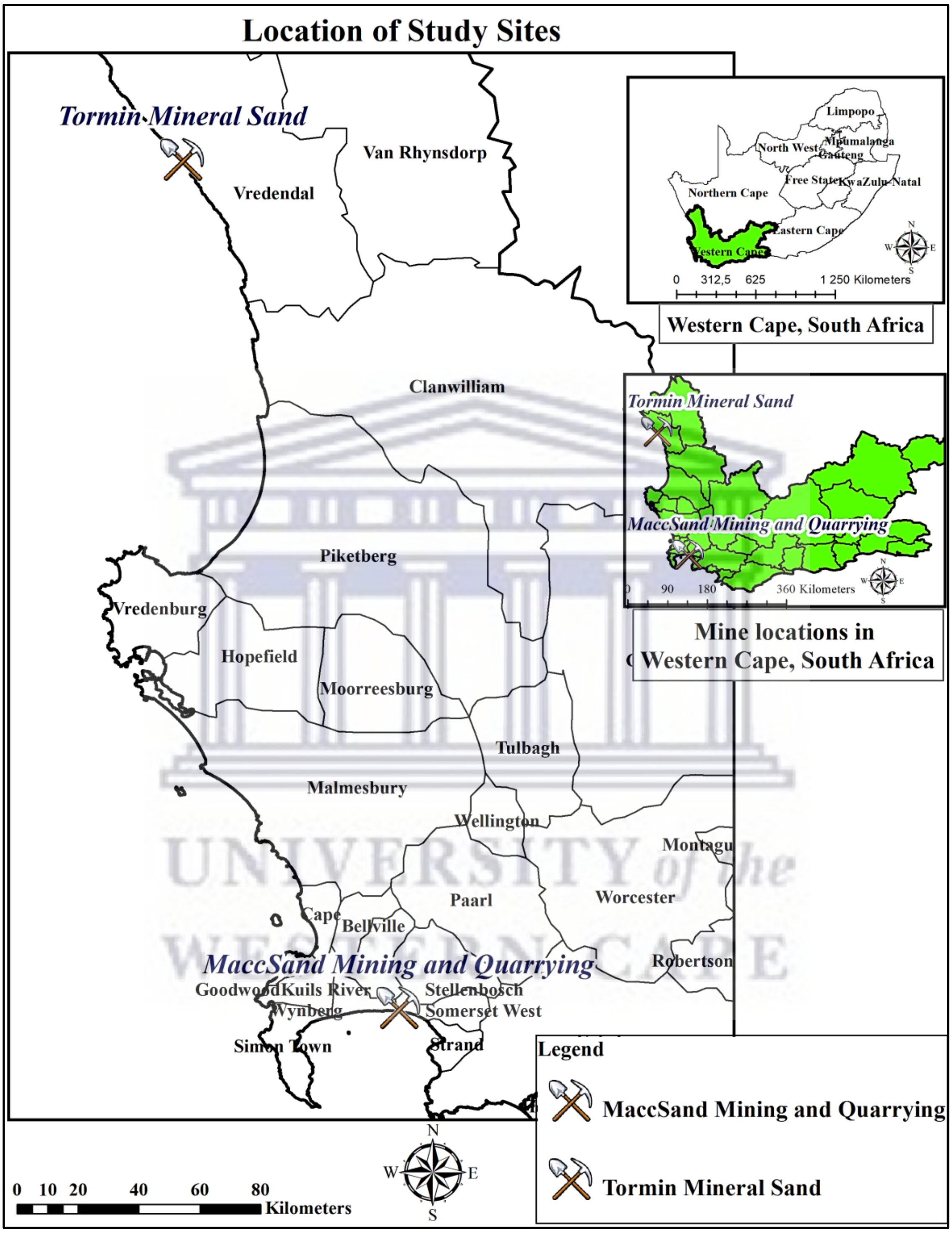

Figure 1. 4: *Locations of the MaccSand Mining and Quarrying and Tormin Mineral Sands mines. (**Source:** ArcMap V.10.8.2)*

Sand can be mined in inland/terrestrial and marine/off-shore areas. Terrestrial deposits include residual soil deposits, river channel deposits which are also known as alluvial deposits (Britannica, 2020), and floodplain alluvial deposits which are deposits that are on flat land adjacent to a stream (Brittanica, 2018). However, the most common marine sources are off-shore, which is sand found within the sea (Economie, 2022), and shore deposits, which is beach sand (Singh, 2020). Sand that is mined for construction and manufacturing purposes needs to be jagged and angular grained. This preferred sand is mostly found along riverbeds, riverbanks, in lakes and along shorelines (Hall, 2020), which is why both mines in this study – the Tormin Mineral Sands Mine and the Maccsand Mining and Quarrying Mine – are located along the coastline as illustrated in Figure 1.4. Both mines are located near Strandveld vegetation - the Namaqualand Strandveld along the West Coast (Eskom, 2007) and the Cape Flats Dune Strandveld near Macassar (Green Map, 2014).

1.2.1 MSR Tormin Mine along the West Coast near Lutzville

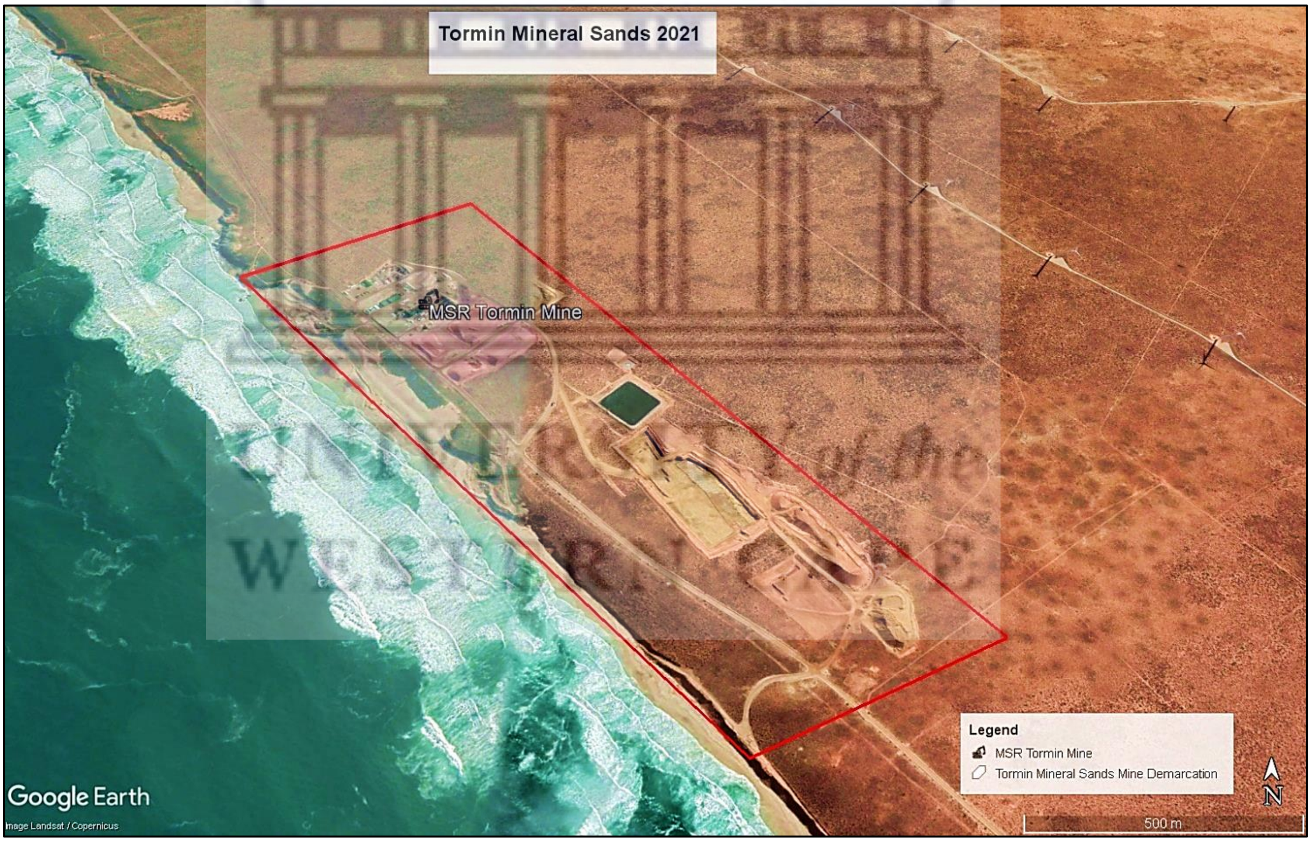

Figure 1. 5: *Extent of the Tormin Mineral Sands Mine. (**Source**: Google Earth Pro)*

The Tormin Mineral Sands mine began operations in late 2013 (MRC, n.d.). As seen in Figure 1.5, the Tormin Mineral Sands mine is quite large, occupying 120 hectares, following approval for extension in 2019. The red lines are demarcating the general outline of the mining site and from this, it is visible that the mine is operating on the beach/coast. The area surrounding the mine looks very dry, and there seems to be little vegetation growth surrounding and adjacent to the sand mining location. It can however be noted that two different satellite images were used to provide an image for this site, specifically Landsat and Copernicus, which is why there is a clear difference in colour palette between the left and right side of the image. Furthermore, it is visible on the left that there are green patches which would suggest vegetation, and it can thus be assumed that the colour palette in the image on the right is concealing the vegetation data.

The Tormin Mineral Sands Mine currently occupies 120 hectares of land and the mine has secured approval for an extra 28.7 hectares along the Graauw Duinen 152 and portions of the Klipvlei Karoo Kop 153 farm, as well as 90 hectares on the Geelwal Karoo 262 farm as documented in the EIA-BID Report (Masson and Reuther, 2017). The Tormin Mine received the approval for the 28.7 ha extension in 2019. However, two appeals were filed against the Tormin mine in 2019 – one for illegal activities and another for the extension which was approved (Yeld, 2019). Figure 1.6 illustrates the current extent of the Tormin Mineral Sands Mine.

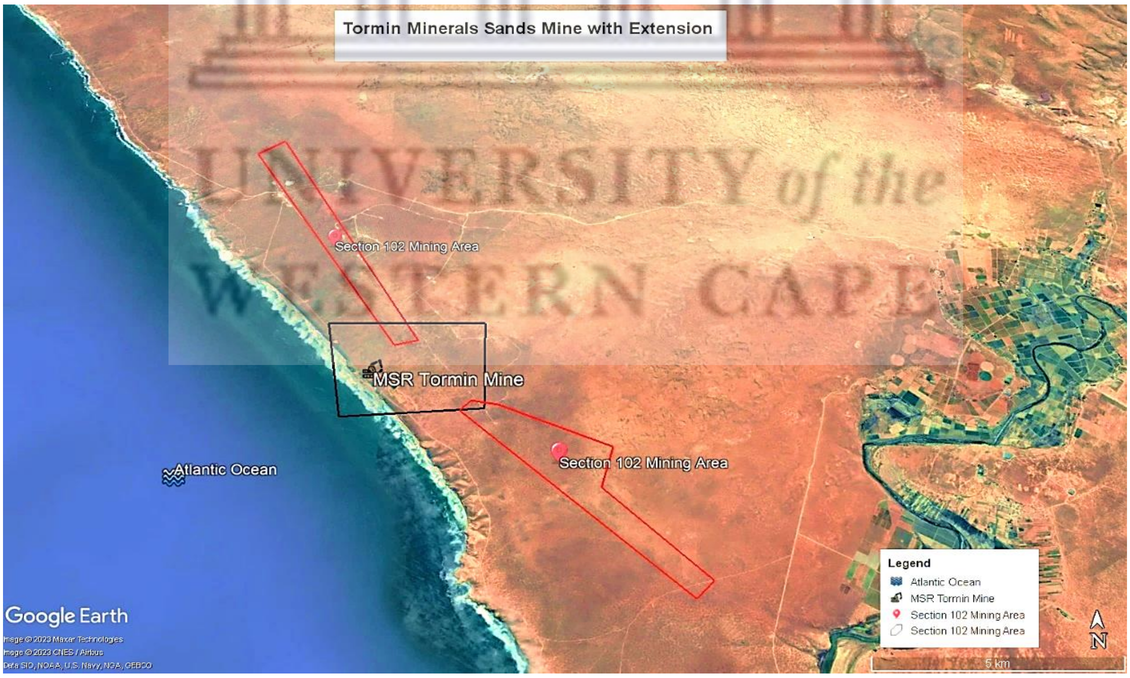

Figure 1. 6: *Tormin Mineral Sands mine with extension as per Section 102 of the Mining Right. (**Source**: Google Earth Pro)*

Figure 1.6 shows the approved extension of the Tormin Mineral Sands mine, and the Section 102 mining areas. According to the MRC website (n.d.), the Section 102 Mining Right includes two areas which are approximately 5.6 km in total length, and they cover about 75 hectares of land adjacent to the mining operations on the Geelwal Karoo 262 farm. In 2020, Tormin Mineral Sands was granted an amendment to the existing mining right under Section 102 of the Mineral and Petroleum Resources Development Act (Act No. 49 of 2008)), which is known as the "S102 Mining Right". Section 102 of the MPRDA provides that any right holder, which mines any mineral under the mining right (S102), may mine in surrounding or adjacent areas in which the mined mineral also occurs, although the company does not own the right/permission/permit for those areas or zones (Hogan Lovells Publications, 2014). This means that although MSR does not hold the rights to the surrounding land, as per Section 102 of the MPRDA, they could mine those areas after receiving approval in 2020. This mining right has given the Tormin Mineral Sands mine an additional 43.7 hectares of beach deposits to mine; these are adjoined to their current site, along the northern beaches. They have also been granted an additional 75 hectares of inland strand which is adjacent to the existing mining operations (MRC, 2020).

1.2.2 MaccSand Mining and Quarrying near Macassar

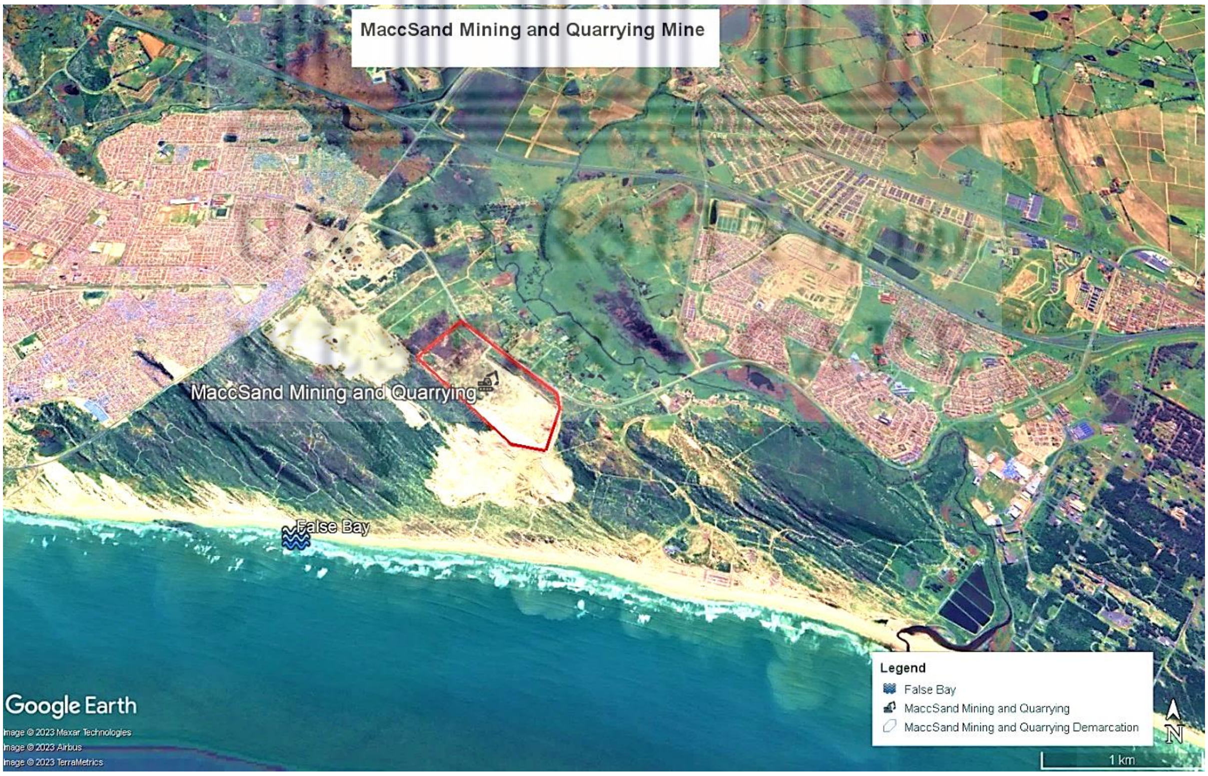

Figure 1. 7: *MaccSand Mining and Quarrying along the False Bay Coast. (**Source**: Google Earth Pro)*

As seen in Figure 1.7, MaccSand Mining and Quarrying has been demarcated with a red outline. It can be seen in the image that the site consists of half vegetation and half sand. It can also be seen in figure 1.7 that there are two sand mines on both sides of MaccSand Mining and Quarrying, both of which are closer to the False Bay than MaccSand, which is the most inland.

1.3 Research aim

The aim of the study was to use a Social-ecological Systems (SES) approach to document and analyse polemics, varied impacts, and desirability associated with continued sand mining operations at the chosen study sites.

1.4 Objectives

1. To analyse polemics associated with mining operations at the study sites by using a Social-ecological Systems approach.
2. To examine thespatiotemporal changes of the mining operations and their implications on the geo-biophysical environments and vegetation using remote sensing and GIS applications.
3. To analyse approved environmental management authorisation regulations and capture the opinions of the relevant competent authorities, i.e., the DMRE and DEADP in the wake of different opinions on the impacts, operations, and rehabilitation of sand mines.
4. To capture the opinions of anti- and pro-sand mining I&AP/stakeholder groups regarding the continuation of mining operations.
5. To provide a synthesis of the environmental and socio-economic desirability of the continued operations and planned extension of the studied mining activities (based on the outcome of objectives 1-4).

1.5 Research framework

For this study, a social-ecological systems (SES) approach was used. This framework includes considering all impacts on the environment which include humans and nature and aims at finding a way both the environment and humans may find a sustainable approach in which both may work together for the best health or condition of the environment itself (Clements and Casani, 2016). SES is a transdisciplinary approach, which means that it involves mixing different approaches to solve issues on either temporal, spatial, or organisational scales (Van der Leeuw et al., 2011). Figure 1.8 illustrates the components of the socio-ecological systems approach.

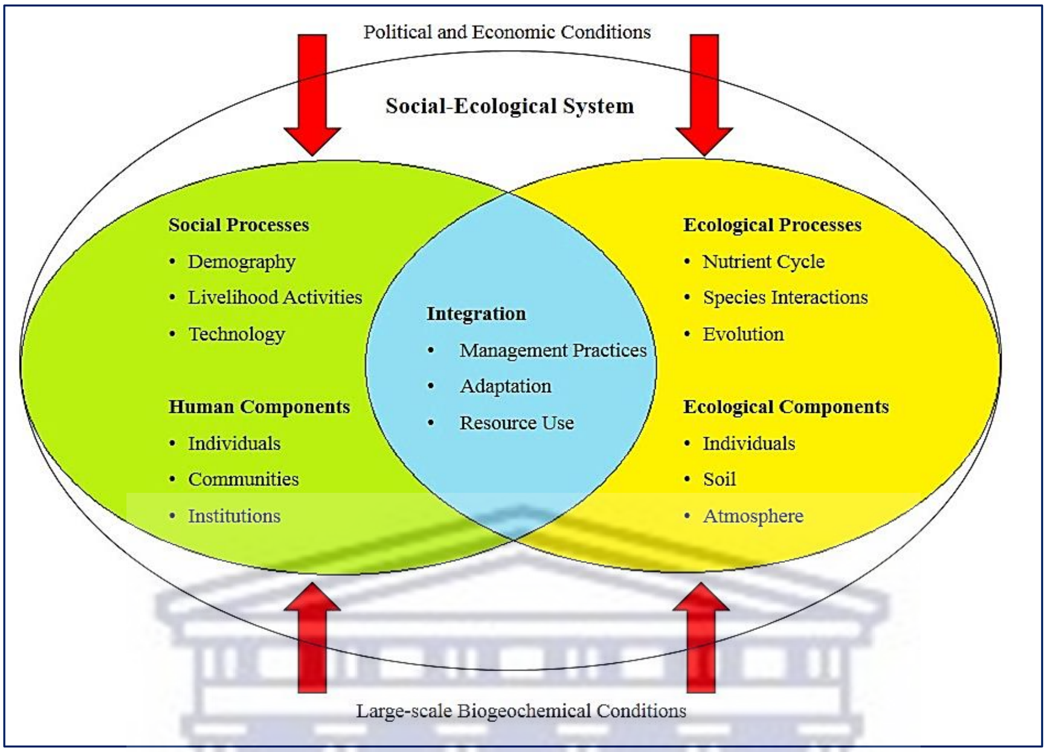

Figure 1.8: *Social-Ecological Systems approach. (**Source**: Adapted from Virapongse et al., 2016)*

For this study, the SES approach was used to address environmental management within environmentally contested areas (Virapongse et al., 2016). As seen in Figure 1.8, the elements which the SES approach incorporate includes the integration of "social processes, human components, ecological processes and ecological components". These components are considered to integrate suitable management practices, adaptation as well as appropriate resource uses, which factors in all conditions to find the most appropriate solutions. SES thus provides perspectives on more sustainable environmental management solutions, which encompass all the components, namely social processes, human components, ecological processes, and ecological components (Virapongse et al., 2016).

1.6 Chapter Summary

Research on sand mining in the Western Cape is deficient, and although there is some information on the negative impacts associated with this type of mining on coastlines and dunes, there is a lack of information on all polemics surrounding this topic, on site-specific research, and research speaking to the South African context. Most of the research on sand mining in the Western Cape focuses on illegal sand mining and its negative impacts, with a lack of interest in polemics surrounding legal sand mining companies in the Western Cape, and the proceedings unfolding at these locations (Friot and Gallagher, 2021).

Sand is a necessity in today's world as it is used in many products and specifically in the construction industry, without a viable substitute, making it a vital commodity, but one which is becoming a scarcity due to its non-renewability despite persistent exploitation (Gavriletea, 2017). The study sites are thus near coastal areas, as the mining occurs directly on the beach itself, or on the coastal sand dunes systems. The aim was to ascertain the polemics surrounding these sand mining companies, their impacts, and the sustainability of the overall practice, by means of the socio-ecological systems approach. The study sites have had pushback from interested and affected parties pertaining to their mining practices and the unsustainability of their activities. This study addresses the desirability of sand mining and whether it is viable for these mining companies to continue their operations based on the opinions of authorities, interested and affected parties, mining representatives from the study sites, as well as remote sensing and GIS applications. The next chapter focuses on literature review.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This literature review provides a context for sand mining operations as a backdrop for the various challenges with which it is associated. This includes mining legislation, mining commodities in the Western Cape, negative impacts of mining, and controversies regarding mining activities. This review provides an idea as to the current legislation in place, how legislation may lead to controversy and why sand mining in the Western Cape is an important topic to address.

2.2 Mining in South Africa

According to Hodge et al. (2022), the global mining community is not just mining companies, but there are other interests that drive the mining community. These include contract miners, trading companies, technical support companies, maintenance providers, financial and technical support services, the energy providers, the providers of the equipment, and much more. All these different sectors and corporations thus support and drive the global mining community and they are meant to be considered when assessing the mining sector and its impacts, as the system is complex, intertwined and interdependent on each other. Society focuses on the actions and performance of the core mining companies, but the focus should extend to the entire mining community. Hausmann et al. (2011) address the complexity of a country based on corporation, imports, exports, and so forth, and thus consider the entire complex ecosystem involved with mining (Hausmann et al., 2011; Hodge et al., 2022).

2.2.1 The Economic Complexity Rating

The country complex rating is a rating system that visualises global trade flows across markets. It tracks the dynamics of trade flow over time and looks for new growth opportunities for every country. The country complexity ratings are calculated using 15 parameters, which include knowledge on a product, diversity of product, and intra-region trade to name a few (Hausmann et al., 2013). The parameters thus make it a complex ranking system that attempts to consider all relevant parameters when ranking a country's complexity. This index thus monitors the progress of countries determining who is progressing and to what extent. The Atlas itself looks at the industrial competences and knowledge at the centre of a country's growth prospects, in which diversity and complexity of already existing capabilities influence the potential and occurrence of growth. The index looks at imports, exports, trade, drivers of growth within a country, opportunities for new industries and the obsoleteness of old industries, as well as the potential future gross domestic product (GDP) of a country. This Atlas is used globally by policymakers, investors, academics, entrepreneurs, and the general public as an important resource to understand a country's economic structure (Hausmann et al., 2013). The complexity of a country can directly relate to the exportation of materials, as the knowledge and considerations regarding a material are important to export and receiving support from other countries. This index rating can thus directly influence whether there is an increase in imports from South Africa, or a decrease (Chun and Larrick, 2021). The country complexity rating of South Africa is shown in Table 2.1.

Table 2. 1: South Africa's Country Complexity Rating 2000-2020. (Source: Atlas of Economic Complexity, 2020)

COUNTRY COMPLEXITY RATING OF SOUTH AFRICA (OUT OF 133 COUNTRIES)	
Year	**Rank**
2000	44
2003	40
2010	56
2015	55
2020	70

Table 2.1 indicates that in the year 2000, South Africa ranked 44 out of 133 countries for country complexity, but since then, it has dropped to the rank of 70 out of 133 globally by the year 2020. This means that in 20 years, South Africa's complexity rank decreased by 26. The year 2003 is included in the table to show the lowest rank (best rank) South Africa has achieved in the last 20 years, that of 40. The most complex country is Japan, which is in Asia, and the least complex is Angola, which is in Africa. For context, the USA and China, which are both in the top 10 largest sand exporting companies globally, rank 12th and 17th for this index respectively, indicating that the index does not solely consider the quantity of materials exported, but who the country exports to, how it is exported, and much more (Hausmann et al., 2013).

This ranking system thus indicates that South Africa has not made strides pertaining to new technologies or related to the other parameters from this index, but this also indicates that other countries have been increasing their industrial complexities and know-how. It is significant to note that the top 10 ranked countries for Economic Complexity are all developed countries, which would imply that developing countries fall lower on the ranking system, and the level of development within a country directly impacts the rating of a country. Shown in Table 2.1 is South Africa's Market Share for the period 1995-2020.

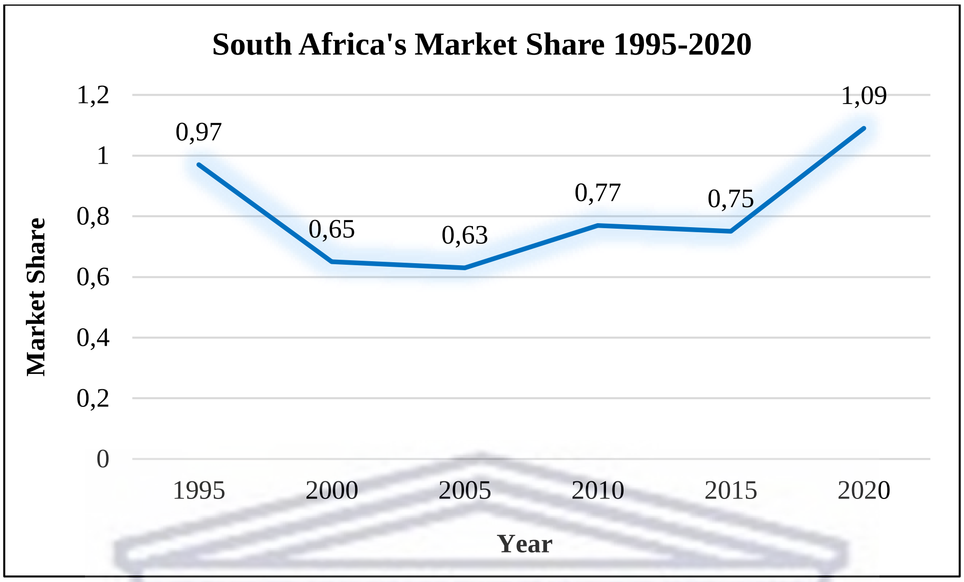

Figure 2. 1: *South Africa's global market share in mineral exports.* ***(Source****: Atlas of Economic Complexity, 2020)*

Figure 2.1 illustrates South Africa's contribution to the global market share of exports in mineral exports. As shown, in 1995, South Africa contributed its second largest amount of mineral exports to the global market, after which the market shares continuously dropped until 2005. Afterwards, South Africa's market share began to rise, and is currently the highest it has ever been, contributing 1.09% to the global mineral export market. "Minerals" does, of course, refer not only to sand, but also other commodities mined in South Africa, and this is not specific to the Western Cape either, as it includes all provinces within South Africa.

The economic complexity index is important in a developing country like South Africa, as exports are a large source of revenue for South Africa which can predict whether a country will experience rapid growth in future or not, thus providing a measure of economic development (Khayati, 2021).

2.3 Mining legislation in South Africa

2.3.1 Mining law

According to Emrich (2022), mining law is regulated predominantly by the Mineral and Petroleum Resources Development Act (MPRDA) of 2002, which must be considered in combination with the National Environmental Management Act of 1998 (NEMA). NEMA is the primary statute that regulates environmental-related aspects of mining. The government entities responsible for regulating the mining industry include the Minister of Mineral Resources and Energy, the Department of Mineral Resources and Energy (DMRE), but both national and regional offices must comply with the MPRDA. The DMRE is however responsible for enforcing said compliance to the MPRDA (International Comparative Legal Guides, 2000). Today, the DMRE is the competent authority in the Western Cape for sand mining, and the Department of Environmental Affairs and Development Planning (DEADP) is the commenting authority. This means that the DMRE is the organ of state that delegates power and has the hierarchical authority to either approve or decline a mining application/operation (Government Gazette, 2006).

According to Ameehi (2009), the South African government introduced legislation concerning responsible and sensible mining to protect the integrity of the environment, but implementation is lacking, and thus general non-compliance and degradation continue. For the situation to improve, all organs of state must cooperate and work together to ensure that the environment is protected from harm and degradation (Pretty and Odeku, 2017). Pretty and Odeku (2017) conclude that if mining companies do not adhere to the legislation, they are to be held accountable for their activities, thus legally implementing the salient provisions in the legislation to the mining companies. Although the MPRDA provides the overarching legislative framework for mining in South Africa, there are pieces of legislation that are implemented by other government departments such as the Department of Water and Sanitation, the Department of Mining, Minerals and Energy, and others, which causes confusion in relation to mining activities, as a combination of legislations from different departments must be adhered to for a mining permit/approval/ right. Furthermore, this can also cause controversy and corruption in the mining sector, as different mining corporations may have differing standards and paperwork needed for approval (Provincial Spatial Development Framework, 2005; International Comparative Legal Guides, 2020).

2.3.2 Relevant legislation regarding mining in South Africa

South Africa has excellent legislation which aims at achieving sustainable development, and to achieve this, it includes laws that facilitate public participation and impact assessments as part of constitutionally mandated environmental management. The legislation is geared towards protecting South Africa's rich biodiversity and part of this fabric is the Mineral and Petroleum Resources Development Act (Act No. 28 of 2002). The MPRDA (Act No. 28 of 2002) is the main piece of legislation which governs all stages of mining and production processes within South Africa.

Figure 2.2 shows the relevant legislation related to mining in South Africa, with the MPRDA being the overarching legislation which uses other pieces of legislation to "ensure the sustainable development of South Africa's mineral and petroleum resources within a framework of national environmental policy, norms and standards while promoting economic and social development" (DEA et al., 2013, p. 8).

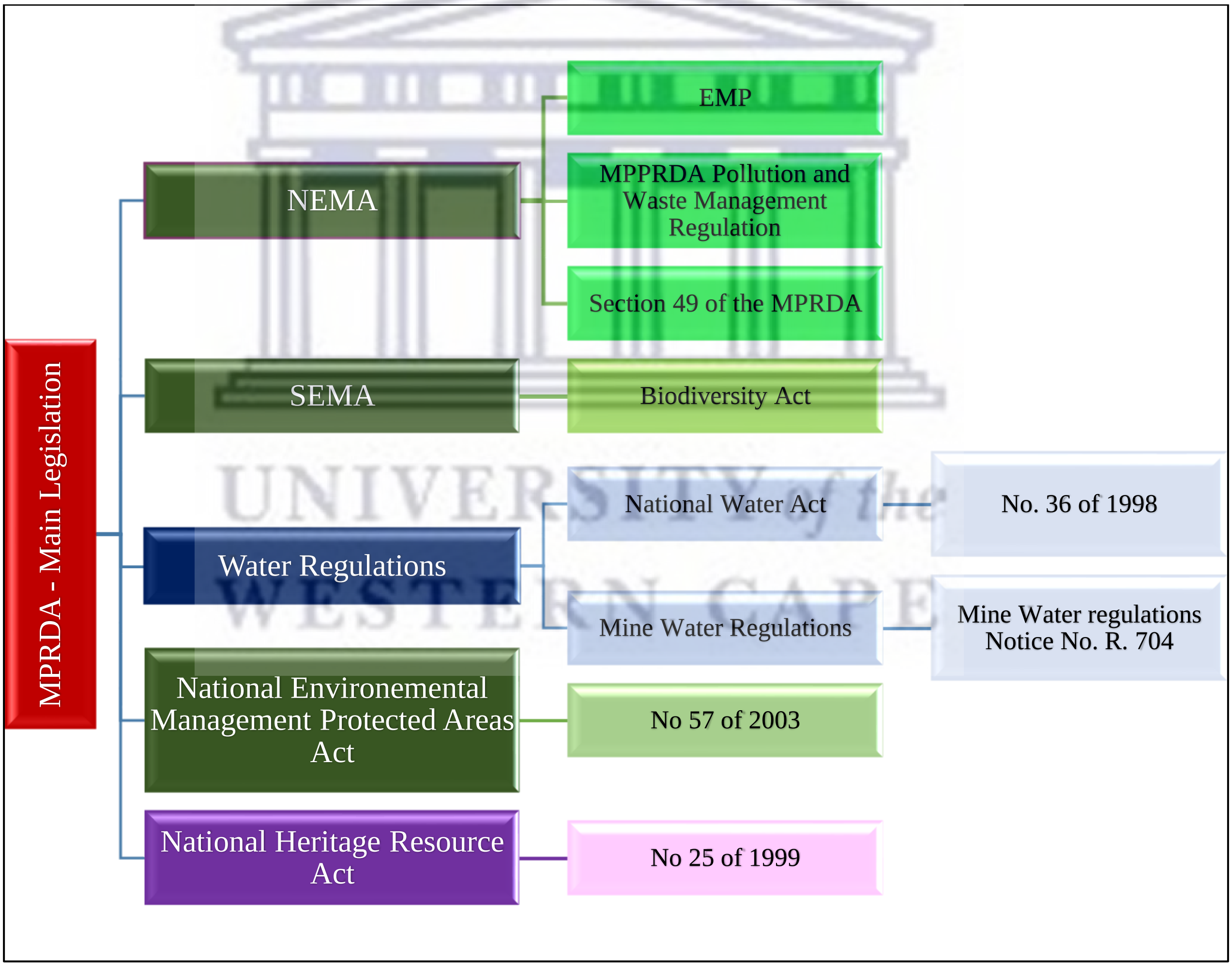

***Figure 2. 2**: Relevant mining legislation in South Africa. (**Source**: Adapted from DEA et al., 2013)*

2.3.2.1 The MPRDA

The MPRDA uses the principles of the National Environmental Management Act (NEMA) and applies them to all mining practices to ensure the sustainable use of resources. NEMA serves as a guideline for the interpretation, administration, and implementation of the environmental requirements as per the MPRDA. As a result of NEMA, a holder of a mining permission/right or permit must consider their impact on the environment, and they must rehabilitate the environment to its natural or predetermined state. In addition, the holder is responsible for any environmental damage, pollution or ecological degradation to all areas which are granted in the permit, whether it is on or offsite. The holder must ensure that the mining operations adhere to the framework of national environmental policies, norms, and standards. To ensure that the holder of the mining right/permit ensures sustainable use of resources, the MPRDA also includes some vital legal and regulatory mechanisms to be adhered to, which include the Environmental Management Plan (EMP), the MPRDA Pollution Control and Waste Management Regulations as well as Section 49 of the MPRDA. The Pollution Control and Waste Management Regulations ensure that water management, soil erosion and pollution control strategies comply with specific and applicable legislative requirements. Furthermore, Section 49 of the MPRDA ensures that the Minister of Mineral Resources has the ability to restrict access to any permissions, rights or permits that are in specific areas, such as critical biodiversity areas (CBAs), heritage sites, and hydrologically important areas.

2.3.2.1 Laws other than the MPRDA aimed at protecting the environment

In addition to the MPRDA, there are other laws which regulate the impacts of mining companies on the environment. The Constitution of the Republic of South Africa enshrines the right 'to an environment that is not harmful to their health or well-being' (Constitution of South Africa, 1996, Chapter 2, Section 24a). To ensure this is adhered to, NEMA has environmental management principles and other Specific Environmental Management Acts (SEMAs) that are meant to guide decision-making throughout the mining life cycle. Loss of biodiversity, pollution, degradation of the environment, disturbance of ecosystems and other impacts that would negatively impact sites which constitute to the nation's cultural heritage are meant to be avoided, minimised, rehabilitated or as a last resort, offset. This notion is supported by two pieces of legislation. These are the Biodiversity Act, which relates to the loss of biodiversity, and the Environmental Impact Assessment Regulations (GN No. R. 543), which was published in terms of NEMA to guide the identification assessment and evaluation of impacts, as well as the determination of appropriate mitigation measure requirements for various listed activities.

The National Water Act (Act No. 36 of 1998) guides water-use authorisation, which is required by most mining operations. In addition to this, there are mine-water regulations as stated in the Government Notice No. R. 704, which aims to protect water resources. NEMA (Act No. 57 of 2003) also prohibits mining and prospecting in protected areas.

In addition, other legislation such as the National Heritage Resources Act (Act No. 25 of 1999) and various land use planning ordinances and zoning schemes may apply. It is a legal requirement that planning and zoning schemes commence only once all of the other required authorisations have been approved, including the water use license and any environmental authorisations for associated activities.

2.3.3 Legislature issues

Sand mining in South Africa is further influenced by the fact that the sector is also subjected to a complex regulatory system which involves three different themes, namely mineral regulation, environmental regulation, and land-use planning regulation. Mineral regulation falls under the national government, with one authority, the Department of Mineral Resources, mostly operating under the MPRDA, claiming jurisdiction over sand mining. Environmental regulation falls under both national and provincial government. Within the national regulators is the Department of Environmental Affairs (DEA), now known as the Department of Environmental Affairs and Development Planning (DEADP), and the Department of Water Affairs, the Department of Mineral Resources, which implement the National Environmental Management Act, the National Water Act and the Mineral and Petroleum Resources Development Act, respectively. There is however, a fourth regulatory authority which is from the provincial sphere of government, and which is responsible for environmental affairs in each province, making it nine provincial departments that form part of the regulatory bodies for sand mining, and that also enact NEMA.

However, the regulatory system is skewed in favour of mineral regulation, noting that the other two themes are ignored by sand miners (Green, 2012), as the Department of Mineral Resources is the competent authority within the Western Cape (Government Gazette, 2006). This has caused conflict between the regulatory parties as there is an overlap between mandates between the regulators and fundamental differences in the interpretation of the Constitution. It is further stated by Gondo et al. (2019) that the problem relating to sand mines being located in undesired areas is poor management policies regarding sand extraction, and that the link between environmental concerns and sand mining remains a controversial matter in South Africa. The conflicts between the environmental, mineral and land use planning regulations have, however, been resolved in recent years, and Green (2012) states that this should be seen as a victory for sustainable development, as the combination of different assessment processes which come from the mineral regulatory body, and those from the land use planning regime will lead to more orderly exploitation of the mineral resources, while also protecting local needs. The only missing aspect now is the environmental regulation, since where sand mining is concerned, the regulatory governing system can never be truly effective unless there is collaboration between the mineral and environmental regulation.

2.3.4 Environmental Impact Assessments (EIAs) in South Africa

According to Sandham et al. (2008), the Environmental Impact Assessment was first introduced in the United States of America in 1969 and many countries readily adopted it, but South Africa only adopted it in 1997 when it was made mandatory by the Environmental Conservation Act (ECA) of 1989, which included a list of activities which mandated an EIA, and was published in the Government Gazette (du Pisani and Sandham, 2006). However, mining was not on this list (Sandham et al., 2008). In 1998, the National Environmental Management Act (NEMA) became more prominent and shared regulations although the ECA was still the main regulatory force (Sandham et al., 2008) and it commenced in January if 1999 (Pasani and Sandham, 2006). However, in 2006, NEMA regulations came fully into effect as the prominent legislation regarding EIAs (Sandham et al., 2008) and in 2006. The second phase of mandatory EIAs commenced which included more detailed EIA regulations (Hildebrandt and Sandham, 2014). According to the study by Sandham et al. (2008), Environmental Impact Reports (EIRs) are of satisfactory quality, and in the mining sector, they conform to the overall standard of quality in the other sector in South Africa, and even conform to international standards. They do however state that the Environmental Impact Report (EIR) is only one aspect of the EIA and cannot alone be used to determine the overall effectiveness of environmental impacts. Rehabilitation is an important factor in an Environmental Impact Assessment as it ensures that after a mining company closes, the environment is sought after and attempts to restore any significant vegetation (indigenous/endemic or critically endangered) lost are made (Sandham et al., 2008).

2.4 Smart policies and alternatives to sand mining

2.4.1 The advanced trade model

Hùbler and Pothen (2021) consider the idea of an advanced trade model, which aims at balancing an importing country's economic growth and the exporting country's economic development in a sustainable manner. This trade model is aimed at registered sand mining companies which are in the database, as it is difficult to track unofficial and illegal sand trading. This method works by means of two steps. First, developing countries would implement a uniform output tax on all sand extraction activities. For this to work, all government sectors need to cooperate with each, and this aims at reducing sand extraction. Secondly, developing countries may introduce export tariffs on sand. This specifically targets export tax and thus is less efficient in reducing sand extraction. The main advantage of import tax is that different countries, whether developed or developing, do not need to coordinate with one another to mitigate sand consumption, but the disadvantage is that there will be small losses in welfare for developing countries owing to the tax revenues accruing to the developed countries. The second positive is that by making the sand more expensive, policies will optimistically change to address the increase in price by finding alternative methods to reduce the import of sand, such as the possibility for concrete recycling, or the replacement of natural sand with modified sand, etc. This will not solve the issue of sand exploitation, but Hùbler and Pothen (2021) address the idea that small policy changes can, to some extent, remedy 'green growth' with sand imports if such policies are implemented and controlled rigorously.

2.4.2 Ore-sand as an alternative to sand

According to UNEP (2022a), an alternative to sand exists, and it is known as ore-sand. Ore-sand is not only an alternative to sand mining, but it can also create a circular economy, by banning the landfilling of mineral waste, while encouraging the re-use of sand in building industries. Ore-sand is mineral waste from ore mining, and waste from ore mines currently represents the largest waste stream on earth (Golev et al., 2022). Golev et al. (2022) state that the ore-sand could be used as a viable substitute for sand used in construction and as an industrial sand. With the implementation of ore-sand, there would be a reduction in the volume in mine waste, as well as carbon emission reduction associated with sand production processes. UNEP (2022a) states that sand is the most extracted solid material globally, and sustainable development needs to be achieved, making ore-sand a step to sustainable development.

2.5 Mining commodities of the Western Cape

According to the Provincial Spatial Development Framework (2005), in 2004, 458 mining licenses were active, of which 369 were issued for construction commodities such as building sand, stone aggregate, gravel and brick clay. These commodities are proven to still have been the most mined commodities in the Western Cape (Cole et al., 2014). According to Cole et al. (2014), there are twenty-six mineral commodities which have economic or potentially economic viability for exploitation, which comprises of stone aggregate, brick clay and building sand being of the most sought after in the Western Cape. The data that Cole et al. (2014) used were largely based on a map created by the South African Mineral Deposits Database (SAMINDABA) in 2012, which consisted of data points showing all the closed, abandoned, and operating mines within South Africa. The DMRE (2021) list of active mines in the Western Cape displays mines that are predominantly building sand mines followed by aggregate mines and then clay brickmaking mines. It can thus be deduced from the data from all sources that sand is being exploited within the Western Cape, and that continuous extraction for years has made sand mining a significant issue within the Western Cape, as the sand mining operations continue to grow and expand while the overall sand desirable for sand mining continues to decline since it is a non-renewable resource (UNEP, 2014). Although the data from the Provincial Spatial Development Framework (2005) and Cole et al. (2014) are older than the 2021 data from DMRE, it still mostly corroborates the current data by the DMRE (2021), exemplifying the possible exploitation of sand mining within the Western Cape today. The commodities mined in the Western Cape are shown in Figure 2.3.

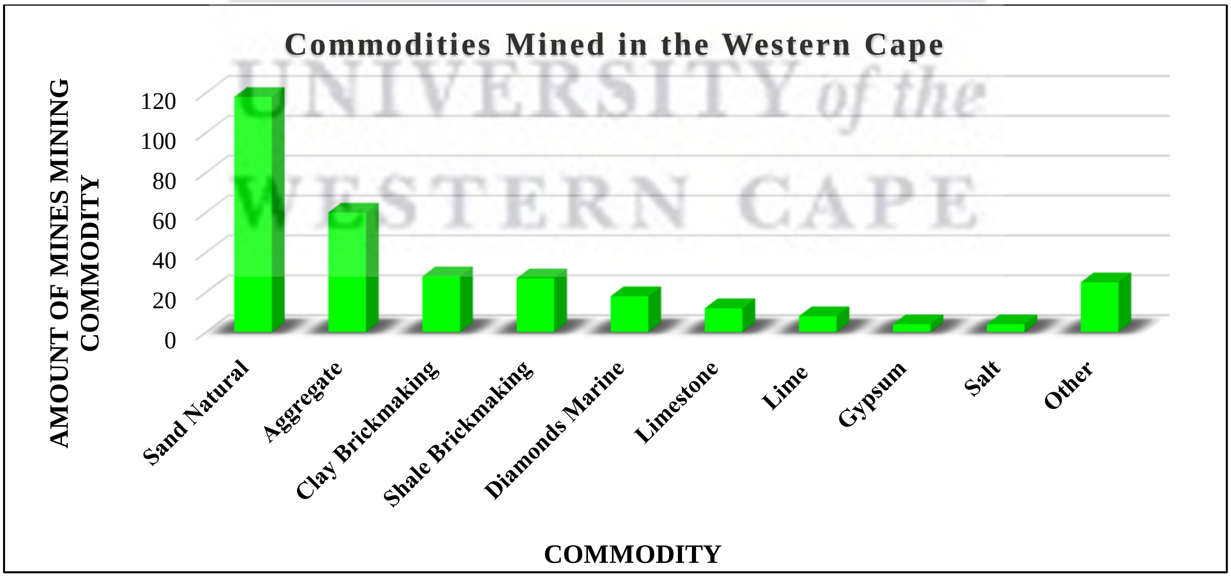

Figure 2. 3*: Commodities mined in the Western Cape. (**Source**: Adapted from DMRE, 2021)*

Figure 2.3 shows that the most mined commodities in the Western Cape from most to least mined are Sand Natural, Aggregate, Clay Brickmaking, Shale Brickmaking, Diamonds Marine, Limestone, Lime, Gypsum, and Salt followed by "Other", which are commodities mined by only one or two mines within the province. These include shale for cement, titanium concentrate, silica, bentonite, etc. (DMRE, 2021).

Table 2.2 shows a comparison between what is stated by Cole et al. (2014) and the DMRE (2021) regarding the most mined commodities in the Western Cape.

Table 2. 2: Most commodities mined in the Western Cape. (Source: Cole et al. (2014); DMRE, 2021)

MOST MINED COMMODITIES IN THE WESTERN CAPE	
Commodity according to Cole et al. (2014)	**Commodity according to DMRE (2021)**
Stone aggregate	Sand Natural
Brick clay	Aggregate
Building sand	Clay Brickmaking
Limestone	Shale Brickmaking
Diamonds	Diamonds Marine
Dolomite (Type of limestone)	Limestone
Heavy minerals	Lime
Rare earth elements	Gypsum
Silica sand	Salt
Plastic clay	Shale for Cement [2 mines]
Gypsum	Natural Gas [2 mines]
Bentonite	Phosphate Concentrate [2 mines]
Phosphate	Zircon Concentrate [2 mines]
Dimension stone	Titanium Concentrate [2 mines]
Other	Silica [2 mines]
	Other

As shown in Table 2.2, the list by Cole et al. (2014) does not include "lime", "salt" or "shale brickmaking". Cole et al. (2014) also combines commodities into categories such as "Rare earth elements" and "heavy minerals", and they do not state which commodities would fall into these categories in their paper. It is also interesting that in Cole et al. (2014) paper, they list "building sand" as the third most important commodity in the Western Cape, while DMRE (2021) lists it as the most mined commodity within the province. This is also corroborated by the data on the DMRE (2021) website showing that most mines in the Western Cape are sand mines, and more so, most of the other mining companies mine sand in addition to their other minerals.

2.6 Impacts of sand mining

2.6.1 Positive Impacts

According to Gavriletea (2017), there are three categories in which the positive environmental impacts of sand mining can be categorised, namely land, air, and water. For land, sand mining practices can increase slope stability and decrease the possibility of land erosion. The next positive relates to water, and it is that new water reservoirs and supply systems are created, supporting new aquatic and terrestrial wildlife. Sand mining is also linked to dust control and thus less air pollution. The sand mining industry also contributes to job creation, investment in the industry, and exportation of the product, all which promote economic growth. The largest producers of sand are, however, China, the United States, and Netherlands (Filho et al., 2021). The positive impacts generally correspond to economic growth and job creation, as sand mining can uplift the communities in which they are located by providing jobs to the residents, community engagement, and support.

2.6.2 Negative impacts

There may be long-term or hidden negative impacts that continue to affect biodiversity and ecosystem services after sand mine closures. There are direct, indirect, induced, or accumulative impacts on biodiversity due to mining activities and activities related to mining. Direct impacts would be that of extraction of water, contamination of water, blasting, sedimentation, and changes in the water table levels (Koehnken and Rintoul, 2018; Seki, 2022). Indirect impacts are those which result from mining practices, like reduced downstream flow of rivers, etc. Induced impacts are those which are not directly attributable to the mining project but occur due to the presence of mines or mining activities. For instance, settlements occurring near the mining site can increase pressure on biodiversity in the area or lead to biodiversity loss (Koehnken and Rintoul, 2018; Worlanyo and Jiangfeng, 2021). Cumulative impacts are impacts which are occurring now added to impacts of the past within the same or nearby area, resulting in a combined impact on biodiversity and natural resources in the area. An example of cumulative impacts would be multiple mines within the same area, which would then all impact on the water table, and affect the same endemic local species within a region (DEAT, 2004).

Long-term impacts may permanently alter water tables and destroy endemic biodiversity to a degree where it cannot be restored owing to the degradation of the environment (DEA, 2010). General direct harmful impacts of sand mining include loss of habitats through the removal of floodplain and gravel beds, and physical changes to river systems. Indirect harmful impacts include changes to habitats due to sediment grain size changes, water quality changes which affect chemical and physical conditions, and hydraulic changes which affect the movement of fish and habitat availability (Koehnken and Rintoul, 2018).

According to Zapico et al. (2016), opencast mining impacts all ecosystem components such as the sub-strata, topography, hydrology, soil, vegetation, fauna, atmosphere, and landscape, and at the mine site, there are also on-site effects. One of the worst side effects are sediment discharge from mines which end up in fluvial systems, as it can affect fish populations and their ecosystems by causing a reduction in visibility and oxygen availability; it also causes temperatures to rise, breathing difficulties and it damages the spawning beds (Kjelland et al., 2015). The increase in sediment can also cause damages to infrastructure like roads and bridges, or even reduce the water capacity of reservoirs, further damaging fluvial networks (Batalla and Vericat, 2011). However, there is not much information of the discharge of sediment within the Western Cape province, and more studies are thus needed (Oyarzun et al., 2011). According to Gavriletea (2017), the negative impacts of sand mining have an array of consequences categorised into the main impacts affecting air, water, flora and fauna, soil, and land. These consequences include increased soil and coastal erosion, water pollution, increased levels of air pollutants, vegetation destruction, landscape disturbances, mine-induced seismicity, etc. Sand mining activities harm vulnerable habitats and protected areas, such as mangroves, seagrass beds, and coral reefs. By correlation, species biodiversity within these habits is affected (Global Witness, 2010; UNEP, 2014). Although there is large concern with the impact that sand mining has on protected areas and critically biodiverse areas, there is also an impact on areas outside of these protected areas. This impact relates to the marine currents and water flow changing, as ocean currents movements move fauna and flora, but also redistribute heat (Gavriletea, 2017; Hays, 2017) affecting organisms and habitats, mortality rates, growth and development rates and the movement of species (Gillanders and Kingsford, 2002), the benthic fauna could be destroyed, fish and crab populations declining in rivers and the sea, impacting the livelihoods of fishermen (Gavriletea, 2017).

In addition, the pressure on endangered species increases, impacting biodiversity negatively, and bridges, river embankments and coastal infrastructure can be damaged. Furthermore, flood regulation and protection are impeded, and the agricultural use of floodplains can be restrained (Hùbler and Pothen, 2021). The water table can be lowered, water supply impeded, and recreational functions can be reduced. A study by Mossa and James (2013) found that sand and gravel mining from the coast and coastal watersheds combined is the largest anthropogenic cause of habitat loss to the littoral zone on the US west coast, followed by dams. Owing to this, it is illegal to remove sand from the littoral active zone in many countries. A media report by Young and Griffith (2009) compiled data from different sources and found that in 35 countries across six continents, sand mining in many regions has led to complete destruction of beaches and related ecosystems, adversely affecting coastal protection and tourism. Beach and dune mining also adversely affect coastal habitats, alters sediment budgets, and hastens erosion (Masalu, 2002). Hùbler and Pothen (2021) make the prediction that if political neglect regarding the global sand mining challenge is not addressed, it could harshly hinder urban economic growth where housing and infrastructure are concerned, which is crucial for developing and emerging countries, but also for industrialised countries.

There are more negative environmental impacts associated with sand mining practices than positive impacts. This can be related to the indigenous fauna and flora found within South Africa and the devastating impact its loss would have for the country as South Africa is signified by its species' biological diversity (Raimondo, 2011).

2.7 Biodiversity of South Africa

South Africa is famous for its biodiversity and is recognised as one of the 17 megadiverse nations on Earth, and combined, the 17 megadiverse nations contain two thirds of the world's plant diversity. Furthermore, South Africa is within the top 10 nations for species richness globally. The species richness is attributed to the climate, topography, and geology within South Africa, which has resulted in high levels of endemism across the different ecosystems, meaning that many species within South Africa can be found nowhere else on Earth (Poulsen, 2020). There are 37 biodiversity hotspots worldwide, of which 8 are found within Africa. One of the world's 'hottest biodiversity hotspots' is the Cape Floristic Region, which is predominantly found in the Western Cape province (Myers, 1990). The Cape Floristic Region (CFR) is one of the six floral Kingdoms globally, and is the smallest, yet most diverse of all, with 68% of the species within this hotspot being endemic (UNESCO, 2019). The second important biodiversity hotspot within the Western Cape is the Succulent Karoo Biodiversity Hotspot, and this can be found along the West Coast of South Africa. The Succulent Karoo is important as it homes the world's highest diversity of succulent plant species, of which 40% are endemic (Manning and Goldblatt, 2012).

The reason the Cape Floristic Region is so important and of incredible value to the country is due to its biodiversity (Edwards and Abivardi, 1998). The most dominant species within the Cape Floristic Region is the Fynbos Biome (Turpie, 2003). The West Coast is home to thousands of endemic species and for this reason, UNESCO (2004) deemed the Cape Floristic Region a Protected Heritage Site and proclaimed the West Coast the Cape West Biosphere Reserve, stretching from the Diep River mouth in the South to the Berg River in the North (UNESCO, 2019). This is because the Cape Floristic Region has barely been explored and yet, and in the tiny fraction of land in the Western Cape investigated, it is host to almost 20% of all floras on the continent, showing the wealth of this unique region (UNESCO, 2004).

The Western Cape is comprised of five biomes, namely Fynbos, Succulent Karoo, Nama Karoo, Albany Thicket, and Afrotemperate Forest (Mucina et al., 2006), with Figure 2.4 showing the percentage of the total extent of each biome as contained within the Western Cape.

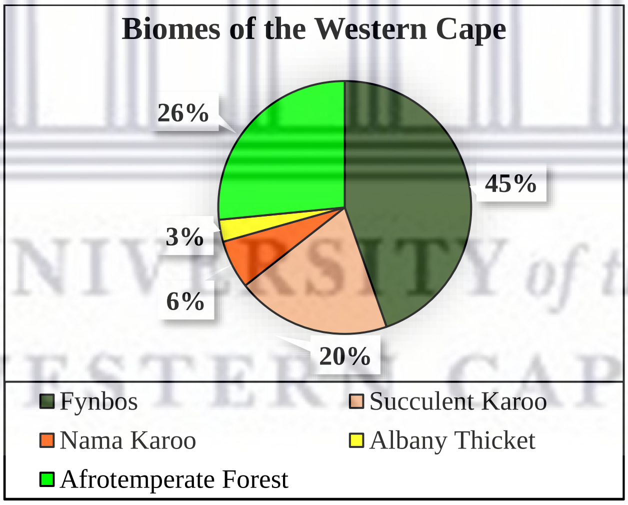

Figure 2. 4: *Biomes of the Western Cape. (**Source:** Adapted from Pool-Stanvliet et al, 2017)*

As seen in Figure 2.4, the Fynbos biome covers the most area, consisting of 45% of the total biomes within the Western Cape, followed by the Afrotemperate Forest Biomes. The Succulent Karoo is the 3rd largest biome in the Western Cape. This is important as the sand mines focused on in this study fall within the Fynbos and Succulent Karoo biomes. Therefore, only the Fynbos and Succulent Karoo Biomes, which cover the current study's locations – Macassar in Cape Town and Lutzville along the West Coast, is discussed.

2.7.1 Fynbos Biome

The Fynbos Biome comprises three vegetation types, namely Fynbos, Renosterveld, and Strandveld (Mucina et al., 2006). The Fynbos biome is characterised by fine-leaved, sclerophyllous shrubs, which is a characteristic shared with other Mediterranean-type ecosystems. Fynbos is fire dependent, and the species which inhabit Fynbos are adapted to periodic fires (Pool-Stanvliet et al., 2017). The Fynbos biome contains high levels of diversity and endemism, specifically at taxonomic levels and there are four plant families which are endemic to the Fynbos biome, namely Geissolomataceae, Grubbiaceae, Roridulaceae, and Penaeaceae (Manning, 2007). Fynbos requires nutrient-poor soils and is categorised by the prevalence of three plant families, namely Proteaceae, Ericaceae, and Restionaceae. The Renosterveld and Strandveld are characterised by a lack of these plant families (Pool-Stanvliet et al., 2017). This is important, as the MaccSand Mining and Quarrying Mine falls within the Fynbos Biome, speaking to the fact that there are many endemic species that would occur within the area.

2.7.2 Renosterveld

Renosterveld occurs in nutrient-rich and less leached shale and granite-derived soils. It grows on the lower areas of the coastal plain, and grass and bulbous geophytes are prominent species within the renosterveld vegetation unit (Pool-Stanvliet et al., 2017). Renosterveld grows between mesic fynbos and arid Karoo or Thicket elements (Walton, 2006). It is an old vegetation which has grown within the province for many years, and it forms the base of the agricultural economy of the Western Cape, such as grain, vineyards, and fruits. The highest levels of transformation are found within renosterveld, specifically the coastal plain renosterveld vegetation units. Renosterveld has special habitats which occur within lowland sandplains, and seasonal wetlands develop at these locations because of the permeability of the soil substrate and the fluctuation within the water table. The seasonal wetlands are home to many endemic species, but they are under high threat, specifically in Capiucne Town and surrounding areas (Pool-Stanvliet et al., 2017).

2.7.3 Strandveld

Strandveld is found along the coastline, occurring mostly on marine derived calcareous sands. This vegetation type falls into the Fynbos biome and has prominent thicket and succulent karoo component. Strandveld contains less microphyllous shrubs, and therefore does not burn frequently, if at all (Pool-Stanvliet et al., 2017). Soils which support Strandveld are not suitable for agricultural purposes or cultivation, and this is due to its location, but this does not mean that there is no transformation occurring. The transformation occurs because of urban expansion in areas such as the Cape Metropolitan area, Saldanha, and the Garden Route towns (Bergh et al., 2014).

Strandveld is a seasonal vegetation with its growth peak occurring mostly from Autumn to Spring, and flowering and fruiting occurring in Spring to early Summer. Leaves begin to fall from Summer to Autumn and most Strandveld species have the same phenophases. The species is dependent on moisture availability, and this is what controls the growth (Liengme, 1987).

Figure 2. 5*: Cape Flats Dune Strandveld growing on the sand dunes of False Bay, Cape Town. (**Source**: Abu Shawka, 2010)*

Figure 2. 6: *Strandveld Vegetation in Papendorp at the Olifantsrivier. (**Source**: Author)*

Figures 2.5 and 2.6 show the two types of Strandveld which occur in the study sites, which are the Cape Flats Dune Strandveld in Macassar and the Namaqualand Strandveld along the West Coast. The Strandveld is the bush-like species seen in the images and is typically characterised by dark green leaves (Gibson, 2021).

2.7.4 Succulent Karoo Biome

The Succulent Karoo Biome is located in arid areas of the winter rainfall region, and thus occupies northern sections of the West Coast region and the Little Karoo, between Swartberg and Outeniqua/Langeberg Mountains (Pool-Stanvliet et al., 2017). This vegetation type is characterised by succulent species from families such as Aizoaceae, Crassulaceae, Euphorbiaceae and other leaf succulents from other families. The remainder of the vegetation is filled by small microphyllous shrubs with annual geophytes which appear in spring. The succulent Karoo is a biodiversity hotspot which reaches beyond the Western Cape and is considered the most diverse region in the world. The Succulent Karoo Biome occurs North of the Fynbos Biome along the West Coast. The Succulent Karoo is typically too dry for cultivation, but overgrazing and intensive ostrich farming impact the vegetation. Mining also presents a significant threat to this biome, specifically mineral mining companies (Pool-Stanvliet et al., 2017). This is important for my study, as the Tormin Mineral Sands Mine falls within the Succulent Karoo Biome, which is filled with Strandveld, a typically bush-like shrub (Eccles, 2000).

2.7.5 Biodiversity Importance

Biodiversity is important for an array of reasons, ranging from job creation to ecosystem services (Skowno et al., 2019). Job creation within the biodiversity sector is comparative to that of the mining sector, and for every one job dedicated to protecting biodiversity, there are five jobs that are directly dependent on using that biodiversity (Skowno et al., 2019).

According to Skowno et al. (2019), biodiversity is important because different ecosystem types perform different functions which are important for the functioning of ecosystems, and to both fauna and flora. Indigenous forests act as carbon sinks and are harvest areas for wild foods as well as fibre. Inland wetlands absorb flood waters, thus reducing the impact of floods, and they clean pollutants from freshwater, and thus purify water. Lakes and reservoirs provide habitats for endemic species and are also important for cultural and spiritual purposes within South Africa. Estuaries form nursery grounds for commercial fish stock and they are important holiday destinations in South Africa. Mangroves provide protection against storms, and they are also a key nursery habitat for fish species; they store carbon, and they also stabilise sediment with their roots. Dunes protect settlements near them from coastal storms, sea-level rise, and tsunamis, and they are thus a natural defence against these natural disasters (Everard et al., 2010; Srinivasan and Moorthy, 2015). Beaches act as a water filtration system, keeping the surf area clean. Rocky shores provide food and fishing bait such as mussels and oysters (SAIAB, 2004), and are important for protection from wave surges. Kelp forests provide food and fertilizer, as well as sheltering the shore from wave action. Reefs provide shelter and spawning grounds for marine species, and they are highly attractive sites for diving. Seamounts and pinnaces are oases in the open ocean which are nutrient-rich and support an array of marine life. Islands have productive water surrounding it, supporting abundant biodiversity and important fisheries. These small, but extremely valuable ecosystems need to be prioritised through planning, management, protection, and restoration efforts, as they provide a high return on investment, for not only biodiversity conservation, but also for the benefit of society. These ecosystems can also help fight climate change in the case of extreme weather events, aiding the country's resilience to climate change (Skowno et al., 2019).

2.7.6 Biodiversity concerns

The Western Cape holds 3-4% are of the global totals of higher plant species (Pool-Stanvliet et al., 2017) and is under the highest threat with twice as many threatened species as other provinces within Africa. The West Coast corridor alone holds over 1200 plant species, of which 194 are threatened by extinction (UNESCO, 2019). Furthermore, the Western Cape is one of the hot spots for plant extinction on the planet, having an average of 3 species going extinct annually. This is 500 times higher than the background extinction rate, which is the rate at which species would go extinct naturally (Wild, 2019). Habitat loss is the biggest cause of biodiversity loss, not only in South Africa, but in much of the world (Driver et al., 2004). This is devastation as 70% of species within the entire region are endemic (Pool-Stanvliet et al., 2017). There are four categories of ecosystem threats, and these are the Critically endangered, Endangered, Vulnerable, and Least Threatened (IUCN, 2001), as shown in Table 2.3 from the worst threat level to the least threatening.

Table 2. 3: Categories of ecosystem threat level from worst to best-case scenario. (Source: Adapted from IUCN, 2001)

CATEGORIES OF ECOSYSTEM THREAT LEVELS	
Category	**Definition**
Critically Endangered	Ecosystem types with very little of their original extent left in natural or near-natural condition, and are thus at a high risk for extinction
Endangered	Ecosystems close to becoming critically endangered
Vulnerable	Ecosystem types that have most of the natural extent left or in near-natural condition
Least Threatened	Ecosystem types that have experienced little or no loss of its natural habitats or deterioration; they are widespread and abundant

According to the IUCN (2001), the status of least threatened species decreased overall, and the species which are vulnerable, endangered, and critically endangered increased from 2011 to 2016. Therefore, the level of ecosystem protection has generally increased from 2011 to 2016 as well, with an overall ecosystem protection increase of 1.3% (IUCN, 2001).

The most threatened and least protected ecosystems in South Africa are wetlands and estuaries, resulting in freshwater fish being the most threatened species within South Africa (Skowno et al., 2019). According to Skowno et al. (2019), Cape Flats Dune Strandveld falls into the category of irreversible loss of natural habitat and threatened plant species associations and it is an endangered species. The Matzikama municipal area falls into the "Least threatened to Vulnerable" category for species concern, and the Cape Town municipal area falls into the "Endangered to Critically endangered" category (Jacobs et al., 2017). The issue with this is that according to Le Roux et al. (2012), the total hectares of these two biomes are over 8 million, yet only 3.8% of the Succulent Karoo is under protection compared to the 27.7% under protection in the Western Cape. From 2007 to 2012, the Fynbos protected areas increased by 1.8% and the Succulent Karoo biome protection increased by 1.3%. Table 2.4 shows the biomes in the Western Cape with its extent at the time.

Table 2. 4: Biomes in the Western Cape with total extent and protected extent. (Source: Adapted from Le Roux et al., 2012)

BIOMES IN THE WESTERN CAPE					
Biome	**Total hectares in South Africa**	**Percent of Biome in the Western Cape (%)**	**Percentage Protected in Western Cape (%)**		
			2007	**2012**	**2020**
Fynbos Biome	8 525 176	79	25.9	27.7	22.7
Succulent Karoo Biome	8 700 652	35	2.5	3.8	7.8

In the Western Cape, approximately 14.1% is deemed protected (CapeNature, 2021) and 4.1% of protected areas are in the mainland. CapeNature (2020) further states that in 2020, 22.7% of the Fynbos Biome is protected and 7.8% of the Succulent Karoo Biome is protected, adding that in 2000, the Succulent Karoo had 3.4% protected, differing from Le Roux et al. (2012) who state that in 2007, 2.7% was protected, which is less than previous years. This suggests a decline in protected areas from the years 2000 to 2007. For the Fynbos biome, StatsSA (2021) states that in 2000, Fynbos occupied 22.4% of land, which is plausible as in 2007, Fynbos' protected areas increased to 25.9%.

The study locations chosen, both fall within Critical Biodiversity Areas as shown in Figures 2.7 and 2.9. Figure 2.8 shows the protected areas near the MaccSand Mining and Quarrying Mine.

***Figure 2. 7:** Critical Biodiversity Areas near MaccSand Mining and Quarrying Mine. (**Source**: CapeFarmMapper, 2022)*

***Figure 2. 8**: Protected areas near the MaccSand Mining and Quarrying Mine. (**Source**: CapeFarmMapper, 2022)*

Figure 2.7 illustrates that a large portion of the area surrounding MaccSand Mining and Quarrying is a critical biodiversity area. Figure 2.8 illustrates the protected areas near the MaccSand Mining and Quarrying Mine, which illustrates that the protected areas near the study site are not critical biodiversity areas, and none of the critical biodiversity areas are being protected. This is similarly seen in Figure 2.9, as the entire West Coast area near the Tormin Mineral Sands Mine is a critical biodiversity area, yet there are no protected areas.

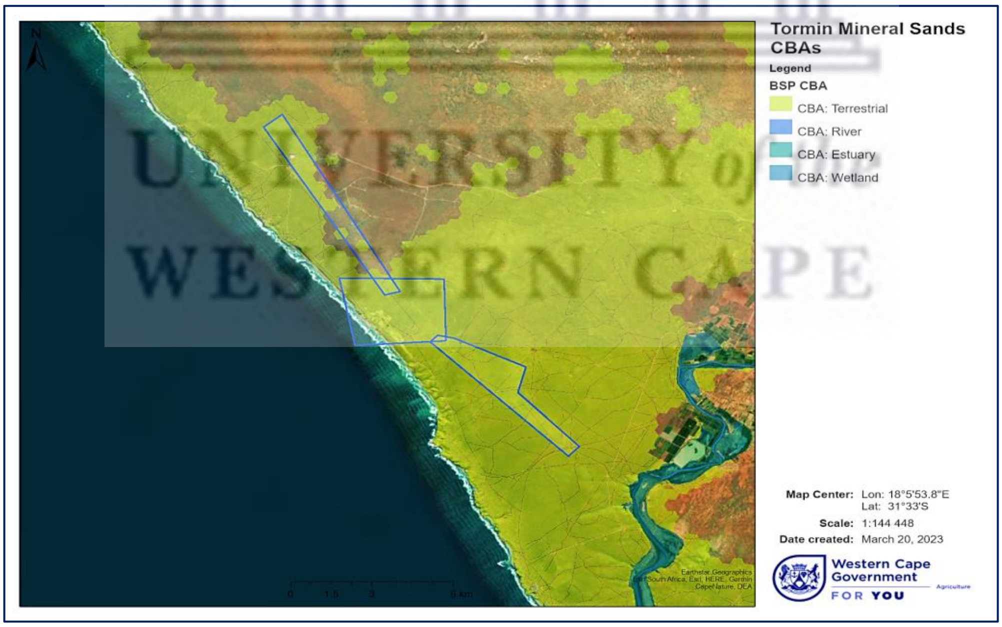

***Figure 2. 9:** Critical Biodiversity Areas near Tormin Mineral Sands Mine. (**Source**: CapeFarmMapper, 2022)*

Figure 2.9 shows that the Tormin Mineral Sands mine and the entire West Coast area seen in the map is a Critical Biodiversity Area. This is astonishing because along the West Coast alone, there are over 20 mining threats (Protect the West Coast, n.d.), and almost the entire West Coast has been overtaken by mining companies associated with diamond mining, oil and gas exploration, and valuable heavy mineral deposits (Masterson, 2021).

The extent of vegetation loss in such critically biodiverse areas thus needs to be assessed and a suitable tool for this assessment is Geographic Information Systems (GIS), using satellite imagery. GIS is discussed further below.

2.8 Geographic Information Systems

According to Huisman and de By (2009), Geographic Information Systems (GIS) is a tool used for working with geographic information that was developed in the late 1970s. It can be used in multiple disciplines, and the data used is called spatial data, which refers to where things are and where they will or could be in future. The questions which GIS is used to answer relate to geographic spaces and the data is positional relative to the earth's surface. GIS is a computer system, and the GIS data is capable of handling georeferenced data sets in different ways such as managing data, capturing data, preparing data, storing data, manipulating data, analysing data, and presenting data. GIS is the most powerful geoinformatics technology and has been a very important tool in many disciplines across the society of modern information (Blišťan et al., 2015; Chang, 2019). It can be used to map similarities and differences and find trends within different global communities. GIS makes it possible to represent data through time and space and can even be used within the medical field. It also makes it possible to map phenomena, such as diseases, and link it to environmental and spatial data (Musa et al., 2013). GIS is allied with other technologies such as surveying, remote sensing, Global positioning systems, air photography, and mobile computing and communications, which has also led to growth within these technologies (Clarke, 2003). GIS has been incorporated into disciplines such as anthropology, forestry, geology, epidemiology, facilities management, and business. In addition, due to its culling of the body of knowledge, it can be used in parallel fields as a new approach to science (Clarke, 2003). Clarke (2003) also states that local, state, and federal governments use GIS, but so do businesses, planners, foresters, geologists, architects, archaeologists, and many more professionals. One of the sites which provides freely accessible

GIS data is the United States Geological Survey (USGS), which is where the Landsat images were retrieved from.

Landsat images are high resolution satellite images taken (from space) of the earth's surface, which can then be accessed by different people and communities who are interested in specific images or data. These images can be used to assess previous or past images and compare them and can be processed using GIS applications in a relevant or desired way. The first Landsat system was launched in 1972 and ended in 1978 (NASA, n.d.). Landsat images are optical or infrared remote sensing satellites for earth's observation and provide freely accessible images that can be downloaded from USGS and other domains. Landsat takes images in different colour bands or wavelengths to show different phenomena in the image. There are typically seven bands associated with Landsat images, namely Blue, Green, Red, Near Infrared, Mid-Infrared, Thermal Infrared, and Mid-Infrared (DAI, 2006), as shown in Table 2.5, but there can be up to 11 bands depending on the satellite and image processing requirement (USGS, n.d.-a).

Table 2. 5: Different Landsat satellites bands. (Source: Adapted from USGS, n.d.-a)

LANDSAT IMAGES' BANDS, SATELLITES AND WHAT THEY REPRESENT									
Satellite	**Band 1**	**Band 2**	**Band 3**	**Band 4**	**Band 5**	**Band 6**	**Band 7**	**Band 8**	**Band 9**
Landsat 4-5	Blue	Green	Red	Near infrared	Near infrared	Thermal	Shortwave infrared		
Landsat 7	Blue	Green	Red	Near infrared	Shortwave infrared 1	thermal	Shortwave infrared 2	Panchromatic	
Landsat 8-9	Coastal Aerosol	Blue	Green	Red	Near infrared	Shortwaves infrared 1	Shortwaves infrared 2	Panchromatic	Cirrus

Landsat 8-9 also has an additional 2 bands, which are bands 10 and 11. These are thermal infrared bands, but it was not necessary to include them in the table as they relate to surface temperature and are not a part of the main nine spectral bands (USGS, n.d.-a) since images derived from the Thermal Infrared Sensor (TIRS) were not used in this study.

Table 2. 6: Satellite bands and their applications. (Source: Adapted from USGS (n.d.-a) and GIF, 2008)

DIFFERENT SATELLITE BANDS AND THEIR USAGE	
Band	**Use**
Coastal Aerosol	Costal and Aerosol studies
Blue	Monitoring aquatic systems: water, coral reefs, etc.
Green	Matches the wavelength for the green we see when looking for vegetation
Red	Used to distinguish between vegetation and soil, and to determine how healthy vegetation is
Near infrared	Used to define the water and land interface, as water appears dark due to absorption of light and vegetation and soil reflect light.
Shortwave infrared 1	Monitors vegetation and soil moisture due to its light sensitivity
Shortwave infrared 2	Monitors vegetation and soil moisture, although shortwave infrared 1 is preferred.
Panchromatic	Sensitive to all visible colours of the spectrum (Merriam-Webster, n.d.-c)
Cirrus	Cloud detection
Thermal Infrared 1	More accurate surface temperature
Thermal Infrared 2	More accurate surface temperature

Table 2.6 shows the use of the spectral bands and the applications that they are ideally suited for. For this study, the near infrared and red bands will be used to assess the vegetation extent at the study sites chosen and they are thus the most relevant bands for this study.

2.8.1 GIS in the mining industry

Prasad et al. (2016) illustrates satellite images used to show tempo-spatial variations in India from 2003 to 2013, as well as pits that were formed due to sand mining. Variations between undisturbed sand dune areas versus mined dunes are also shown. It is further stated that Google Earth is sufficient and cost-effective in monitoring sand mining areas, and satellite images can be used to quantify monitoring. Furthermore, using satellite images is more cost effective compared to field work (Santo and Sánchez, 2001; Prasad et al., 2016). Isah (2022) found that, in Yenagoa, Nigeria, a direct link between sand mining activity and damaged infrastructure, natural environment and shoreline migration. Sand mining activities were found to increase bare land and river expansion, with increased dumpsites and shoreline erosion.

According to Werner et al. (2019) the mining industry used GIS and RS to explore, plan and in service of corporate relations, but the work compiled by these companies is not publicly available. Spiegel et al. (2012) notes that GIS has been associated with those in power and technical knowledge and capabilities, but Werner et al. (2019) argues that spatial technologies such as GIS and RS can be used in public education to illustrate the potential impacts of the mining sector. Furthermore, Werner et al. (2019) argues that GIS can be a tool for residents within communities affected by mining to debate and educate these communities as well. Rudke et al. (2020) states that GIS can not only be used to assess the impacts of mining, but also country vulnerability regarding minerals, implementing conservation units, and can be used to create databases for spatio-temporal comparisons that may increase the efficiency of inspection and supervision of public authorities while reducing the cost related to field trips to sites. The limitations of GIS and RS is of course, the limitation of available satellite data, and the ground truth phenomena (Prasad et al., 2016).

2.9 Chapter summary

This chapter focused on the possible negative impact that sand mining has on surrounding and adjacent vegetation as well as the challenges and continuing polemics of sand mining within the Western Cape. This chapter also discussed the importance of biodiversity and its significance within South Africa, which can be shown using satellite imagery to assess vegetation density, vegetation loss, and so forth. This chapter illustrated that GIS is a viable tool to assess the impacts of sand mining and that there are significant negative impacts associated with sand mining globally and not only in the Western Cape. The next chapter focuses on research methodology.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The mixed methods approach used to conduct this study included opinion surveys, observations, and GIS applications. The surveys included face-to-face and electronic interviews as data gathering tools used to document the opinions of interested and affected parties, mining stakeholders/management as well as the mining-related officialdom. Observations at or close to the study sites were largely done as part of reconnaissance/pilot visits and ground-truthing for the desktop GIS applications that were used to inform and/or verify the results of the opinion surveys. These methods were chosen as they are suitable for and augment the Socio-ecological Systems (SES) framework that underpinned the study.

The interviews provided an in-depth understanding of the views of different stakeholders associated with the sand mines and their perspectives on the socio-ecological challenges associated with the mines. The GIS applications were used to ascertain and quantify the spatial-temporal impacts the mines had/have on the biophysical environment, specifically the sensitive indigenous coastal vegetation at, and in proximity to the mines. These methods and tools were used to coherently link the different components of SES, as they pertain to the study sites, to better inform and address some of the challenges and polemics associated with the continuation of mining at the sites.

3.2 Mixed-methods approach

The mixed-methods approach was used in conducting this research. The qualitative data, which is not necessarily non-numerical (Robson, 2011), were derived from the interview surveys conducted, and the quantitative data included survey questionnaires and Geographic Information Systems (GIS) data, to assess the extent of the impact of the activities of Maccsand Mining and Quarrying Mine and the Tormin Mineral Sands Mine on the immediate and adjacent environment at which they are located. Figure 3.1 illustrates all the methods used in this study.

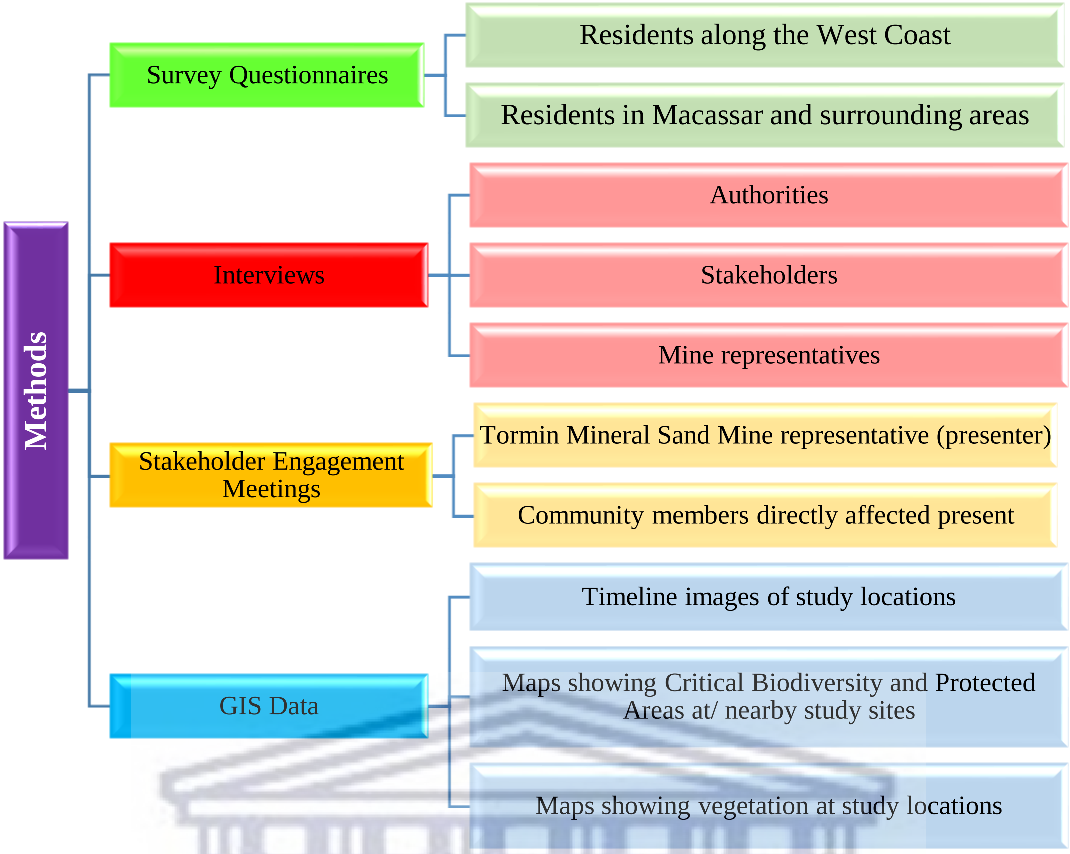

Figure 3. 1: *Methods used in this study.*

3.3 Questionnaire survey

Questionnaires were compiled in both English and Afrikaans and posted online, making it an 'internet survey' (Fowler, 2009). The dominant language in the Macassar and Lutzville communities is Afrikaans (StatsSA, 2018). The questionnaires were targeting residents of the West Coast for the MSR Tormin Mineral Sands Mine, and at Macassar and surrounding areas for the MaccSand Mining and Quarrying mine. Facebook groups were joined, and specific groups were targeted, and then links were posted with survey links within these groups for residents or interested and affected parties to fill in. The surveys were open for both target areas for approximately four months, starting from April 2022 and ending September 2022. The goal was to receive responses within a month or two at most, but because of lack of responses, it was open for five months. The goal was to receive a minimum of 50 responses per survey, but after over a month without a single response, the surveys were closed in September 2022.

3.3.1 Sampling

The sampling method used for the survey questionnaires was both purposive and convenient. It was purposive in the sense that the researcher selected specific Facebook groups and targeted certain communities to post the survey questionnaires. Afterwards, it became convenience sampling as all respondents to the survey questionnaires were included into the data analysis to find themes in the responses. The Facebook group for the MSR Tormin Mineral Sands survey were those targeted for residents along the West Coast or in Lutzville specifically. The groups for the MaccSand Mining and Quarrying mine were those targeted for Macassar residents only or those in surrounding areas, which included Macassar residents within the group.

3.3.2 Data analysis

For the survey data, many of the questions were multiple choice or open-ended. The participants were able to comment and give additional feedback or personal accounts of events pertaining to the sand mine in question if so desired, and there was an option for any additional comments desired at the end.

The responses were then analysed carefully, and categories were created based on the responses obtained within the surveys. Afterwards, the responses were tallied into the suitable and most appropriate categories, and averages of the total responses were calculated. The responses are represented visually as graphs and charts within the study.

3.3.3. Ethical considerations

For the survey, all participants were treated anonymously as per the ethical clearance granted to the study. Only an initial or X, or any means they chose to sign at the end of the survey giving permission to use their responses were provided. These were of course not shown, as there was a need to protect the participants' anonymity.

This study reflects the opinions as a general overview response, and not separate specific individuals' responses to the survey. In an instance where a specific response is pertinent to the study, the individual who wrote is kept anonymous and any information in the statement which could hint at who they are is excluded to maintain anonymity.

3.3.4 Challenges

An issue with internet surveys is that one does not know the respondents' technical abilities and they may not trust unknown websites (Fowler, 2009) and links. This could be the reason only 25 and 30 responses were received within the period of the four months in which the surveys were open. Of course, the study locations are in low-income communities (StatsSA, 2018), and not all residents may have had access to the internet.

3.4 Interviews

Interviews were conducted with authorities, interested and affected parties (I&APs), as well as with representatives of the mines. Despite limited willingness to participate in the interviews shown by groupings earmarked, nine interviews were completed. The limited willingness shown by officials of DEADP and DMRE in particular appeared to be largely attributed to 'confidentiality' concerns associated with the mining operations. The impediments placed on the dissemination of information by the Protection of Personal Information Act (POPIA) (Act Number 4 of 2013), were also concerns expressed by the interviewees. It needs to be acknowledged that the regulatory environment within which mining in South Africa operates is contentious (Botha and Bekink, 2015; Leonard, 2018). This is reflected in challenges experienced across the spectrum of environmental management procedures – from applications for mining rights and prospecting up to decommissioning and rehabilitation (DEA et al., 2013). The interviews done can be categorised as three with authorities, two with mine representatives, and four with I&APs. This can be elaborated on as follows:

- Two interviews were conducted with two members of the Department of Environmental Affairs and Development Planning (DEADP).
- One interview was conducted with a member of the Department of Mineral Resources and Energy (DMRE).
- Two interviews were conducted with botanists who were primarily interested in the Tormin Mineral Sands mine.
- One interview was conducted with an environmental activist who was primarily interested in the Tormin Mineral Sands mine.
- One interview was a combined interview with two representatives of the MaccSand Mining and Quarrying mine.

- One interview was additional information provided by one mine representative of the MaccSand Mining and Quarrying mine.
- One interview was with an I&AP who was primarily focused on the MaccSand Mining and Quarrying mine, as well as the surrounding mines.

3.4.1. Sampling

The study used both probability and non-probability sampling for interview participants. Probability sampling was used for I&APs, since whoever was willing to do an interview was considered for the interview, which was also convenience sampling. Purposive sampling, a type of non-probability sampling, was used in choosing the representatives of authorities interviewed and representatives of workers at the mine(s). Perspectives from the competent authority as well as the commenting authority were needed, and both were obtained. The competent authority decides whether or not an environmental authorisation may be granted, whereas the commenting authority may give their opinion on whether it should be granted or not. The competent authority, however, has the final say and can override decisions made by the commenting authority.

3.4.2 Data analysis

Following Punch (2003), the interview data were transcribed, and then variables (themes) were identified from the transcripts. These themes reflect different polemics which arose from the interviews and tie in largely with the (environmental) public's concerns about the continuation of the mining operations. Relationships between variables were then identified using bivariate analysis (Punch, 2003) and then multivariate analysis (Hair et al., 2010). Bivariate analysis refers to examining how two things are related to one another and assessing if there is a statistical link between the two variables. Multivariate analysis examines multiple variables (more than two) and assesses whether there is any relationship among them. Descriptive analysis was thus used to find patterns in the data/information collected (Blaikie, 2003).

3.4.3 Ethical considerations

Due to the POPI Act and ethical considerations such as anonymity, confidentiality, and minimisation of harm (Langford, 2011), participants are treated anonymously and no information that could identify the participants is provided. This is because most participants asked to remain anonymous, and the POPI Act prohibits the release of any personal information such as names, etc. As per Limb and Dwyer (2001), attempts not to state where certain information came from are adhered to and information is written up in a general way, sacrificing reality for ethically compliant and secure information.

3.4.4 Challenges

The main challenge faced in relation to interviews was that an interview could not be secured with the Department of Water and Sanitation, or with a mine representative for Tormin Mineral Sands. Furthermore, it was intended that an interview with the ward councillors for Lutzville and Macassar would be secured, but no response was provided when attempts to contact these parties telephonically as well as via online platforms, such as WhatsApp, email, LinkedIn and Facebook were made on numerous occasions. Phone numbers of MSR Tormin Mineral Sands available on public platforms were, for example, either not operational or calls to them not answered.

3.5 Stakeholder engagement meetings

MSR Tormin Mineral Sands Mine advertised public meetings to be held in different towns in the Matzikama Municipality (See Figure 3.2). Two stakeholder engagement meetings were attended to obtain the opinion from a mine representative of the MSR Tormin Mineral Sands Mine. The stakeholder meetings took place in March 2023 in the towns of Doringbaai and Vredendal. There was a total of 11 interested and affected parties at the Doringbaai meeting, and a total of 10 at the Vredendal meeting.

MINERAL SANDS RESOURCES (PTY) LTD

KENNISGEWING - PUBLIEKE DEELNAME IN TERME VAN REGULASIE 45 VAN DIE WET OP MINERALE PETROLEUM HULPBRONNE EN ONTWIKKELING, REGULASIES VAN 2020

Tormin Myn is 'n mineraal sand onderneming geleë 30 km noord van Lutzville aan die weskus van Suid-Afrika, is 'n hoë graad plaser strand minerale en sand neerslag wat van die rykste grade in die wêreld van natuurlik voorkom en desirkoon, ilmeniet, rutiel,magnetiet en granaat huisves.
Mineral Sands Resources ("MSR") nooi hiermee die Matzikama gemeenskappe sowel as die Belanghebbende en Geaffekteerde Partye ("B&GP's") na die Maatskaplike en Arbeidsplan ("SLP") openbare deelname vergadering wat gehou sal word op die volgende datums in terme van Regulasie 45 van die Wet op Minerale Petroleum Hulpbronne en Ontwikkeling, regulasies van 2020. Die doel van die vergadering is om aan belanghebbendes terug te rapporteer oor die implementering van die Maatskaplike en Arbeidsplan ("SLP") van 2022.

WYK	DORP	PLEK	DATUM	DAG	TYD
1	Lutzville-Wes Lutzville	Gemeenskapsaal Uitkyk - Gemeenskapsaal	24 Maart 2023 24 Maart 2023	Vrydag Vrydag	10:00 12:00
2	Doringbaai Papendorp Ebenhaezer	Doringbaai- Gemeenskapsaal	27 Maart 2023	Maandag	10:00
3, 4 & 5	Vredendal-Noord	Vredendal-Noord Thusong Sentrum	27 Maart 2023	Maandag	14:00
6	Klawer	Klawer - Gemeenskapsaal	29 Maart 2023	Woensdag	10:00
7	Vanrhynsdorp	Vanrhynsdorp Thusong Sentrum	29 Maart 2023	Woensdag	12:00
8	Rietpoort Putsekloof Molsvlei Stofkraal	Rietpoort - Gemeenskapsaal	28 Maart 2023	Dinsdag	10:00
	Koekenaap	Koekenaap - Gemeenskapsaal	28 Maart 2023	Dinsdag	14:00

Vir enige navrae gedurende kantoorure (08:00 -16:15) kontak asseblief die "SLP" kantoor by telefoonnommer: 060 980 8360 OF e-pos slp@mineralcommodities.com

ALGEMENE BESTUURDER

Figure 3. 2: *Public meeting dates and times of MSR Tormin Mineral Sands. (**Source**: Ons Kontrei, 2023)*

3.5.1 Sampling

The meetings attended were chosen based on transport logistics, locations, and the socio-economic profiles of Doringbaai and Vredendal. On one hand, Doringbaai is a small coastal town with high unemployment and limited economic opportunities for the poorer strata of the community, most of which are directly and or indirectly dependent on fishing (Stellenbosch University, 2013). Vredendal, on the other hand, is a central town located more inland, with much more services and economic opportunities for people to sustain their livelihoods. The West Coast has a poverty rate of 25.4% (Pauw and Du Plessis, 2005). Zweig (2015) states that Vredendal, which is in the Matzikama municipal area, is a low-income area, with two to three families living in the backyards on one property because of lack of housing in the area. Vredendal is the largest town within the Matzikama municipal area, and it is the administrative centre (Eskom, 2007). The sample at the meetings was thus 'convenient', as interested and affected parties who attended the gatherings were community members from different socio-economic standings with varying ideas as to how the mine could aid community development.

3.5.2 Data Analysis

Notes were taken during the stakeholder engagement meeting as events transpired, including of the questions asked and responses given to interested and affected parties. The results from both meetings were compared and are discussed relating to the different issues addressed in each meeting. A common thread of interests and concerns expressed in the meetings, as expected, relates to 'bread-and-butter', i.e., livelihood issues of communities and how the mining operations curtail or enhance livelihoods improvement.

3.5.3 Ethical considerations

As per the ethical clearance permission granted to the study, no personal information of community members who attended the stakeholder engagement meetings are provided.

3.5.4 Challenges

The time slots for the meetings were generally quite early, considering that these would be working hours for the community members. The ideal would have been to attend all the planned I&AP meetings scheduled for different towns in the Matzikama Municipality. It was impossible though due to practical challenges related to accommodation and distances that had to be travelled. (Doringbaai and Vredendal are more than 250 kilometres from Cape Town). As some envisaged interviews could not be arranged, because of lack of response from mine management, attending the stakeholder engagement meetings was the best course of action to have a representative from the mine on record for the study. Owing to attending stakeholder meetings, a different perspective was obtained as the community representatives who attended the meeting were directly and indirectly affected by the mine and hearing their opinions provided interesting contributions and bottom-up viewpoints to this study. This challenge thus became an opportunity.

3. 6 GIS mapping

For this study, a range of GIS software and tools were used to illustrate the impacts of sand and mineral sand mining on the biophysical environment and vegetation. This is in line with the ecological part of the SES approach that underpins the study. The GIS methods and platforms used include Google Earth Pro, ArcMap V.10.8.2, and USGS. The GIS applications are used, as illustrated in Chapter 5, to corroborate, or question specific spatial impacts and polemics associated with the continuation of mining at the study sites.

Table 3. 1: GIS Tools used in this study

GIS TOOLS USED	
Commercial	**Free and Open-source**
Esri ArcMap (https://www.esri.com/en-us/arcgis/products/arcgis-desktop/resources) ESRI ArcMap Free trial (https://www.esri.com/en-us/arcgis/products/arcgis-desktop/resources)	CapeFarmMapper (https://gis.elsenburg.com/apps/cfm/)
	Google Earth Pro (https://earth.google.com/web/)
	USGS (https://earthexplorer.usgs.gov/)

Table 3.1 displays the GIS Tools which were used in this study, differentiating between what is open source and freely accessible compared to what is commercial/ proprietary software. On one hand, the free/ open-source software can be downloaded free of charge and used without a license. The commercial software, on the other hand, needs a license to use and needs to be paid for. However, the commercial software provides a trial version of up to 30 days.

3.6.1 Google Earth Pro

Google Earth Pro was used to indicate the locational characteristics of the study areas. It was also used to show a sequence of conditions pre and post the establishment of the MaccSand Mining and Quarrying and Tormin Mineral Sands mines. The Google Earth Images capture the extent of vegetation distribution before the Tormin Mineral Sands Mine was established and afterwards. However, it does not show the vegetation extent prior to the MaccSand Mining and Quarrying Mine as there were no Google Earth images available prior 2000. The only image available is from 1985, but it is extremely pixelated and therefore impractical to use for this study. To redress this, other methods were used to represent the 1999 extent, namely the Normalised Difference Vegetation Index (NDVI) and the Soil-Adjusted Vegetation Index (SAVI) as elaborated on in Section 3.6.2.

3.6.2 Landsat images and ArcMap V.10.8

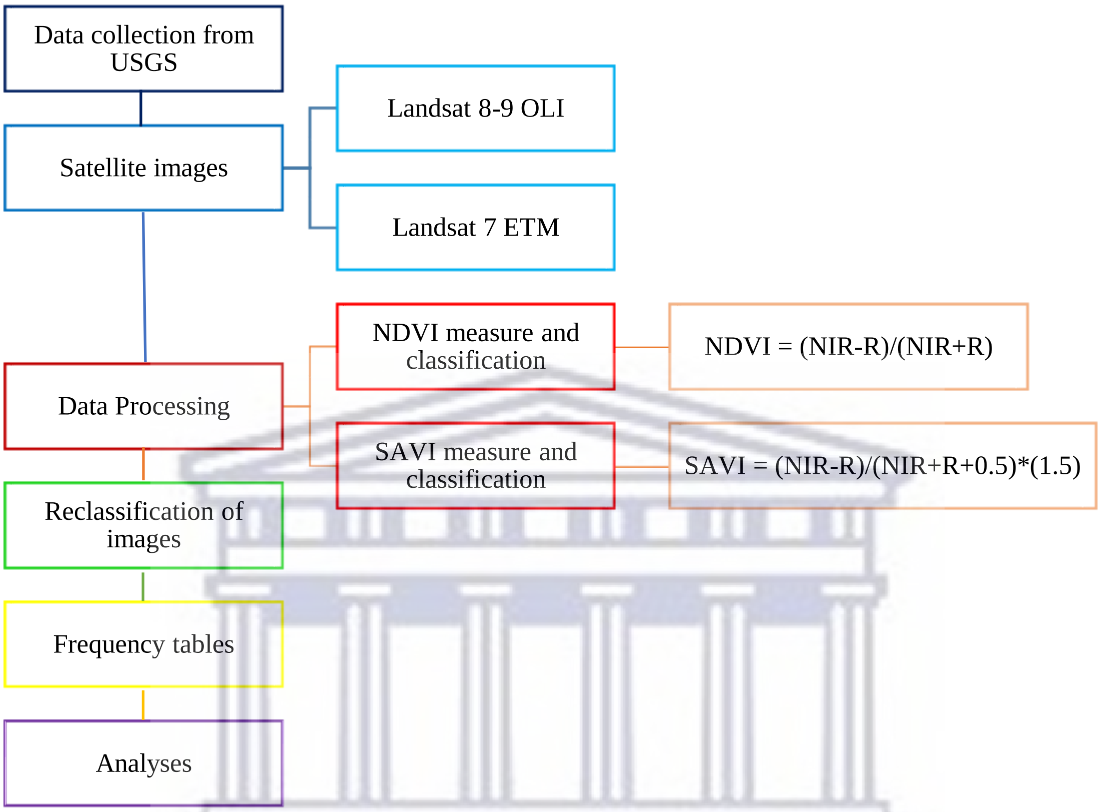

Figure 3. 3: *Flow chart of image processing done using Landsat images*

Figure 3.3 shows the method used for the vegetation density indices. Figure 3.3 illustrates that Landsat images were downloaded from the United States Geological Survey (USGS) website. Landsat 5, 7 and 8 images were downloaded and used for spatial analyses of changes in the distribution of vegetation. The path and row used for the study sites are shown in Table 3.2.

Table 3. 2: The path and row used in USGS to identify the study sites and the appropriate Landsat images. (Source: USGS (https://earthexplorer.usgs.gov/)

Path and row used in USGS		
Mine	**Path**	**Row**
MaccSand Mining and Quarrying	175	084
MSR Tormin	176	082

ArcMap is a GIS data application which is used to represent geographic information and other spatial elements in different map formats. The format used for the USGS topographical maps is the PDF format. This is because it is a common format that can carry raster data, vector data, and formatted text annotation (USGS, n.d.-b). ArcMap 10.8.2 was used to run indices such as the NDVI (Normalized Difference Vegetation Index) and SAVI (Soil-Adjusted Vegetation Index) to illustrate and quantify the extent to which vegetation has been lost based on the analysis of satellite images taken prior and post mining operations. For MaccSand Mining and Quarrying, the NDVI was used to determine the extent of vegetation loss or increase in the area (presumably after rehabilitation).

The NDVI is widely used due to its simplicity regarding the calculation and it being easy to interpret. The NDVI was first used by Rouse et al. (1973) and measures the vitality of vegetation. The NDVI ranges from -1 to 1, with 1 being the highest and healthiest vegetation, and -1 being no vegetation, and water bodies (Bid, 2016; Vani and Mandla, 2017). The formula for NDVI is:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

where NIR refers to the pixels derived from the near infrared band and R refers to the pixels derived from the red band in the electromagnetic spectrum. An NDVI of 0 or less would indicate water, snow, bare areas, and built-up areas; an NDVI of 0.2 to 0.3 would represent shrub and grassland, and an NDVI of >0.6 would indicate temperate and tropical rainforests (Rouse et al., 1973). As shown in Table 3.3, for Landsat 7, bands 4 and 3 would be used to calculate the NDVI, and for Landsat 8 images, bands 5 and 4 would be used. The NDVI was used for the MaccSand Mining and Quarrying mine, as the vegetation surrounding the mine is the Cape Flats Dune Strandveld, which is a mix of dark green plants, trees as well as flowers (Graham and Ernstson, 2012), suggesting that the NDVI would be suitable as it would classify the greenery within the area proficiently.

Table 3. 3: Landsat images used in the study and bands used for NDVI and SAVI image processing

Landsat satellite and bands used for image processing (NDVI and SAVI)		
Landsat	**Near-infrared Band**	**Red Band**
7	4	3
8	5	4

For the MSR Tormin Mine, the Soil-Adjusted Vegetation Index (SAVI) was used. This was done because the Normalised Difference Vegetation Index (NDVI) would not account for the soil coverage in the area, and the vegetation, which is predominantly Namaqualand Strandveld, was blending in with the colour of the soil. NDVI has a non-linear relationship with the biophysical characteristics and sensitivity to soil as a background and is therefore a big drawback of this index. NDVI can therefore not discriminate between soil and Strandveld vegetation on, and in the vicinity of the MSR Tormin Mine. However, SAVI, in turn, eliminated the influence of soil on the index, by graphically transforming the reflectance in vegetated canopies and by shifting the origin of the NIR and Red spectral bands (Vani and Mandla, 2017).

The equation for SAVI is:

$$SAVI = \frac{NIR - Red}{NIR + Red + L} \times (1 + L)$$

NIR and Red are the reflectance in the respective spectral bands. L is a consistent parameter value which can be 0, 0.5 or 1 (Vani and Mandla, 2017). Zero (0) is used if there is a high vegetation density, 0.5 is used if there is moderate green vegetation density and 1 is used if there is no green vegetation cover in an area (Huete, 1988). The consistent parameter chosen for the SAVI equation was 0.5 as there is moderate green vegetation cover in the area near the Tormin Mineral Sands Mine, making it the most suitable soil-brightness correction factor.

Appendix F shows the specifics of all satellite images used for the NDVI and SAVI indices.

3.6.2.1 Accuracy Assessment

Accuracy assessment is used to determine the quality of the remotely sensed data used and to assess if the map used for image processing can be supported by what is truly on the ground. Figure 3.4 illustrates the method used for the accuracy assessment points. To generate the accuracy assessment points, a high-resolution image was obtained of both study sites from the National Geo-spatial Information (NGI) Department. A land cover map was then generated with the land uses in the area, to which 200 accuracy assessment points were randomly generated.

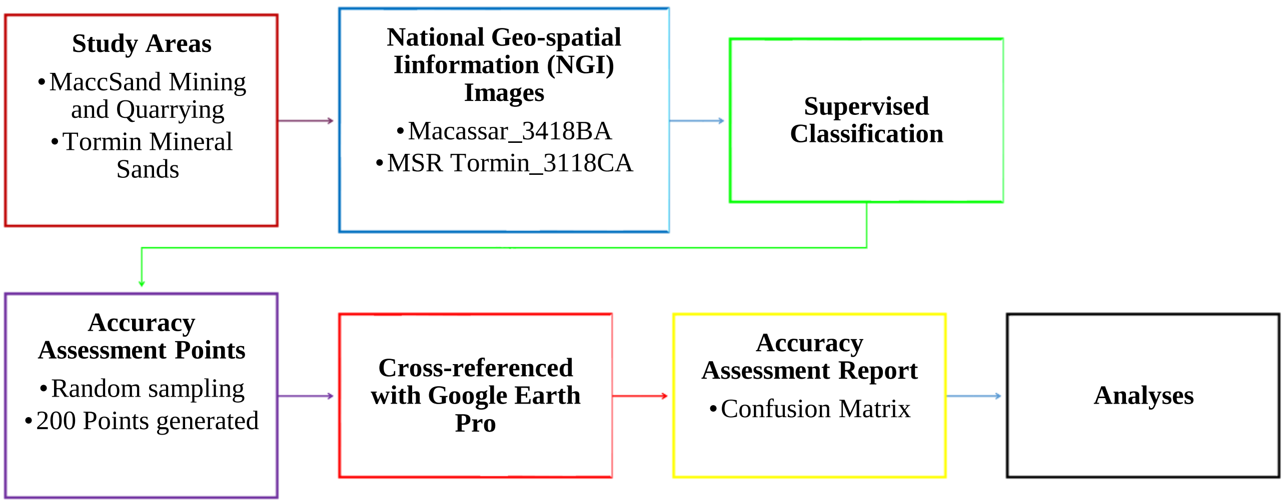

Figure 3.4*: Flow chart showing the method for Accuracy Assessment. (***Source***: Adapted from Rwanga and Ndambuki, 2017)*

3.6.3 CapeFarmMapper

CapeFarmMapper is a free online GIS program, which is powered by the Western Cape Department of Agriculture. An attempt was made to use CapeFarmMapper for the NDVI application, but the program could not generate an appropriate legend for the purposes of this investigation. For this reason, the NDVI was generated manually using ArcMap as stated and explained in 3.6.2. CapeFarmMapper was, however, used for the Vegetation Map (VegMaps), Critical Biodiversity Areas (CBAs) and Protected Areas (PAs) for both study areas. The land cover maps show the surface of an area and identifies the land covers present, such as vegetation, urban areas, water, bare ground, and so forth. 'Land' is where humans conduct their activities (Naboureh et al., 2020), and land cover represents the physical and biological areas of the earth's surface; the physical land type such as water, forest, etc. (Rujoiu-Mare and Mihai, 2016). VegMaps are used to classify diverse vegetation. VegMaps map the natural vegetation cover of an area and attempt to reconstruct the previous vegetation cover which has been altered due to human impacts and is meant to be used as a means to determine future land uses within Southern Africa (McDonald, 1997). Critical Biodiversity Areas are areas, terrestrial and aquatic, which are needed to be protected as they provide natural habitats which are essential for biodiversity conservation and maintenance of ecosystem functionality (Driver et al., 2005). Protected areas are those which have been legally designated to be protected, mostly by an organ of state, to conserve nature and protect biodiversity. The CBA maps were used to illustrate that both study sites are in CBA areas, and although it is a CBA, the PA extent is not large. The VegMaps are used to illustrate the vegetation present at both study sites.

3.6.4 Data Analysis

3.6.4.1 Visual and Spatial Analysis

Visual data analysis is the graphical portrayal of data and information in a pictorial or graphical presentation. Visual data analysis can be done so in charts, graphs, and maps. The purpose of visual analysis is to make an argument based on visual evidence (Llobera, 2003). When performing a visual analysis, things such as line, colour, scale, composition, space, and the function of the maps must be considered for analysis (Keim et al., 2008).

Spatial analysis allows one to solve complex problems related to location. It also allows one to understand data from a geographical perspective, determine relationships between variables, quantify patterns, make predictions, and assess trends. Spatial analysis also allows one to study characteristics of places and relationships that exist which can lead to new perspectives. Spatial analysis allows one to incorporate and combine different data and information to derive new information. This allows one to address important questions that extend beyond the scope of visual analysis (de Smith et al., 2018). GIS platforms have multiple functions such as data acquisition, data management as well as visualisation, with the ability to combine these methods with analytical operations, which makes it even more efficient (Unwin, 1996).

Spatial analysis was used in conjunction with visual analysis in this study. Spatial analysis was done on the images of USGS, to which the NDVI and SAVI results were applied and modelled, to represent the vegetation extent at the study sites. A visual analysis was then done on the processed images. A visual analysis was also done on the images from CapeFarmMapper and Google Earth Pro to corroborate claims made in the questionnaire surveys or in the interviews conducted.

3.6.4.2 Descriptive Statistical Analysis

Statistical analysis assists in summarising and visualising data. It is used to identify patterns and trends, removing bias. Descriptive statistics was used as the data was summarised into tables and graphs to draw conclusions (Parsons et al., 2012).

The descriptive statistics were derived from the GIS image processing, of which the NDVI and SAVI results were converted to show the frequency of the different land classes. The frequency provides a summary of the number of occurrences for each land class used, illustrating the extent of each land class on the map, based on its unique field number (Pawar et al., 2022).

Descriptive statistics was also used to calculate the sum of the annual rainfall data provided by the South African Weather Service, and this data was then graphed (Chapter 5).

3.7 Chapter summary

A range of methods were used to illustrate how the polemics and continued contestations identified by this study can be verified. From the results of interviews and GIS applications, which underpin the methodology of the study, relevant themes were identified, i.e., thematic analysis of opinion, secondary data, and spatial data. The following chapters focus on the findings of this study.

CHAPTER 4: RESULTS I: DATA ANALYSIS OF SURVEYS

4.1 Introduction

The opinion-based results encompass the survey results of the questionnaires, interviews, as well as meetings with interested and affected parties that were attended. These results are important as they provide perspectives of different parties involved or affected by the sand mining operations – the Tormin Mineral Sands Mine and the MaccSand Mining and Quarrying Mine. The results encompass the viewpoint of authorities, representatives of the mining sites, and interested and affected parties pertaining to the study sites. These viewpoints include opinions on mine locations, how the environment and people are affected, and other positives and negatives associated with these sand mining operations.

4.2 Questionnaire survey results

4.2.1 Introduction

For the MaccSand Mining and Quarrying questionnaire survey, 30 questionnaires were completed and 25 were completed for the MSR Tormin Mineral Sands questionnaire survey. Although the desired number of respondents were not met, the questionnaire survey results were incorporated and analysed to ascertain the opinion of the respondents who had completed the questionnaire survey.

The aim of the questionnaire surveys was to obtain the opinions of residents in or near the study sites, regarding sand mining challenges and how informed they were and have been by the mining companies. The questionnaire survey results are compared per area to assess the level of knowledge on sand mining from both study sites.

The questionnaire survey responses showed that, in general, the residents of Macassar seemed to be more knowledgeable compared to those from Lutzville and the West Coast regarding the impacts of a sand mine on the community. Respondents in both areas did however address similar concerns, and the idea that the mining companies did not adhere to the environmental regulations related to the concerns of interested and affected parties (I&APs). The list of survey questions asked can be found in Appendix B. It is thus important to note that the participants for the MaccSand Mining and Quarrying questionnaire have a higher level of education and there is less unemployment within the City of Cape Town municipality than that of Matzikama. Although there are inadequacies associated with demographic censuses conducted (Mba, 2004; Kordos, 2017), this demographic information is important for this study, as it encompasses that the study sites are located within low-income areas (Graham and Ernstson, 2012; Eskom, 2007) and can explain the manner of responses in the questionnaire surveys, as demographics impacts on the level of education performance (Refae et al., 2021) and can assist in finding differences as well as similarities between population groups (Hammer, 2011).

However, it was observed in the results that participants did not answer all questions and there are some which have been skipped, or participants who did not answer accordingly, as they attempted to get to the end of the survey. Overall, the opinions on both mining site locations were poor and participants were not happy with the operations occurring.

4.2.2 General Questions

Figure 4.1 shows the results of multiple general questions asked in the questionnaire. The results are combined as they are not pertinent to the study but are important to address and understand the overall opinions of the respondents.

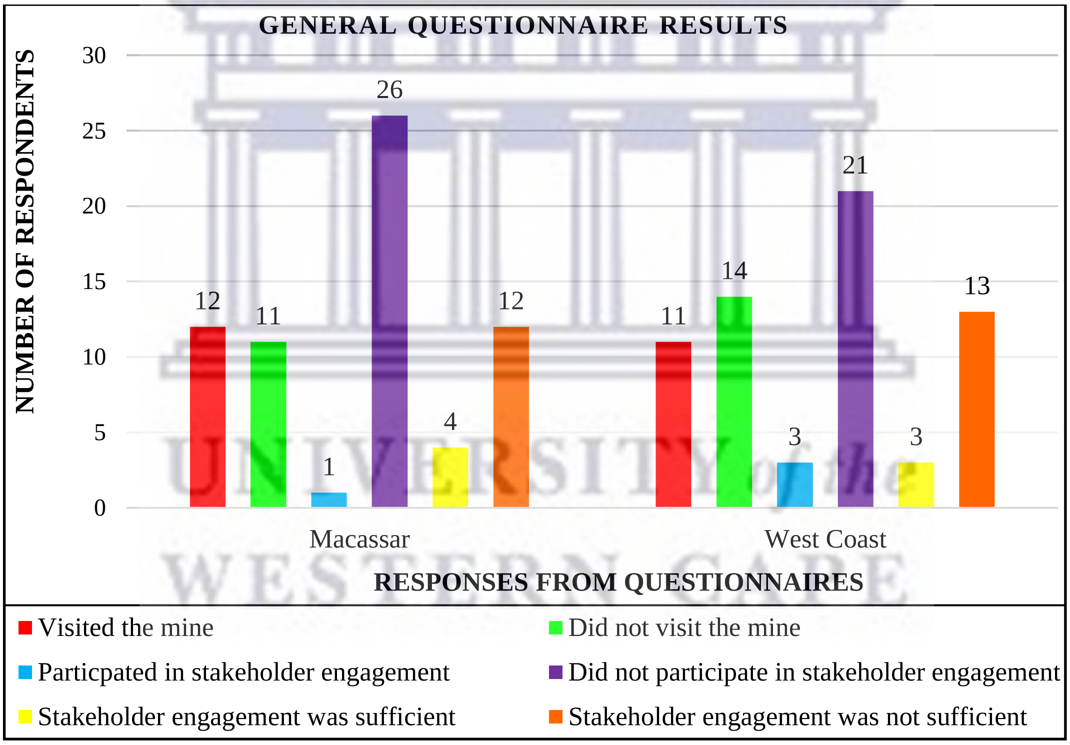

Figure 4. 1: *Results of questionnaire surveys done at Macassar and Lutzville*

Macassar, n=30 and Lutzville, n=25

Where n = total respondents

4.2.2.1 Mine visits

Figure 4.1 illustrates that for the MaccSand Mining and Quarrying mine, more participants visited the mine than those who did not, and for the MSR Tormin Mineral Sands mine, over 50% of the participants had not visited the mine.

For the MaccSand Mining and Quarrying mine, 40% of participants had visited the mine and 36% had not, whereas for the MSR Tormin Mineral Sands mine 44% of participants had visited the mine and 56% had not. This is interesting, as gaining access to visit the MSR Tormin Mineral Sands mine is extremely difficult and the procedure is lengthy, yet 11 participants managed to visit the site. It does however make sense that over 50% of the participants had not been able to visit the mine owing to the strictness of the owners. For the MaccSand Mining and Quarrying mine, it appears that there was a more open-door policy, which means that residents could visit the site at any time and be informed about the operations occurring.

4.2.2.2 Stakeholder engagement

Figure 4.1 shows that most of the participants for both surveys did not participate in the stakeholder engagement for the mines. The reasoning for the lack of participation can be seen in Figures 4.2 and 4.3.

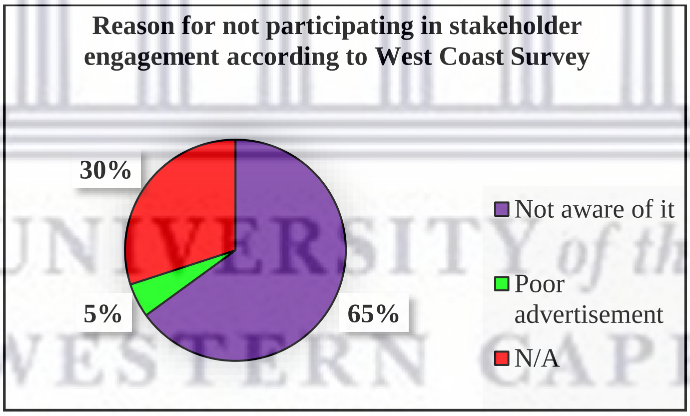

***Figure 4. 2**: Reason participants did not participate in stakeholder engagement according to the West Coast survey*

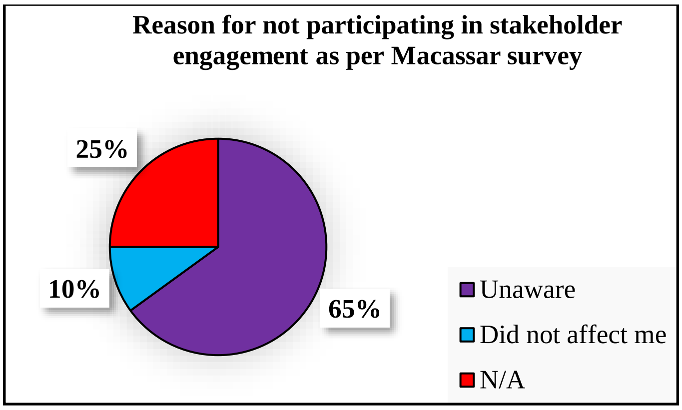

Figure 4. 3: *Reasons participants did not participate in the stakeholder engagement according to the Macassar survey*

Figures 4.2 and 4.3 illustrate that the main reason that most of the participants did not participate in stakeholder engagement was due to them being unaware there were such. Participants stated that they were not informed of meetings, an indication that there was poor advertising of stakeholder engagement sessions.

For the MSR Tormin Mineral Sands survey, 13 participants stated that they had not been informed of the meetings. This accumulates to 52% of the participants who claimed that they were not aware of meetings.

For the MaccSand Mining and Quarrying survey, 13 participants stated that they were unaware of the meetings occurring, which accounts for 43% of the participants in the survey being unaware of meetings.

Most participants thought that stakeholder engagement was insufficient, with 13 participants of the MSR Tormin Mineral Sands survey stating that it was insufficient, accounting for 52% of the participants. However, 12% of the participants found that stakeholder engagement was sufficient. For the MaccSand Mining and Quarrying survey, 12 participants stated that it was insufficient, accounting for 40% of the participants, while 13% of participants thought that stakeholder engagement was sufficient.

4.2.3 Rehabilitation

Table 4. 1: Participants' opinions on rehabilitation

Participants' opinions on rehabilitation at the two study sites				
Opinion on Rehabilitation	**Macassar**	**Percentage of total respondents**	**West Coast**	**Percentage of total respondents**
Satisfactory	0	**0**	3	**13%**
Unsatisfactory	9	**41%**	18	**78%**
Unsure	0	**0**	2	**9%**
N/A	13	**59%**	0	**0**
Total	**22**	**100**	**23**	**100**

Table 4.1 shows the opinions on rehabilitation at the mining locations with the number of participants who thought that it was satisfactory or unsatisfactory. For both surveys, most of the participants stated that the rehabilitation occurring is insufficient, and pertaining to the MaccSand Mining and Quarrying survey, the majority of the responses were not applicable to the question. This was in respect to the response being vague and not specifying a standpoint on the opinion whether rehabilitation was satisfactory or unsatisfactory.

For the MaccSand Mining and Quarrying mine, none of the participants thought that the rehabilitation occurring was satisfactory, and for the MSR Tormin Mineral Sands mine, 13% of the respondents thought the rehabilitation to be satisfactory. Furthermore, for the MaccSand Mining and Quarrying mine, 41% of the respondents stated that the rehabilitation occurring was unsatisfactory, and 78% of respondents for the MSR Tormin Mineral Sands survey believed the rehabilitation to be unsatisfactory. It is important to note that during the MaccSand Mining and Quarrying survey, participants referred to the mining sites along the coast and not specifically to MaccSand and it was apparent that the respondents may have believed all three mining companies – MaccSand, SSB and AfriMat – to be one company or a joint sand mining enterprise.

Satellite imagery can corroborate the claims that the rehabilitation is unsatisfactory at MaccSand Mining and Quarrying. Figures 4.4 and 4.5 illustrate that rehabilitation is occurring at MaccSand Mining and Quarrying, but the vegetation is different from what was initially present, nor is the vegetation as thick or dense as before.

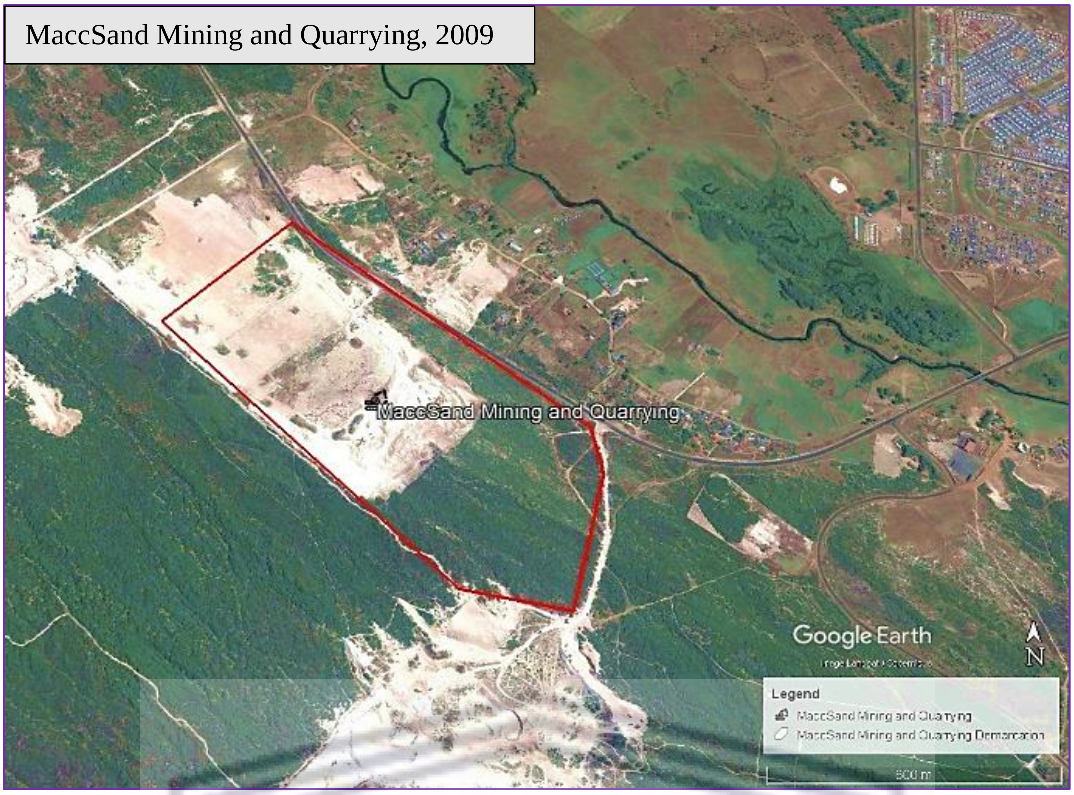

Figure 4. 4: *Vegetation density at MaccSand Mining and Quarrying in 2009 and vegetation clearance at the North-West section of the mining site. (**Source**: Google Earth Pro)*

Figure 4. 5*: MaccSand Mining and Quarrying in 2011. (**Source**: Google Earth Pro)*

Figure 4.4 illustrates that in 2009, a large portion of the Northern section of MaccSand Mining and Quarrying was cleared for mining, with the Southern section still intact. Then, Figure 4.5 shows that the Northern section of the mining site was then rehabilitated as species growth can be seen in the satellite image. The vegetation regrowth is notably less thick than previously, although there is only a two-year difference between the images and may thus be too soon to make this judgement.

Alternatively, satellite images for the Tormin Mineral Sands mine illustrate that no rehabilitation is occurring at the site, and there is simply continuous expansion as shown in Figures 4.6 and 4.7. Figure 4.6 illustrates the size of the mining site when operations began, compared to its size in 2022, nine years after operations began. Figure 4.7 illustrates the immense extensions associated with the Tormin Mineral Sands mine, and how since starting operations, they have expanded, which is one of the concerns raised pertaining to this mine in the questionnaire survey and interview results. Figures 4.6 and 4.7 are the same mine with the same scale, nine years apart. These images show the impact the mine has had on the coastline, and the vegetation within the area. These images were taken in February 2013 and February 2022, illustrating the loss of greener vegetation near the mining site.

***Figure 4. 6**: Tormin Mineral Sands Mine extent in 2013. (**Source**: Google Earth Pro)*

Figure 4. 7*: Tormin Mineral Sands Mine extent in 2022. (****Source****: Google Earth Pro)*

4.2.4 Impacts of Sand Mining

Figure 4.8 shows that most of the positive impacts in relation to the MSR Tormin Mineral Sands mine survey were related to job creation. The second most frequent response was that there were no positive impacts of sand mining, and lastly, that there was an economic benefit. Furthermore, the responses from the MaccSand Mining and Quarrying mine survey had five different categories arising from the responses, and the two most stated positive impacts of sand mining are job creation and there being no positive impact. The next highest positive impacts are cheap sand and the category "other".

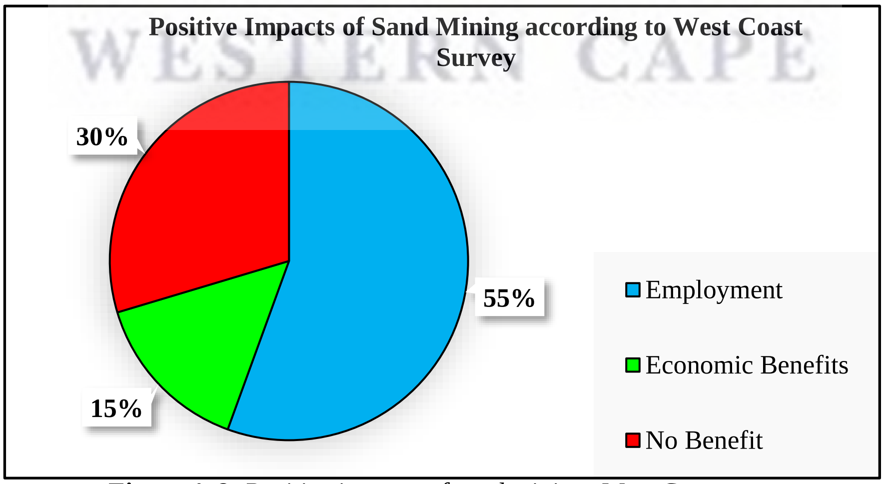

Figure 4. 8: *Positive impacts of sand mining -West Coast survey*

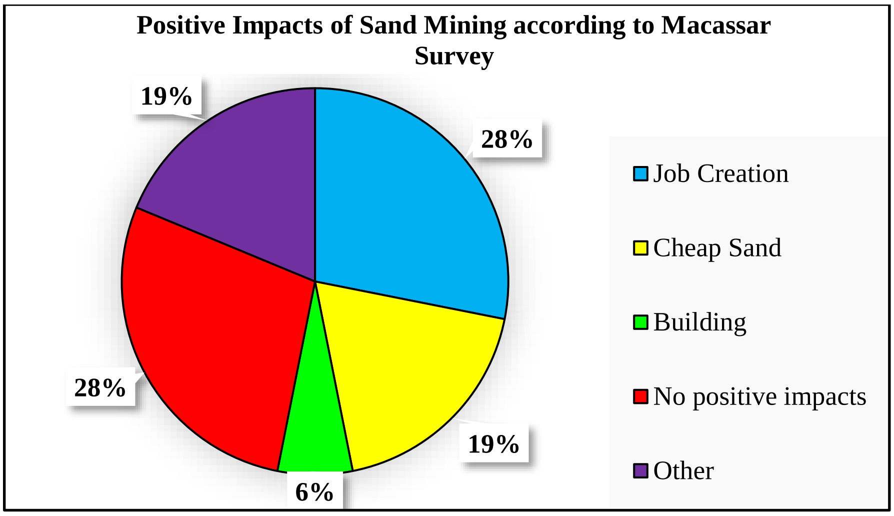

Figure 4. 9: *Positive impacts of sand mining - Macassar survey*

Figure 4.8 illustrates that 55% of respondents agreed that employment/job creation is a positive impact of sand mining, while 30% of respondents stated that there was no positive impact. Figure 4.9 similarly shows that 28% of the respondents thought that a positive impact was job creation/employment, but a further 28% stated that there was no positive impact of sand mining.

The main difference between the responses from the surveys is that the MaccSand Mining and Quarrying survey had more responses, whereas the MSR Tormin Mineral Sands survey only encompassed three categories for the positive impacts. This is seen in Figures 4.10 and 4.11.

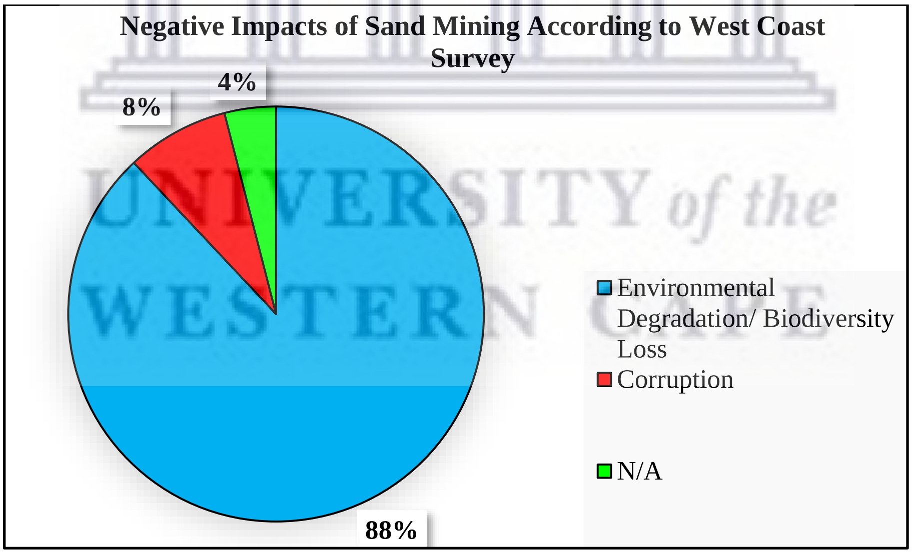

Figure 4. 10: *Negative impacts of sand mining - West Coast survey*

Figure 4.10 shows the negative impacts of sand mining according to the MSR Tormin Mineral Sands survey. Most respondents stated that a negative impact was environmental degradation or biodiversity loss. The second largest negative impact recorded was corruption. As much as

88% of respondents stated that a negative of sand mining is environmental degradation and/or biodiversity loss, and 8% of respondents stated that there was corruption associated with the sand mining company.

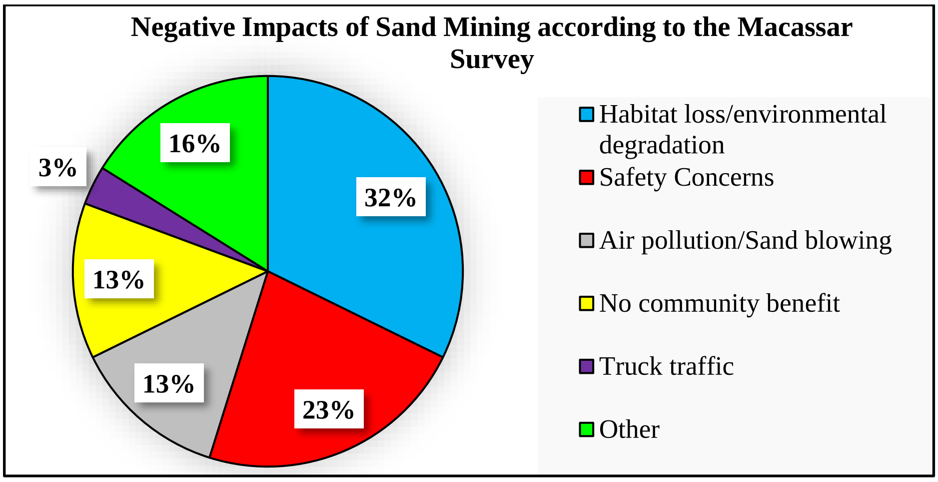

Figure 4. 11: *Negative impacts of sand mining - Macassar survey*

Figure 4.11 shows the negative impacts of sand mining according to the respondents of the MaccSand Mining and Quarrying survey, in which it was indicated that there were five concerns pertaining to sand mining. The biggest category of concern was habitat loss and environmental degradation, and the second largest was safety concerns. The third was air pollution and no community benefit and, lastly, truck traffic.

The top concern for participants in both surveys was environmental concerns, with the environmental concern in the MSR Tormin Mineral Sands mine survey accounting for 88% of the respondents. Environmental concerns accounted for 32% of the responses in the MaccSand Mining and Quarrying survey.

4.2.5 Summary of Results

The opinions obtained in the questionnaire surveys indicated a strong negative viewpoint of sand mining operations from a majority of the participants. Most participants did not believe that there was sufficient community involvement of sand mining companies, nor did they believe that there were any positive impacts on the environment. It was apparent that most of the participants believed the sand mining companies had the capacity to be more involved and assist the community more than they were. The communities were also concerned about the environment and the impacts these sand mining companies had on the vegetation within the areas.

It can be deduced from the questionnaire results that the participants from Macassar and surrounding areas had more concerns regarding the positive and negative impacts, and different concerns thus arose from the responses. The main concern within the West Coast community is, undoubtedly, environmental degradation. The difference in knowledge pertaining to sand mining impacts could be associated to the level of education from the district municipalities. The negative responses related to the Tormin Mineral Sands mine could be rooted in the fact that there is restricted access to the mining site, resulting in uncertainty about the company's activities, whereas MaccSand Mining and Quarrying appears to be more accessible by surrounding communities, addressing uncertainties that residents may have.

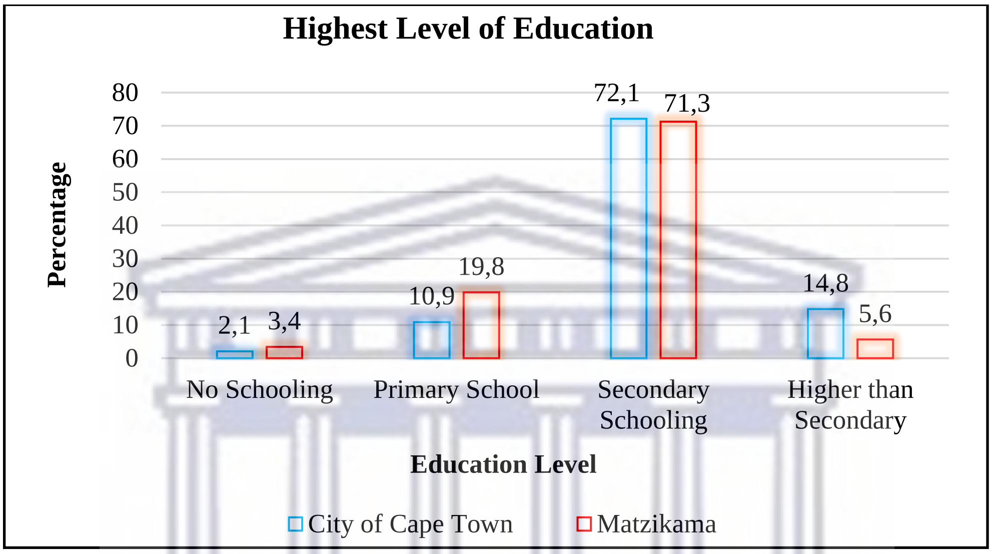

Figure 4. 12: *Education levels in areas close to the study sites. **(Source**: Adapted from StatsSA, 2018)*

Figure 4.12 indicates that the highest education level among participants for the City of Cape town and Matzikama municipalities was secondary schooling, which is more commonly known as high school. The second highest education level for the City of Cape Town was Higher than secondary schooling, and for the Matzikama municipality, the second highest education level was primary school. It is important to note that for the categories of 'primary school' and 'secondary schooling', this does not indicate that the entire schooling was completed within the education system, as this percentage includes both those who completed the schooling level, and those who dropped out and may not have completed. From this, it can be presumed that the residents of Macassar had a higher level of education than those from Lutzville and nearby areas, which would explain the difference in knowledge pertaining to the questionnaire results. Furthermore, RSP6 states that there is lack of knowledge within the Lutzville community, owing to it being mostly a rural area, and lack of assistance from the Tormin Mineral Sands mining company.

It is significant that in both surveys, the main concerns are similar, even though it can be inferred that participants in the Macassar and surrounding areas are more well-informed and aware of the impacts sand mining may have. The interest may also be different, because along the West Coast, the residents rely on the environment for their livelihoods, such as for fishing. This directly relates to the reasoning that continued mining operations along the West Coast are not environmentally or socio-economically desirable, as they are allegedly negatively impacting these communities' livelihoods. The mining operations in Macassar were also described as undesirable, both socio-economically and environmentally, with the participants believing there had been no community involvement or upliftment from the company.

4.3 Interview results

4.3.1 Introduction

From the interview, most polemics emanated from many contrasting opinions regarding sand mining. The aim of the interviews was to ascertain the opinions of authorities as well as representatives from the mining companies. Interviews were also conducted with relevant parties interested in and affected by the mining operations. The interviews were conducted by a means chosen by the interviewee, and focused on impacts of sand mining, whether positive or negative, and the rehabilitation of study sites.

Information gathered was in response to questions prepared for the interviews as well additional information shared that fell outside the scope of the interviews. The findings incorporate events that have occurred at the sand mining sites as well as the impact of externalities such as physical safety and employment security concerns. The interviews incorporate different viewpoints, including those of the authorities, interested and affected parties, as well as mine representatives of the Tormin Mineral Sands and MaccSand Mining and Quarrying mines.

4.3.2 Interview details

Table 4.2 summarises the logistics associated with the interview survey. Respondents are anonymised by using codes for the different respondents, as per the ethical clearance arrangement for this study. Table 4.2 shows the significance of the interviewee, their code for the study, the date the interview was conducted, the duration of the interview, the method used for the interview, and the atmosphere of the interview. These categories are for background information and are not focused on. Table 4.3 then summarises the details of all the interviews conducted, consisting of the total number of hours, the longest interview conducted, the shortest interview conducted as well as the average duration per interview.

Table 4. 2: Nature and context of interviews conducted with representatives

DETAILS OF INTERVIEWS CONDUCTED					
Interviewee	**Code for respondent**	**Date of interview**	**Duration of interview**	**Method interview was conducted**	**Atmosphere during interview**
DMRE	RSP1	27 September 2022	10 minutes 19 seconds	In person	Tense, uninviting
DEADP1	RSP2	01 August 2022	18 minutes, 18 seconds	Microsoft Teams	Friendly, accommodating
DEADP2	RSP3	21 July 2022	1 hour 21 minutes 15 seconds	Microsoft Teams	Friendly, accommodating
MaccSand interview 1	RSP4 and RSP5	26 September 2022	26 minutes 06 seconds	In person – recording on phone	Friendly, accommodating
Activist	RSP6	20 July 2022	39 minutes 39 seconds	Zoom Meetings	Friendly, accommodating
MaccSand I&AP	RSP7	26 September 2022	30 minutes 17 seconds	In person – recording on phone	Friendly, accommodating
MaccSand interview 2	RSP4 and RSP5	26 September 2022	12 minutes 50 seconds	In person – recording on phone	Friendly, accommodating
Botanist 1	RSP8	03 November 2022	35 minutes 40 seconds	Zoom Meetings	Friendly, accommodating
Botanist 2	RSP9	14 November 2022	13 minutes 41 seconds	Zoom Meetings	Accommodating, but not very interested

Table 4. 3: Details of the interviews conducted summarised

SUMMARY OF INTERVIEW DETAILS	
Description	**Quantity**
Number of interviews	9 interviews
Total duration of interviews	266.45 minutes
Average duration	29.6 minutes
Longest duration	1 hour 21 minutes and 15 seconds
Shortest duration	10 minutes 54 seconds

4.3.3 Authorities

4.3.3.1 DMRE

After delays that were not communicated in advance, the interview began at 10h54. The interview took place in the boardroom and there was an additional DMRE official who appeared to merely oversee the interview. The person was not introduced, and the reason for the individual's presence was not stated. The DMRE interview was the shortest interview conducted. This was because of a lack of responses for some questions and a very evasive manner in which the respondent addressed those questions they answered. Many of the responses were, "It is case-specific, so I cannot answer," or the response was not a direct response to what would have been asked. When asked for the negative impacts of sand mining, the respondent stated that:

RSP1: *Are you talking about in a socio-economic context? In what context?... Uhm, I can't think of anything right now at the moment, to be honest.*

RSP1 was asked the extent to which she believed sand mining could impact on the environment, to which the response was:

RSP1: *Vegetation and the landscape constantly changes. The environment is not a stagnant entity, so again, from my standpoint, it's difficult to pinpoint exactly the full- ja, so the environment's not stagnant, so it's not easy to ascertain at this point.*

RSP1 also attempted to avoid questions on rehabilitation and mitigation, stating that "each application is unique" multiple times when prompted for a response. RSP1 was then asked about the enforcement of rehabilitation, to which the response was that it is dependent on the stage that the sand mining operation was in, and that rehabilitation could not occur in a "current operation". This, of course, was a contradiction to what was stated later in the interview, when RSP1 stated that there were sand mining sites which rehabilitated while they were still operational, as they mined a specific area, then they moved onto a different section and rehabilitated the portion previously mined.

The questions then addressed rehabilitation after site closure, and the response was:

RSP1: *Like for instance, an operation on an active cultivated land, for example like I said, sand mining operations occur everywhere, so it'll depend on where it is. So, from there, first of all, where the sand mine is located, you will then see the* *surro- the receiving environment to see is this area, has it established itself to look like the surrounding area? That is the one measure used to gauge as an example. So sometimes, they may even propose a different land-use, say, maybe after you've mined this sand dune, the land will be open to the municipality to build houses for example. So, there's a lot.*

The final questions centred around site inspections by environmental control officers (ECOs). The respondent stated that it was done regularly, but could not state how regularly, not even an estimation, and refusing to respond. The respondent asserted thus, "I can't say. Sorry." The interview then ended after these questions, at which point the respondent got up and walked out of the boardroom, leaving the interviewer there alone. This experience of evasiveness seems to be reminiscent of officials in state departments that have to oversee decisions about, and management of contentious projects (Allsop, 2022). Allsop (2022) submits that officials attempt to stifle debates regarding impartial or controversial issues. This is, however, not a new issue, as the Parliament of South Africa (2009) indicated evasiveness from government officials in parliamentary meetings and how unacceptable this behaviour was.

4.3.3.2 DEADP

Two interviews with members of DEADP were conducted. The interviews were both conducted on Microsoft Teams. According to RSP2, the legislation pertaining to sand mining in the Western Cape is excellent, but enforcement is lacking. RSP2 further stated that the competent authority is DMRE, while DEADP is the commenting authority:

RSP2: *Uhm, the legislation is structured good to obviously, to try and manage or minimise or even trying for impacts to be avoided as the result of sand mining, but however, we don't always get it right because there's obviously, sometimes you have political influence and those types of things and seeing that we also not the competent authority anymore with respect to the EIA legislation and the mining stuff, so Department of Mineral Resources don't always take our comments into account. Sometimes, we will object to something, but then you know, they override us, so ja, because in this, for the sand or at least for any mining stuff, we're now only a commenting authority and not the competent authority anymore.*

From this statement, it can be deduced that regardless of what certain parties involved in the decision-making object to, they can be superseded by the competent authority and even political parties may influence decisions that are made and therefore the end result showing the polemic of inter-competent authorities' disagreements. This polemic is further demonstrated by Ashton (2016) and Yeld (2017). In 2016, the Green Scorpions investigated the premises of the Tormin Mineral Sands mine without informing the competent authority [the DMRE]. There were multiple complaints about illegal mining practices that occurred at the Tormin Mineral Sands mines, as well as the collapse of coastal cliffs. This case was however lost by DEADP, as the DMRE agreed with the Tormin Mineral Sands mine that the DMRE did not approve the raid that had occurred, and was thus done illegally, resulting in the Tormin Mineral Sands mine winning the court case. These events were confirmed by RSP3, stating that there was a lack of collaboration between the competent and commenting authorities, resulting in conflict between these departments. Ashton (2016) states that "DMR appears to have insufficient capacity, knowledge, or will enforce good environmental governance. This has been evident at Tormin" (para. 12), which implies incompetence by the competent authority.

RSP3 agreed that the legislation was excellent, and that enforcement was lacking, but further stated that owing to DMRE being the competent authority and DEADP being the commenting authority, there was a tendency for "drama" between the two departments. This is a different opinion from that of the DMRE representative (RSP1), as DMRE stated that both legislation and enforcement were good. This in itself could also be the reason the DMRE representative was evasive regarding the questions asked, specifically about the enforcement.

RSP2 was asked about the positive and negative impacts of sand mining, to which the respondent stated that there were social impacts such as job creation and sand for developments, but there was a cost to the environment:

RSP1: *There is positives in terms of that, but with mining, it's very intrusive and it's like you never get the environment back to what it was… it's actually a win-lose situation… even if you rehabilitate, it will never be what it was before, so it's, technically you're rehabilitating, but it will always be a different use thing; the end-use will be something else.*

This is an interesting notion, as RSP1 stated that rehabilitation was not always the strategy chosen by mining companies once a mine closed down. A mine may propose a different land-use once the mine is decommissioned, such as building houses in the area. This is because what is proposed after decommissioning is dependent on the surrounding area and where the mine itself is located. However, RSP1 had a stance on rehabilitation which was that, if it was implemented with strict mitigation measures, then rehabilitation could happen effectively. Again, this is a difference in opinion between DMRE and DEADP, with both DEADP representatives taking the stance that rehabilitation is not effective, and the previous vegetation could never be adequately restored. This reflects a polemic theme of inter-competent authorities' disagreements, as when the competent authority and commenting authority pertaining to environmental matters are in disagreement. This is problematic because of conflict of interests and ultimately a lack of enforcement based on what has been stated within the interviews. Green (2012) discusses the polemic of inter-competent authorities' disagreements, referring to conflict between the competent and commenting authority in relation to regulations and enforcement, and this is undoubtedly an enduring problem.

RSP2 directly refers to the Tormin Mineral Sands Mine when asked about the extent of sand mining on the surrounding and adjacent vegetation, stating that the company got approval for their plans, but they did not adhere to it, and instead extended their operations without approval. This is likewise mentioned by RSP8 who, referring to the Tormin Mineral Sands mine, stated that the extent to which they will mine, and then they continuously extend, not keeping their "word". These expansions are concerning for botanists, as many species are lost. RSP2 also states that these mining companies just assume that it is random "bossies" [bushes] surrounding the site, not knowing what it is or the endemism. This addresses the polemic theme of conservation-development, as development appears to be prioritised over conservation, having the study sites located within critical biodiverse areas. Rist (2009) argues that there is a contradicting goal between development and conservation, and one should work towards sustainable development, rather than favour development or conservation solely.

4.3.4 Mine Representatives

4.3.4.1 Maccsand Mining and Quarrying

The interview with the MaccSand Mining and Quarrying representatives occurred on-site near Macassar. Arrival was at 10h00, at which time, many discussions which were not recorded took place, off-the-record information was shared, and new workers shared information. With permission from the respondents, two of the conversations were audio recorded, but other conversations were not, only documented in writing during the interviews. The interviews took place in office space, as well as during on-site walkabouts. Photographs were also taken during the walkabouts.

MaccSand Mining and Quarrying first applied for approval to start a sand mining company in 1993 and received their approval in 2000. The mining operations then began in June 2000 and the mine has been operational ever since. MaccSand Mining and Quarrying has also had court cases against it pertaining to legislation issues in 2011. The issue surrounding this mine involved different pieces of legislation – Land Use and Planning Ordinance (LUPO) of 1985 and Mineral and Petroleum Resources Development Act (MPRDA) of 2002 – which are provincial and national legislations respectively. The Macassar land use permit was authorised by the MPRDA, but the City of Cape Town argued that the MaccSand mine did not have the appropriate zoning permits as per LUPO. National and provincial legislation need to be upheld, for mining application approval and for this reason, MaccSand CC needed LUPO approval for the mine and not just that of the MPRDA. MaccSand CC thus abided by this regulation, submitted their regulations to LUPO and in the end, after the permits were approved, MaccSand was able to continue their mining operations (SAFLII, 2011). This was corroborated by RSP7 during an interview, who stated that although MaccSand Mining and Quarrying were shut down, the neighbouring mines were allowed to continue operations despite officialdom knowledge of the discrepancy.

According to RSP4, the biggest challenge faced by the company was the implementation of, and changing, environmental laws and their application. One of the biggest challenges reported across was also that it is a coloured-owned operation. It was also stated, rightly or wrongly, that racism is still a huge factor in the system, as certain officials were uncooperative and favour the two-neighbouring white-owned sand mines. The largest positive impact pointed out by these representatives was the community involvement and upliftment the company does, addressing their interests, investment, and collaboration with the community. MaccSand Mining and Quarrying contributed to the upgrading of schools, building of additional classrooms, and facilitating outdoor environmental education to learners through mine-site visits during which an appreciation for vegetation and surface rehabilitation is fostered. One respondent said:

RSP4: *When mining is done properly and within the law, and I don't know if you stated it, but you bring man and land together.*

Challenges that have been faced by the company were then discussed, such as sand blowing into the Khayelitsha township, and MaccSand Mining and Quarrying being accused, when the neighbouring mine is closest to Khayelitsha and has no mitigation measures in place to ensure that sand does not blow into the surrounding suburbs. According to RSP5, MaccSand Mining and Quarrying has mitigation measures for the sand blowing, by means of suppressing the dust blowing through watering. In contrast to the neighbouring mines, MaccSand Mining and Quarrying have water trucks as part of the dust-suppression mitigation. According to RSP5, the topsoil was also stockpiled and returned once the sand had been mined. Afterwards, the species which were in the area grew back. Allegations against the neighbouring sand mining companies, such as an illegally built weighbridge were made but could not be verified by this study (See Appendix D for more information on the weighbridge allegation by RSP7). RSP4 also indicated that MaccSand Mining and Quarrying was closed due to zoning irregularities from different governments as discussed prior, but the neighbouring mines were allowed to continue operations. Feris and Naidoo (2013), who argue that Tronox KZN Sands (Pty) Ltd were allowed to continue mining operations although they also did not have the LUPO zoning right, which could support the notion that MaccSand Mining and Quarrying may have been a target once mining approval was obtained.

According to RSP4 and RSP5, it is nearly impossible to close a mine due to all the laws, regulations and departments who need to approve the closure. RSP3 corroborated this, stating that they were unaware of any sand mine closures occurring or having occurred in the past 20 years. According to Mpanza et al. (2021), the trend in South Africa is that actual mine closures barely occur, but mines are rather abandoned or sold to another entity, shifting the environmental responsibility. Watson and Olalde (2019) state that a mine cannot get approval for closure unless an agreed upon amount on rehabilitation is met, and there is an overall lack of information pertaining to mining in South Africa. Mpanza et al. (2021) further state that a reason for abandoned mines is lack of enforcement, lack of responsibility or lack of accountability from the DMRE. Watson and Olalde (2019) thus make the ironic statement that the DMRE, the competent authority in South Africa, is incompetent. It was noted in Chapter 1 that the areas with the most mines are Malmesbury with 31 mines, followed by Vredendal with 16 mines, and then Cape Town and Riversdal each with 12 active mines located there. According to the graph, Murraysburg and Mitchells Plain have the least number of mines, both having one mine at each location. This is however questionable as according to RSP4, in 2020 alone, MaccSand CC closed 17 mines, which were located in places between Eersteriver to

Khayelitsha, suggesting that there are many more mines located in these areas than what are publicly listed on the DMRE (2021) website. Watson and Olalde (2018) state that special permission and access is needed to gain full access to information pertaining to mining by the DMRE, and this proposes that all the current mining companies may not be listed on the DMRE website.

The MaccSand Mining and Quarrying mine does not have a website or any information regarding the mine and its operations online. There is no record of an EIA, EIR or scoping report available for public consumption, but only the record of court cases of 2011 and 2016 from when the mine was under scrutiny owing to the regulatory inconsistencies. Interviews conducted with representatives of the mine cast light on certain practices and operations as discussed.

4.3.5 Interested and affected parties

4.3.5.1 Activist

Many topics which were not included within the interview questions were brought up during this interview. Two polemics which arose in this interview were that of officialdom-information sharing and Civil-society lobbying groups. The officialdom-information sharing polemic relates to scare tactics associated with silencing interested and affected parties pertaining to mining operations. Civil-society lobbying groups' polemics relate to civil society organisations (CSOs) fighting against the Tormin Mineral Sands Mine.

The interviewee indicated that SLAPP suits were issued against anyone who spoke against the MSR Tormin Mineral Sands mine in Lutzville. This is corroborated by Emmamally (2022), who indicates that SLAPP suits are a means to silence and deter public participation, referencing the SLAPP suits from MSR (Tormin Mineral Sands). The Centre for Environmental Rights (2022) also fingered these SLAPP suits, stating that new protection for activists will be provided against SLAPP suits, after MSR Tormin Mineral Sands had filed SLAPP suits against 6 activists and public interest lawyers in South Africa.

Many issues surrounding corruption were brought up and the “silencing” of anyone who stood against the mining company. Owing to this, many people standing against the mining company did so “underground” (RSP6), as it was dangerous to stand against a mining company. There was an allegation made of assassinations occurring on individuals who stood against MSR and

MRC, specifically mentioning someone from Xolobeni which is located in Mbizana in the Eastern Cape province (Sibane, 2012). Sole (2023) also points to the murder of the said activist from Xolobeni, stating that a Hawks member attempted to derail the murder investigation into the murder of the activist. Hawks is also known as the Directorate for Priority Crime Investigation (DPCI), created to target organised crime, corruption, and much more (Montesh, 2013). It has been speculated that the death of the Xolobeni activist was related to opposition of an Australian mining company. This was, however, not pursued since it was beyond the scope of the study.

During this interview, it was also raised that the flora in the area was being affected, because in summer, there were no longer beautiful flowers which bloomed, and the bird species at the Olifantsrivier breeding ground were being impacted. It was also indicated that the fish species within the area had also been affected in Doringbaai, such as Snoek, resulting in fishers having to go further into the ocean to catch crayfish as there is less fish in the rivers. It was also stated that mining was happening opposite the Papendorp community, impacting marine species.

The polemic of officialdom-information sharing also came forth when RSP6 stated that someone stood against the Tormin Mineral Sands Mine and feared for their life for doing so, which then resulted in an inability to find employment. RSP6 stated that the mining company manipulated the community into deeming the community member an outcast by retracting funding from the community and placing the blame on said person for criticising the company.

When asked about the stakeholder engagement and its sufficiency, RSP6 stated that it occurred, but MSR Tormin Mineral Sands held it at a location in Vredendal only, and many community members could thus not attend as there was no means to get there. For context, it is a 22-minute drive from Lutzville to Vredendal, and alternatively, a five-hour walk (GoogleMaps, 2023). Furthermore, there was allegedly someone who wrote an article on the events pertaining to the Tormin Mineral Sands mine, but this person was then verbally attacked by the community members and taken to court, where the journalist lost the court case. The court case was lost, as those mentioned in the article stood against the journalist, stating that what had been written was dishonest. The workers at the MSR Tormin Mineral Sands Mine who joined unions were all dismissed as well, at which point those dismissed took the mine to court, and they won the CCM cases, but then lost the labour court case, resulting in these workers struggling to find work afterwards. Gontsana (2015) corroborates that there was a strike by workers from the Tormin Mineral Sands mine and teargas was allegedly shot at the strikers, resulting in 27 workers being arrested and 25 being suspended. Gontsana (2015) also indicates unfair dismissals, salary cuts, and mistreatment of employees by the mining company. During the time of these strikes, a gyrocopter was shot down by the bodyguards of the Tormin Mineral Sands after an order from the company's general manager (Gontsana, 2015).

RSP6 also mentioned that there was an incident at one of the dams along the West Coast, where there was a coastal collapse and the mine simply fixed it by placing rubble into it, and for this reason, the community did not want MSR to be allowed to mine on the shoreline. According to Yeld (2018), there have been four sea cliff collapses since MSR began operations. The impact on the coastline can be seen in Figures 4.13 to 4.15.

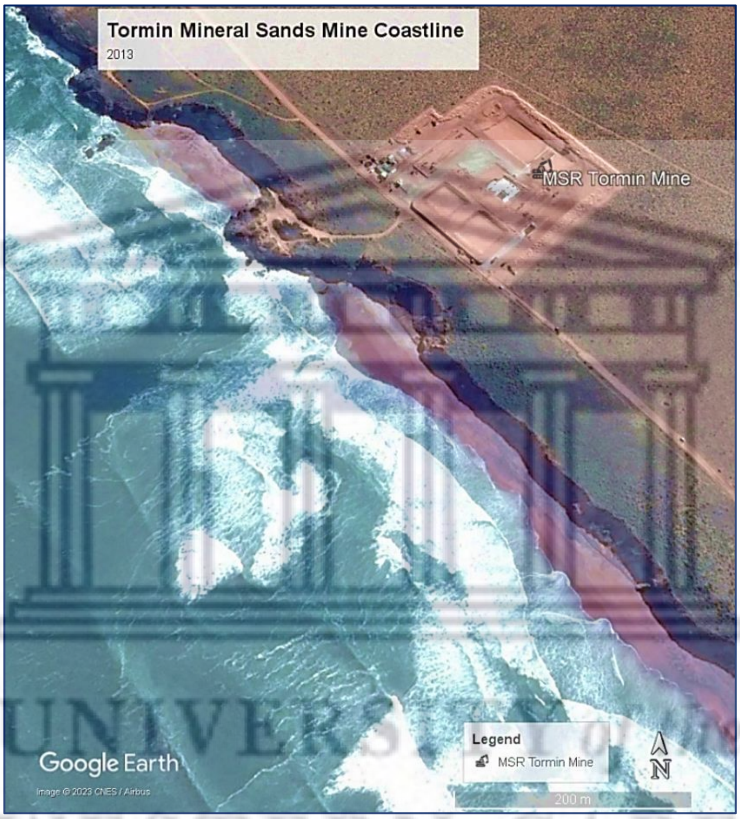

Figure 4. 13: *Tormin Mineral Sands coastline 2013. (**Source**: Google Earth Pro)*

Figure 4. 14: *Tormin Mineral Sands coastline 2016, after sea cliffs collapsed. (**Source**: Google Earth Pro)*

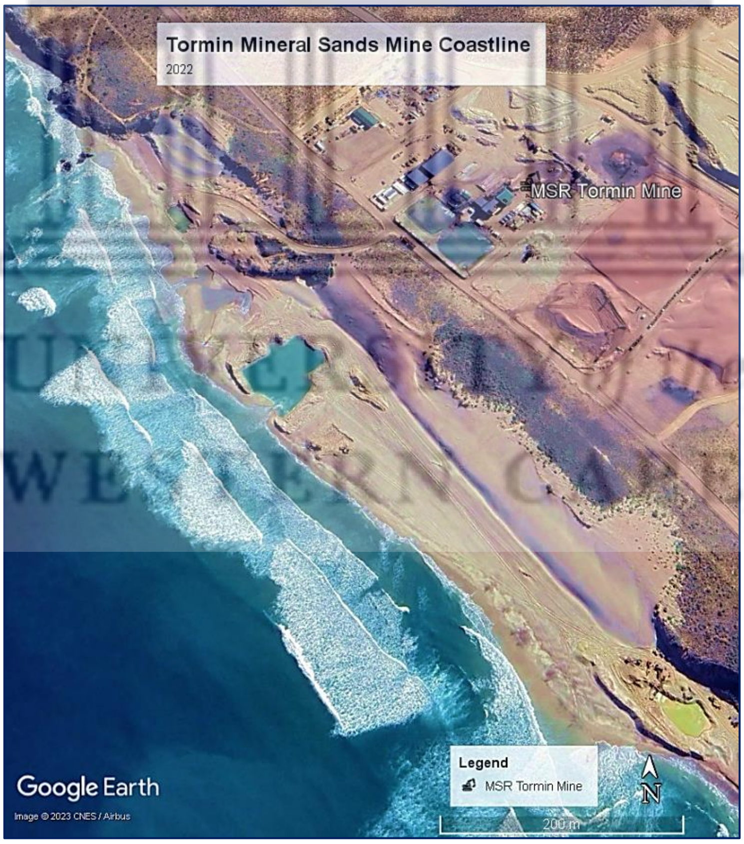

Figure 4. 15: *Tormin Mineral Sands coastline 2022. (**Source**: Google Earth Pro)*

Figure 4.13 shows the coastline when MSR Tormin Mineral Sands began operations in 2013, and Figure 4.14 shows the coastline after the sea cliffs collapsed in 2015. Figure 4.13 shows the degradation of the coast within the period of only three years, while Figure 4.15 shows the coastline today. It can be seen in Figure 4.15 that the sand mining occurring on the beach and the shoreline is being pushed back to provide more sand to mine. It can also be seen that the entire coastline has almost completely collapsed, as it is now covered with only sand and barely any coastal rocks. According to SACSIS (2015), the Tormin Mineral Sands company changed its mining practices without permission, building illegal hard breakwaters and jetties on the beach. RSP6 indicated that the trucks from the mining company have also damaged roads; some of the materials are radioactive and there is a lack of proper management of materials.

RSP6 said the radioactive materials were stored within the Lutzville community, and the community had appealed the storage of said radioactive material. RSP6 stated that the Tormin Mineral Sands mine takes advantage of the residents in Lutzville, as they are predominantly a rural area and do not have much knowledge pertaining to sand mining impacts, regulations, and so forth. Due to this, the community reached out to NGOs to educate them on regulations and laws related to sand mining operations, but there is lack of accountability and assistance from Tormin Mineral Sands to assist the community gain the needed knowledge relating to mining operations.

An effort at bribery was also allegedly attempted with RSP6, and it was refused. RSP6 stated that they will "speak for the community and not be silenced", adding that since there is a new ruling party over Matzikama, there is less corruption, and the municipality must investigate projects and the needs of the community. The concept of political influence on mining operations and approvals was also addressed by RSP2, a representative of the Department of Environmental Affairs and Development Planning.

4.3.5.2 MaccSand I&AP

The MaccSand I&AP interview was roughly 30 minutes long. Although the questions were based on the MaccSand Mining and Quarrying company itself, the interviewee chose to focus on the neighbouring mines – SSB and AfriMat whose location can be seen in Figure 4.16. MaccSand Mining and Quarrying is bordered by two mines – SSB and AfriMat – indicating that cumulative impacts may be present in the area, as multiple mines within the same area have been found to impact on the water table and affect endemic and local species within a region.

The allegations made against SSB and AfriMat are not discussed or elaborated on, but can be found in Appendix E, as these operations fall outside the scope of this study.

Figure 4. 16: *Location of MaccSand Mining and Quarrying relative to neighbouring SSB and AfriMat Sand mines. (**Source**: Google Earth Pro)*

RSP7 felt that MaccSand Mining and Quarrying had done an excellent job regarding rehabilitation and thus they had nothing negative to say about the company. The respondent alleged that the neighbouring mines did, however, lack rehabilitation, as they have exceeded their mining rights and sold their topsoil. RSP7 acknowledged that it was illegal to sell topsoil and stated that they (RSP7) bought topsoil from the company which is how they know that they sold it. Further allegations were made stating that so much sand was removed at the location, that there were large holes which remained, which the company then filled with concrete, cement, and rubble. It was also alleged that sand blowing from a neighbouring mine blocked the Macassar Wastewater Treatment Works pipes, but Green et al. (2018) and Gaffar (2021) contradict this statement, stating that the cause of blocked pipes is an excess of nutrients and significantly stronger wastewater than the plant can manage, as it was built over 40 years ago and has not been upgraded since then.

When addressing the positive impacts that MaccSand Mining and Quarrying has, if any, RSP7 stated that the company was providing many people with sand and helping the surrounding and neighbouring communities. Examples of the aid included the building of a school in the coastal town of The Strand and financial assistance to the local mosque in Macassar. Further assistance was provided by the company when there was a storm and roads flooded in 2021. MaccSand Mining and Quarrying, according to the participant, sent out their loaders and equipment to clear the roads for free, which is the job of the City of Cape Town. According to RSP7, MaccSand Mining and Quarrying also cleared bushes along Macassar Road in which thieves would hide and then mug people who walk by. RSP7 was asked about stakeholder engagement meetings, and said that the meetings are sufficient, as all residents were made aware of the meetings and they were held at the local Macassar civic centre, which all residents knew of.

The polemic of conservation-development is raised with RSP7, and it is clear when it was mentioned twice during the interview that species in the area were more important than providing employment for people. The statement below addresses the conservation-development polemic, as the coastal dunes within Macassar are within a protected area, and within critical biodiversity hotspots.

RSP7: *Because I can tell you, back in the day, I applied there, the City of Cape Town was the first people to tell me there's a certain plant growing there. So, that plant is so important? But for the economy it's going down.*

RSP7: *It's just negative because there's a certain flower that grows there, I dunno, it's gonna cure hunger, I dunno. That flower is more important than giving somebody a job.*

Although this response is not representative of all and sundry in the area, it reveals, albeit subjectively, an important spatial dimension that enriches the understanding of the continuing polemics (as discussed in Chapter 6).

4.3.5.3 Botanists

Two botanists were interviewed for the study. RSP8 is a field botanist with a focus on a specific species and RSP9 is a botanist for an environmental company who does EIAs. The polemic which arose from the botanists is that of Conservation-development and rehabilitation-development polemics. The conservation-development polemic relates to RSP8 addressing the issue of the Tormin Mineral Sands mine operating along the West Coast, which is home to thousands of endemic species. The rehabilitation-development polemic pertains to RSP8 addressing the lack of rehabilitation occurring at the Tormin Mineral Sands mines, while they are continuously expanding their mining operations.

According to RSP8, the MSR Tormin Mineral Sands mine is of concern as sufficient regulation in terms of rehabilitation and environmental legislation could not be seen. It is a concern that mining is being approved in sensitive areas. For context, according to DEA (2010), South Africa ranks as the third most biologically diverse country in the world and contains three of the world's 34 biodiversity hotspots. As such, South Africa is of major global importance for biodiversity management and conservation. While biodiversity is essentially everywhere, some areas are more important than others in terms of the biodiversity that occurs there. South Africa has the benefit of good spatial and non-spatial biodiversity information and has good systematic biodiversity assessment and planning specialists in the identification of priority areas for biodiversity management and conservation. RSP9 stated that they had heard that the MSR Tormin Mineral Sands mine operations were not sustainable, and that dune systems had been destroyed, but there was no first-hand knowledge of it. The major concern that the botanist raised was the loss of vegetation along the West Coast due to the area's species diversity and richness. The species richness was due to the high turnover. A high turnover means that every 1 or 2 km you travel along the West Coast, a new endemic species can be found. It was further stated by RSP8 that each botanist had a specific lens through which they saw:

RSP8: *Botanists have a special lens which they see through… Firstly, there's a taxonomic lens. Secondary, they cannot be everywhere, so they do representative areas, and how representative are those areas? It is impossible to say. So, there will be things that will be missed, and stuff [species] will be lost as a result.*

RSP8 thus referred to the idea that the speciality of the botanists chosen by mining companies to inspect the sites may be with a different specialty or interest than that of the species at the site. This would result in endemic species being overlooked within an area. Furthermore, representative areas are chosen at mining sites. This means that an area is cornered off and the species within that space – usually a square - is checked and noted as a representation of the entire site. According to RSP8, this is unfitting in areas with such a high turnover, as species will definitely be missed and lost.

RSP8 mostly had concerns regarding sand mining operations and stated that the only positive associated with it would be economic development, which RSP8 mentioned thus:

RSP8: *The positive aspects of mining are economic development, which is a double-edged sword because with it cones greater impacts and empowerment of people resulting in spending more. Development encourages more development… there are positive impacts on people's lives associated with the land, i.e., job creation. No benefit to farming or nature. So, only people's lives and their pockets are positive.*

RSP8 thus implies that the main priority associated with sand mining is people and economics and not the environment itself, which is crucial in the concept of sustainability and sustainable development. RSP8 also gives an example of a mine which was built in Langebaan, and this development attracted more developers and developments to be built in the area. The same can be applied to the case of MaccSand Mining and Quarrying, as it was established on the False Bay Coast near Macassar. After its establishment, people began to build shacks on the dune systems near the mine, and these shacks are located within a protected area (Graham and Ernstson, 2012). RSP7 also mentioned these dwellers when he stated that sand mining applications were rejected by the City of Cape Town based on it being a protected area or due to endemic vegetation growing in the area, but when people put up shacks in the same location, nothing is done.

The representatives of MaccSand Mining and Quarrying stated that they were very proud of the rehabilitation at the site, as they were the only mine within the area that rehabilitated successfully. However, it is important to note that RSP9, who has a specialisation in botany, stated that:

RSP9: *It's very difficult to rehabilitate an area once that integrity has been disturbed. They are also putting aside the topsoil and reincorporating it several months later when the stuff, a lot of the perennials and stuff like that may have been able to reroot will have died. So, you only have your longer-term propagules surviving. So that's something that ought to be addressed. And then they're reprofiling it which is an interesting concept, which puts it back to a facsimile of what it is from a topographical point of view. But the structure of the vegetation is going to be a very poor representation of what was there before. So, how would I rate the rehabilitation? Fairly poorly.*

The notion that rehabilitation is not very effective, and the previous environment cannot be restored is further corroborated by RSP2 and RSP3. This was also seen in Figures 4.4 and 4.5 which illustrate the previous vegetation density in Macassar prior to its removal, and after rehabilitation occurred. These figures illustrate that the rehabilitated vegetation growth and density are not the same as before. The conservation-development polemic also arose from RSP2 when the participant mentioned that the commodities mined were in fact needed, but endemic species were lost in the process and could not be restored to their previous state, displaying a feeling of hopelessness to the situation.

4.3.6 Summary of results

The interviews conducted were riddled with disagreements and differences in opinion related to the same topic. There is an array of polemics which were apparent from the interviews conducted, and once again, it shows that there is not a direct answer to many of the issues surrounding sand mining. It is however notable that the issues pertaining to sand mining companies and legislation have been an ongoing problem for many years. It is also notable that many of the issues are also directly related to the DMRE, as holding the title of the competent authority warrants a sense of accountability to be held and the law to be upheld regardless of the situation. The inter-competent authority conflict is also an issue, as it raises the question of whether those in charge ought to be and that there should be more transparency from the sand mining companies, as well as from the authorities.

Figures 4.17 to 4.19 are additional results which have been summarised into a table to show the overall responses related to positive and negative impacts associated with sand mining, and what the overall opinion on rehabilitation at sand mine sites are.

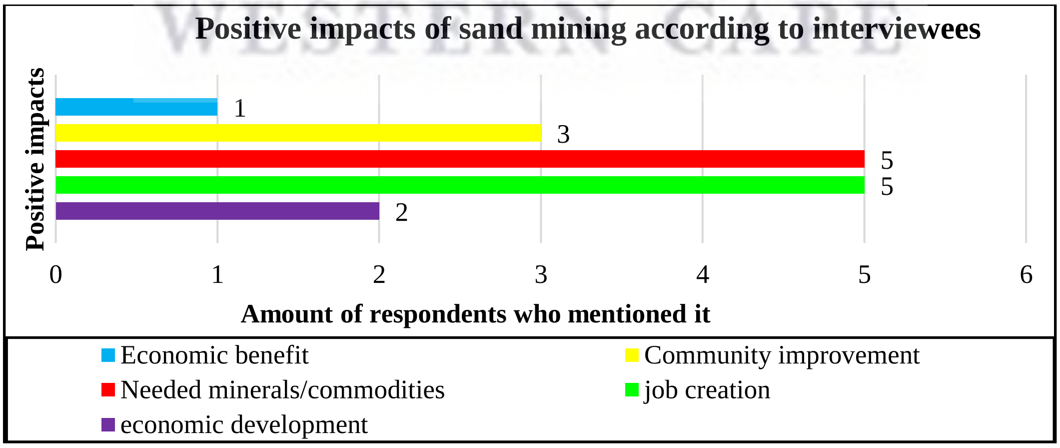

Figure 4. 17: *Interviewees' opinions on positive impacts of sand mining*

Figure 4.17 shows a summary of responses mentioned in the interviews relating to the positive impacts of sand mining. These positive impacts correspond to what was mentioned in the questionnaire survey, with the addition of community improvement, which was not included in the survey. Figure 4.17 shows that most of the interviewees mentioned that sand mining provides needed minerals or commodities, and employment opportunities.

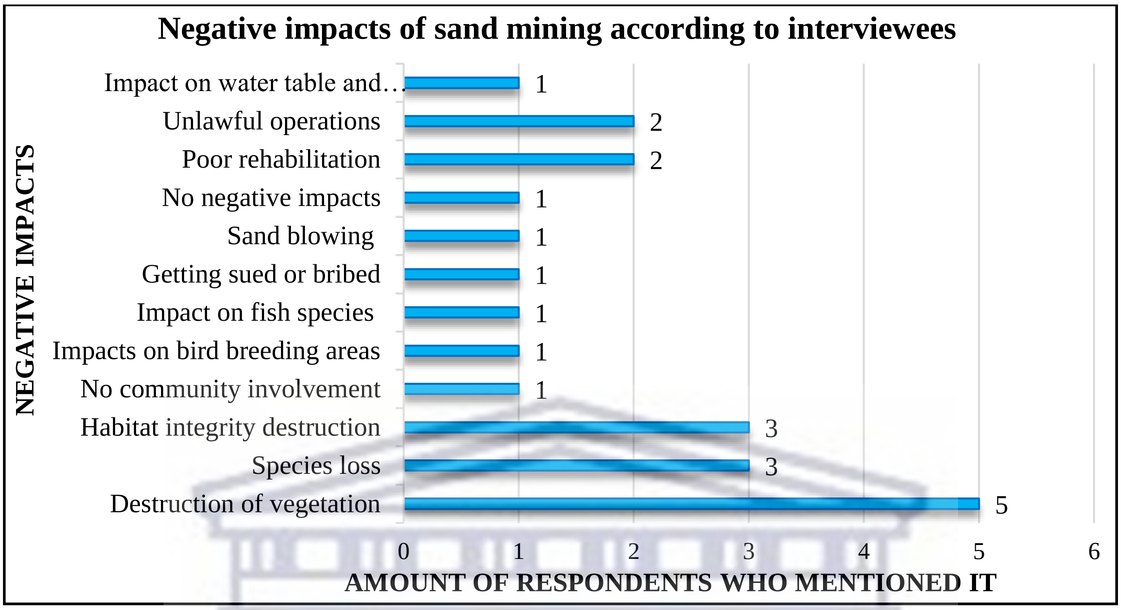

Figure 4. 18: *Interviewees' opinions on negative impacts of sand mining*

Figure 4.18 shows a summary of the negative impacts which arose from the interviews in relation to sand mining operations. The results are much more than that which arose in the questionnaire surveys, addressing habitat integrity destruction, unlawful operations, and impacts on the water table as well as on wetlands. These responses indicate that the interviews were much more rich than the questionnaire surveys, and a reason for this could be that the interviews were a formal conversation, and the questionnaires were done online (Codó, 2009). The loss of vegetation/species and habitat is the most mentioned negative impact across the interviews conducted, and this correlates to the questionnaire surveys, because in the questionnaires, the most mentioned negative impact associated with sand mining related to environmental degradation and habitat loss.

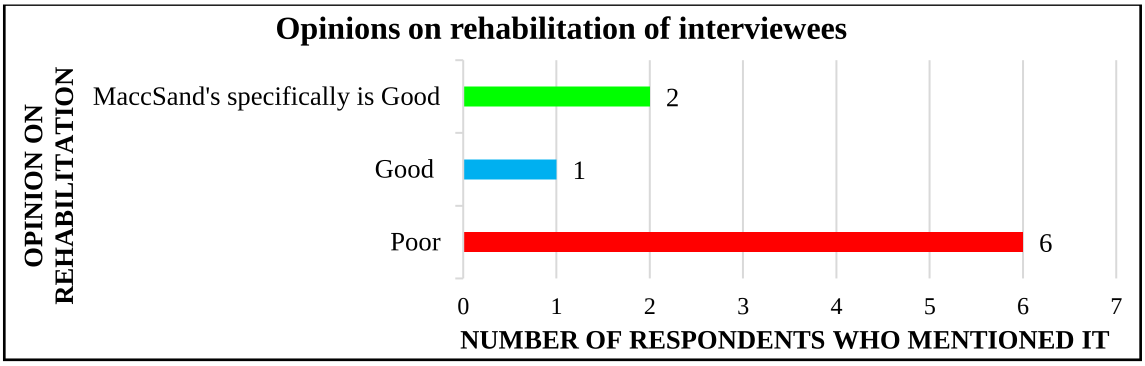

Figure 4. 19*: Interviewees' opinions on rehabilitation*

Figure 4.19 is a summary of the opinions on rehabilitation from the interviews. It shows that 66% of the respondents felt that rehabilitation associated with sand mining operations were poorly done, and that rehabilitation was barely ever done, and when attempted, it could not restore or replace the vegetation which was lost.

These interviews directly addressed the environmental desirability of whether mining operations should continue to operate at the study sites, and the answer is overwhelmingly that there is no environmental desirability, nor is there a socio-economic desirability, as there is little to no community involvement as indicated in the interviews done. Although there were interviewees who deemed that the sand mining operations should take precedence over vegetation in the area, most interviewees deemed that the environmental impacts were unsatisfactory. The overall judgement was that the species loss and environmental degradation had caused concern among interested and affected parties, believing that the environmental cost is not worth continued operations or extensions to these operations.

4.4 Stakeholder Engagement Meetings

4.4.1 Introduction

The stakeholder engagement meetings were about the Social and Labour Plans (SLP) of the MSR Tormin mine. The SLP was implemented in 2004 as a requirement for rewarding a mining right as per the MPRDA (Act 28 of 2002) (Insite, n.d.). An SLP is a 5-year plan and the SLP for Matzikama by the MSR Tormin Mineral Sands mine began in 2019, then 2023 would be the final year to meet its objectives (RP1, 2023). The SLP meeting discussed what funding was allocated to different agendas and what projects were included and meant to be included within the five-year period. It was transparent with how much precisely had been allocated, how much was used thus far, how far the projects were, which have been completed and which have not been. If a project is not completed within the five-year period, it would have to carry over into the new SLP for the following five-year period as an incomplete project (RP1, 2023). Although the stakeholder engagement meeting was meant to focus on the SLP and its progress, the community attended with suggestions prepared prior and questions regarding these projects addressed, as well as new ideas for the community. Out of 8 planned SLP meetings, two stakeholder engagement meetings were attended on Monday, March 27th in the coastal town of Doringbaai and the town of Vredendal, located more inland. The logistics/details of the meetings are summarised in Table 4.4.

Table 4. 4: Stakeholder engagement meeting details for Doringbaai and Vredendal North.

DETAILS OF STAKEHOLDER ENGAGEMENT MEETINGS		
Meeting information	**Doringbaai**	**Vredendal North**
Started	10h40	14h00
Presenter	Social and Labour Plan Specialist	Social and Labour Plan Specialist
Attendees	11	10
Focus from attendees	• Community upliftment and benefit • Community chosen projects for SLP • Funding for schools, etc. • New project ideas	• Community upliftment and improvement • Community chosen projects for SLP • Job creation • Old project queries which were not listed on the new SLP

4.4.2 Doringbaai Meeting

The stakeholder engagement meeting was meant to begin at 10h00, but only began at 10h40. The presenter stated that this was because the person who usually presented the SLP had been in an accident. In total 11 interested and affected parties attended. The meeting was a presentation informing the community about the Social and Labour Plan, its goals for the past five years, what was met, what had not been met, and the road ahead. The projects in 2019-2023 SLP encompassed fencing around the sports field in Lutzville, a freely provided extra Maths and Science tutor programme for all communities in the Matzikama Municipal district, shade ports to be built at frail care centres within Vredendal South, Vredendal North, Rietpoort and Vanrhynsdorp, and new borehole pumps to be built in Bitterfontein.

After the presentation was complete, questions from the attendees were entertained. It was disclosed that farmers in Matzikama were unaware of the zoning and which areas they would specifically fall into (RP2). RP3 stated that there was supposed to be a project at the "Doringbaai Vis Fabriek", which did not occur and there was no communication from the MSR Tormin Mineral Sands Mine pertaining to this project. It was found that Tormin Mineral Sands paid the municipality to do the projects, and they were not done as they were waiting on the appropriate government department for approval on the project since December 2022 (RP1). RP1 assured RP3 that this project to improve the 'Doringbaai Vis Fabriek' would happen as soon as approval was granted by the relevant government department.

It was further alleged by RP1 that the SLP projects were chosen from the IDP directly without research as to whether it was sustainable, feasible, or sensible. The community should thus be involved in the decision-making process pertaining to the projects chosen for the SLP, and in future, the community would have input. RP1 further stated that capital for community projects would have to be provided for by the Corporate Social Investment Fund, and that financial support needed to be split amongst all the towns in the Matzikama municipality. This was difficult as it only accumulated to about R22000 per annum, but RSP1 said they were in the process of establishing a CSI committee.

RP3 and RP4 then explored the situation on rehabilitation at the MSR Tormin Mineral Sands mining site. RP1 stated that there was a nursery on-site at which indigenous vegetation was kept and protected for reincorporation. RP1 did not know whether community members could visit the mining site, and it was not apparent who checks the rehabilitation at the site. Furthermore, RP4 raised the issue of poor communication and lack of response from the mine, to which RP1 shifted the blame to poor signal within the area. This was an unjustifiable response as the mine began operations in 2013, and as the world is in the age of technology, where such an excuse would not be satisfactory (RP5). At the end of the meeting, RP3 affirmed that there had been attempts to visit the MSR Tormin Mineral Sands mine, but the mine did not allow visitors.

4.4.3 Vredendal North Meeting

The stakeholder engagement meeting began at 14h00 at Vredendal North Thusong Centre. The meeting was the exact same as the previous one, as it was about the SLP, its progress, and so forth. There were 10 I&APs who attended the meeting. The attendees of this meeting did not wait until the presentation completed to ask questions, as they interrupted as it was presented. The questions asked surrounded the budget for the community projects, tenders for projects being provided to local businesses in Matzikama, and developments to uplift and empower the community. One of the projects suggested was a school for skills which provides needed skills to work at the MSR Tormin Mineral Sands mine. Attendees at the meeting asked if money could be re-allocated for projects that were found to not be feasible after scoping (RP7), and the presenter (RP1) agreed that it could be re-allocated, but indicated that it was a lengthy process, and the reasoning would need to be excellent for it to be approved. RP1 stated that rather than a re-allocation of funds, the project could be altered to be more feasible or suitable but remained at the same location as initially selected. If a project was incomplete, the project carried over into the new SLP as a backlog project, as it needed to be completed once included into the SLP (RP1). It was said that Tronox did more for the community than MSR, as they provided money to the Matzikama Trust whereas MSR did not (RP6). RP1 responded by stating that the SLP for Tronox and MSR would need to align, or they would need to sit-down and discuss doing combined projects within the community, as they could not overlap projects, and planning them correctly would be difficult.

RP6 stated that children in the community needed to be motivated by building infrastructure for them or starting projects in the community to uplift them. RP7 added that being a part of a project and collaboration on projects motivates you and empowers one. RP6 brought up that alternative water sources were needed in the community in case of drought, as the Olifantsrivier could supply Vredendal during droughts. Projects surrounding water supplies are thus needed in the community.

RP1 stated that they were working on the Xolobeni Maths and Science project, to which the I&APs present commented: “Ignore Oos-Kaap. They don’t care about us.” This indicates that there is a mine owned by MSR operating within Xolobeni as well, but the respondents wanted the focus to be on the issues in Vredendal North, and their concerns, not other Towns. The meeting continued and the last significant comment made by RP6 during the meeting was that the MSR Tormin Mineral Sands mine did not build a clinic, roads, or housing for their workers, and that the mine needed to think 'bigger' in terms of the projects that they did as well as that they needed to consider the legacy they would leave behind.

4.4.4 Analysis of I&AP meetings

From the community meetings held, it can be ascertained that there were serious bread and butter issues which arose. This perspective of communities is a crucial element in understanding not only the polemics associated with the mining operations per se, but also those prevalent in the adjacent communities as well. It is one perspective to investigate the phenomena and impacts of a sand mining company on the vegetation and neighbouring communities, but it is an entirely different perspective once you attend a stakeholder meeting with community members and ascertain their viewpoints on it. In these meetings, the passion and concern of community members were very apparent.

Clearly, there was lack of involvement within these communities other than the SLP projects which could take up to five years to complete. Furthermore, community members asked for monetary contributions for schools and improvement of buildings, schools, etc., within the community, but unless it was in the SLP, the mine had no responsibility to do so or to assist. The communities also indicated that the projects for the SLP were chosen by the mine and did not incorporate ideas from the community, which they felt was crucial as they held most information pertaining to what was needed and what needed improvement within the community. RP1 of course agreed that choosing projects from the IDP is not the ideal solution and manner in which to choose projects, and stated that for the next five-year SLP, the community would be allowed to attend a meeting at which they could suggest projects. It was also interesting that each meeting had a focus on the specific suburb and its improvement, when there are 18 Towns and/or cities situated within the Matzikama Municipality and 8 wards (Matzikama IDP, 2020). RP1 implied that the Corporate Social Investment (CSI) is not provided unless someone applies for it. Therefore, if no one asks for monetary assistance, MSR could not provide it, and the budget was so small there was not much that one could do with the funding (R22000 maximum budget per year). However, within the Matzikama municipality, which is predominantly a low-income municipality, everything helps. RSP6 stated that during the COVID-19 pandemic, MSR provided food parcels to the Lutzville community, to which RP1 stated that it was provided because the community had asked for the assistance, and the food basket budget comes from the CSI budget, which would mean that there would be less monetary funds for other suburbs within the municipality who applied.

RP1 addressed the issue of job creation and the misconception that Tormin Mineral Sands is meant to provide permanent or part-time jobs to community members, as this was not a promise which the company ever made. There are requirements of employment which need to be met by those who apply, and only a select few from the Matzikama municipality meet those requirements according to RP1. It is however understandable why the interested and affected parties, as well as members of the Matzikama municipality, were putting pressure on the mining company for job creation, or opportunities in the community that could lead to employment in future. The reason is the high unemployment rate within the Matzikama Municipality as shown in Figure 4.20.

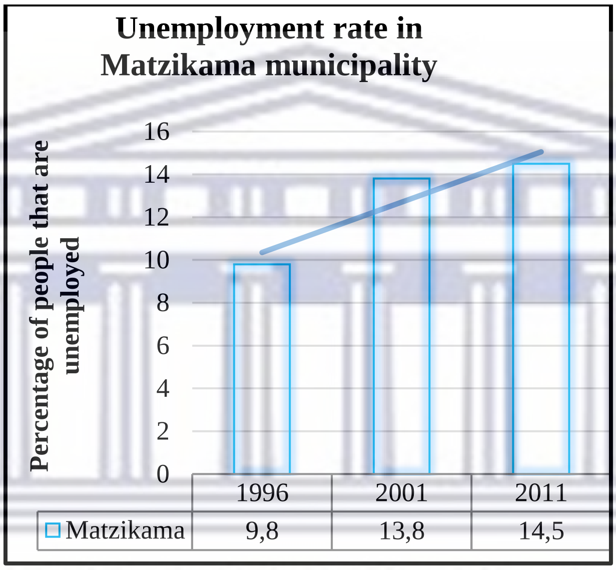

Figure 4. 20: *Unemployment rate in the Matzikama Municipality for 1996, 2001 and 2011. (**Source**: Adapted from StatsSA, 2012)*

Figure 4.20 shows the unemployment rate from 1996 to 2011 in the Matzikama Municipality. The new StatsSA census released in 2018 did not include the unemployment rates, but for the entire Western Cape province, the unemployment rate was 21.4% in 2011 (StatsSA, 2012) and it was 32.9% in 2022 (Githahu, 2022). Figure 4.20 illustrates that there has been an increase in the unemployment rate in Matzikama from 1996 to 2011, having a 4.7 increase in 15 years. Furthermore, the Western Cape unemployment rate increased by 11.5% in 11 years. These rates are alarming, and it can be deduced that the unemployment rate in the Matzikama Municipality would have increased since 2011, signifying that this could be the reason community members were very disappointed by the lack of employment, and passionate about employment opportunities from Tormin Mineral Sands, and other developments along the

West Coast. Although RP1 stated that it was misconstrued by the West Coast communities that there would be job opportunities once the mine was built, RSP6 stated that:

RSP6: *They [Tormin Mineral Sands] promised the community work. So, in the first place, a committee was established inside the community, but at the end of the day, some of them get jobs and then the community stand up against the mine by saying: "You did promise us jobs, but where's the jobs?". So, 28 people was locked up and the police was with the mine, so any action that people had, they were locked up.*

This statement by RSP6 not only disputes the claim made by RP1 but speaks to possible corruption in relation to the Tormin Mineral Sands mine operations. This is not addressed further, as these allegations are beyond the scope of the study.

One of the key issues that arose in the meetings was poor advertising of the meetings, as they were only posted in the local newspaper, and there was no social media coverage of meetings. This is a concern as the local newspaper costs R5, and there may be community members who may not be able to purchase it. RP1 guaranteed that in future, the community meetings would be posted on social media as well, to increase the coverage and attendance. RP1 also stated that the connection issues at the mining site would be addressed, to ensure that phone calls were answered, and emails were responded to, since one of the concerns which arose was the lack of communication and response from the mine.

4.4.5 Summary of Results

The stakeholder engagement meetings present bread-and-butter issues from the Doringbaai and Vredendal communities. It was apparent that the presence of the mining company had been accepted by these communities, and the mine was being held accountable for their actions, promises, and assistance. These communities rely on the mine representatives attending community meetings to assist the community with job creation such as tenders for their companies related to building improvements, etc. within the community, which come from the SLP. The communities indicate the need to be assisted by the mine, in creating opportunities for the necessary skills to be provided to the communities which are required to be employed by the mine. A suggestion for these skills to be obtained was building a technical school in the community, or an existing school being reconstructed to include the needed skills. It was stated that many of the young adults left the community because of lack of employment opportunities in the communities, and this was an issue that needed to be solved. It is of course important to note that the SLP representative only works on the SLP for the Tormin Mineral Sands mine and could not assist beyond the scope of the job held at the company. RP1 was unsure of whether rehabilitation occurred at the site, or if site visits were allowed. However, many of the participants at the meeting knew that visits were not allowed, as attempts to visit had been met with resistance. There is lack of transparency pertaining to the Tormin Mineral Sands Mine's operations, and this, according to Casey (2018), is quite ordinary in South Africa.

These stakeholder meetings directly addressed the socio-economic desirability of the Tormin Mineral Sands Mine, as the residents from these coastal areas along the West Coast rely on the mining companies – MSR and Tronox – to assist the community with employment opportunities not only at the mining site, but also through tenders given to companies within the area. There is also a reliance on the mines to provide funding for community projects and community upliftment, illustrating a possible positive socio-economic impact if the communities' needs and requests are met.

4.5 Chapter Summary

The analysis of the different surveys was quite interesting and informative. The information obtained showed multiple opinions, levels of knowledge, and different polemics which surround sand mining practices within these areas. The polemics surround the contestations between conservation, rehabilitation, development, the different authorities in charge of environmental legislation and enforcement, and the polemic surrounding speaking against large mining corporations. These survey results indicate that issues surrounding sand mining companies are large and the extent is beyond the scope of this study. The overall opinions about sand mining companies are extremely negative, with all survey analyses indicating that rehabilitation is insufficient and vegetation loss is very difficult, almost impossible, to restore. Multiple allegations were also made in interviews, some of which could be corroborated, and others could not. These allegations are beyond the scope of this study as well but were mentioned because although they are not directly related to the study, the allegations would affect and address the polemics at play pertaining to the study sites.

Based on primary research found, the polemics related to the chosen mines are therefore rooted in the biodiversity/ecological and regulatory concerns and rhetoric associated with the environmental and socio-economic desirability of the mining operations. This study thus investigated the polemics which arose from the survey questionnaires, interviews and stakeholder engagement meetings which gathered the opinions of interested and affected parties, as well as the opinion of authorities, and used GIS tools as a secondary data source to support or refute the statements made. Furthermore, these results indicate the difference in opinion between different parties involved, with those at fault taking no accountability, and those affected being extremely unhappy with the operations occurring. It is also apparent that these issues and contestations have been occurring for many years, and a solution does not seem imminent, because, with a lack of enforcement of appropriate legislation, there is so resolution to these matters. Perhaps the best resolution is a change of the competent authority.

CHAPTER 5: RESULTS II: DATA ANALYSIS OF SATELLITE IMAGERY

5.1 Introduction

As part of the biophysical component of the Socio-ecological Systems (SES) approach adopted in this study, the GIS applications in this section provide insight into the vegetation types and protected areas at, and in proximity to, the study sites. It also shows how the mining operations have been extended spatially and temporally and how this impacted on the vegetation. The applications and images also provide a sense of the level to which mandatory post-mining rehabilitation had been successful by using vegetation regrowth and cover as proxy. The results in this chapter are also used to corroborate or refute claims made in the opinion-based data - the interviews and survey questionnaires.

5.2 Accuracy Assessment

Figures 5.1 and 5.2 illustrate the results of the accuracy assessment points, as discussed in Chapter 3. There were 200 points generated to assess the accuracy of the satellite images.

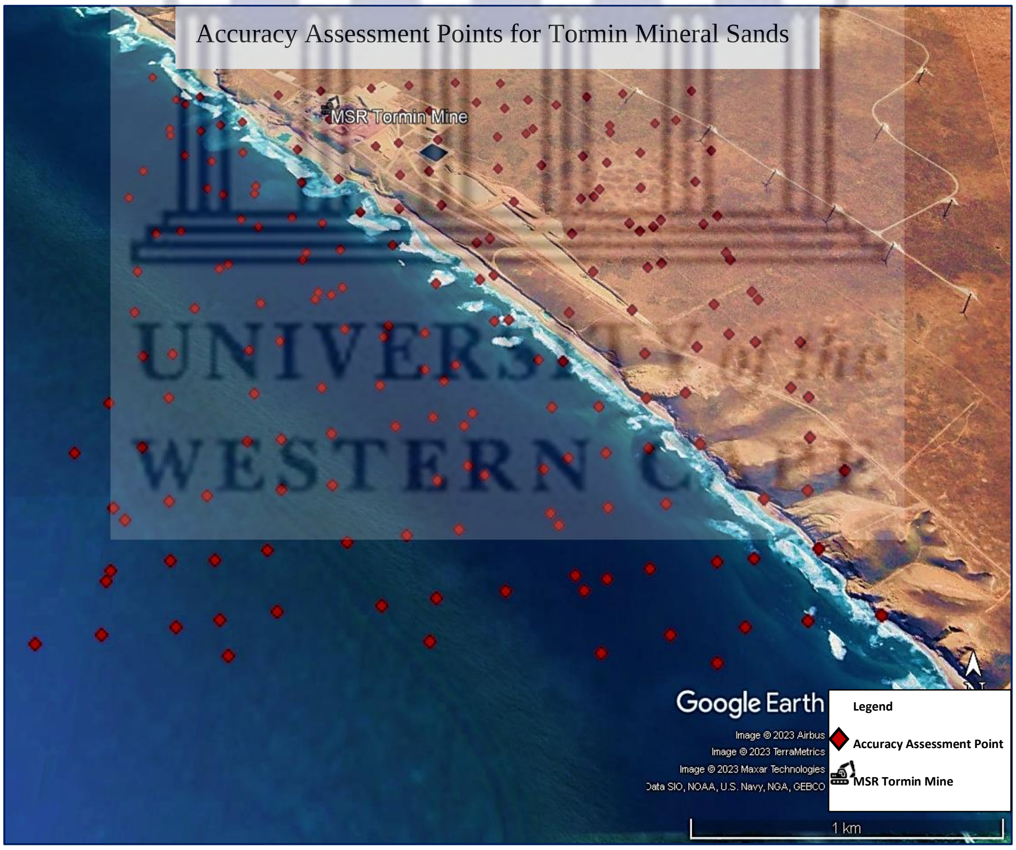

Figure 5. 1: *Accuracy Assessment Points generated and imported into Google Earth Pro to check accuracy using the ground truth value. (**Source**: ArcMap V.1.10.8 and Google Earth Pro)*

Figure 5.1 illustrates the accuracy assessment points which were generated using ArcMap. These points hold a value which represents water, sand, built-up areas, or vegetation, using the value selected in ArcMap. The points illustrated in Figure 5.1 are then randomly generated with the value selected in ArcMap and random land uses are categorised with the value. These randomly generated points are then imported into Google Earth Pro to cross-reference if the generated points correspond to the identified land classification chosen in ArcMap. Afterwards, a confusion matrix was generated, which indicates the accuracy of the satellite image as shown in Table 5.1. This table has a user and producer accuracy which was generated, as seen in Tables 5.1 and 5.2. The producer accuracy corresponds to error of omission and assesses how many of the pixels on the map are labelled correctly. The user accuracy corresponds to error of inclusion and assesses how many pixels on the map are what they say they are (Congalton and Green, 2008).

Table 5. 1: MSR Tormin Mineral Sands Accuracy Assessment for Land Classification. (Source: ArcMap V.10.8.2 and Google Earth Pro)

MSR TORMIN MINERAL SANDS MINE ACCURACY ASSESSMENT							
Class	**Water**	**Sand**	**Built-up**	**Vegetation**	**Total**	**User Accuracy**	**Kappa**
Water	123	4	0	0	127	0.968504	0
Sand	0	46	0	5	51	**0.901961**	0
Built-up	0	0	0	0	0	**0**	0
Vegetation	0	3	0	19	22	**0.863636**	0
Total	123	53	0	24	200	**0**	0
Producer Accuracy	**1**	**0.867925**	**0**	**0.791667**	**0**	**0.94**	0
Kappa	0	0	0	0	0	0	**0.886514**

Table 5.1 shows that for the Tormin Mineral Sands mine, the satellite imagery used was 94% accurate, with a kappa value of 0.88. The kappa statistic reflects the difference between the actual agreement and the agreement which is expected by chance. A kappa of 0.886 thus means that there is an 88% better agreement than by chance alone (Congalton, 1991). This indicates that the Soil-Adjusted Vegetation Index done for the area along the West Coast is 94% accurate.

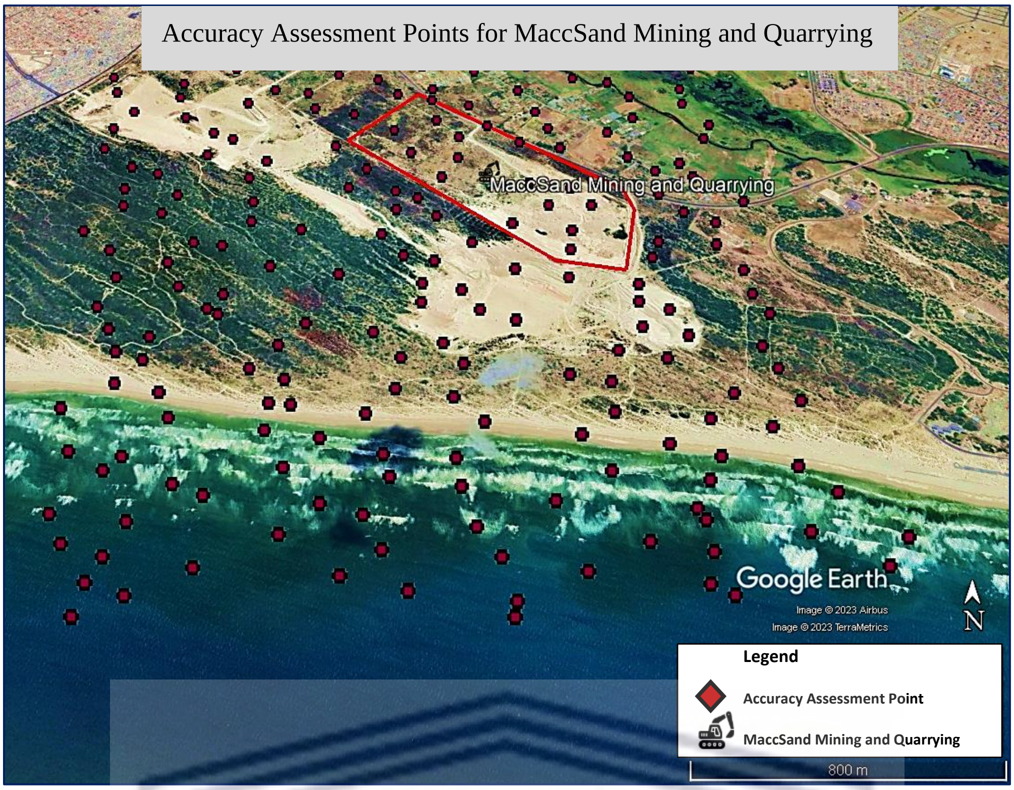

***Figure 5. 2**: Accuracy Assessment Points for the Macassar area, imported into Google Earth Pro to check accuracy using the ground truth value. (**Source**: ArcMap V.10.8.2 and Google Earth Pro)*

Figure 5.2 was generated the same way as Figure 5.1, and the accuracy of this satellite image can be found in Table 5.2. The land classes for Macassar were water, sand, vegetation, built-up/man-made areas, and bare land. The land classes were thus different for the satellite images, as this is based on land uses within the selected area.

Table 5. 2: MaccSand Mining and Quarrying Accuracy Assessment for Land Classification. (Source: ArcMap V.10.8.2 and Google Earth Pro)

	MACCSAND MINING AND QUARRYING MINE ACCURACY ASSESSMENT							
Class	Water	Sand	Vegetation	Built-up/ manmade	Bare land	Total	**User Accuracy**	**Kappa**
Water	49	8	0	1	0	58	**0.844828**	0
Sand	0	55	1	0	3	59	**0.932203**	0
Vegetation	0	2	63	0	2	67	**0.940299**	0
Built-up/ manmade	0	0	0	1	0	1	**1**	0
Bare land	0	5	1	0	9	15	**0.6**	0
Total	49	70	65	2	14	200	**0**	0
Producer Accuracy	**1**	**0.785714**	**0.969231**	**0.5**	**0.642857**	**0**	**0.885**	0
Kappa	0	0	0	0	0	0	0	**0.838375**

Table 5.2 shows that for Macassar, the accuracy of the satellite imagery was 88%, with a kappa value of 0.83. This would indicate that the satellite image for Macassar is less accurate than that of the West Coast image, but the kappa value falls into the category of a ‘strong agreement’, which indicates that overall, the satellite image is accurate, as can be seen in Table 5.2. This would also indicate that there is an 83% better agreement than by chance alone (Congalton, 1991). This further indicates that the Normalised Difference Vegetation Index done within the Macassar area is 88% accurate overall, which means that it would match real-world values by 88%.

Table 5. 3: Kappa Statistic Strength of Agreement. (Source: Adapted from Landis and Koch (1977) and McHugh, 2012)

KAPPA STATISTICS AND ACCURACY		
Kappa Statistic	**Strength of Agreement**	**Percentage of data that is reliable**
<40	Poor Agreement	<15%
0.40 – 0.80	Moderate Agreement	15-64%
0.81 -1.00	Strong Agreement	81-100%

Table 5.3 shows the kappa statistics and what the values in Tables 5.1 and 5.2 represent. As seen in Table 5.3, the kappa coefficient represents the strength of agreement between variables and how reliable the data is. It therefore shows the validity of the test (Viera and Garrett, 2005). The accuracy, precision, and reliability of the GIS data is vital and is dependent on the source data. For this reason, it was imperative to do analyses on the source data assessing its accuracy prior to completing the Geographic Information Systems data results (Detrekői, 1995; Rwanga and Ndambuki, 2017). Owing to a false sense of accuracy associated with spatial data, it is imperative to do an accuracy assessment to ensure that the data used are as accurate as possible, and to note exactly how accurate specifically (Thapa, 1992; Gumma et al., 2019).

5.3 Rainfall Data

The rainfall data for Lutzville along the West Coast and Macassar in the Cape Town Metro were obtained from the South African Weather Service. The data for Helderberg Kollege Station, near Macassar, for the years 1998 to 2023 were used, and the data of the Lutzville Hotel Station for the years 2010 to 2023 were used for the Tormin Mineral Sands Mine. The data from Lutzville Hotel were used as they were situated within Lutzville and are closer in proximity to Tormin Mineral Sands than the Koekenaap Station. The rainfall data provided by the South African Weather Service were provided in an excel spreadsheet. This excel spreadsheet was then re-tabulated and descriptive analysis was used to analyse the data, as the data were summarised and graphed, following Schutt (2014).

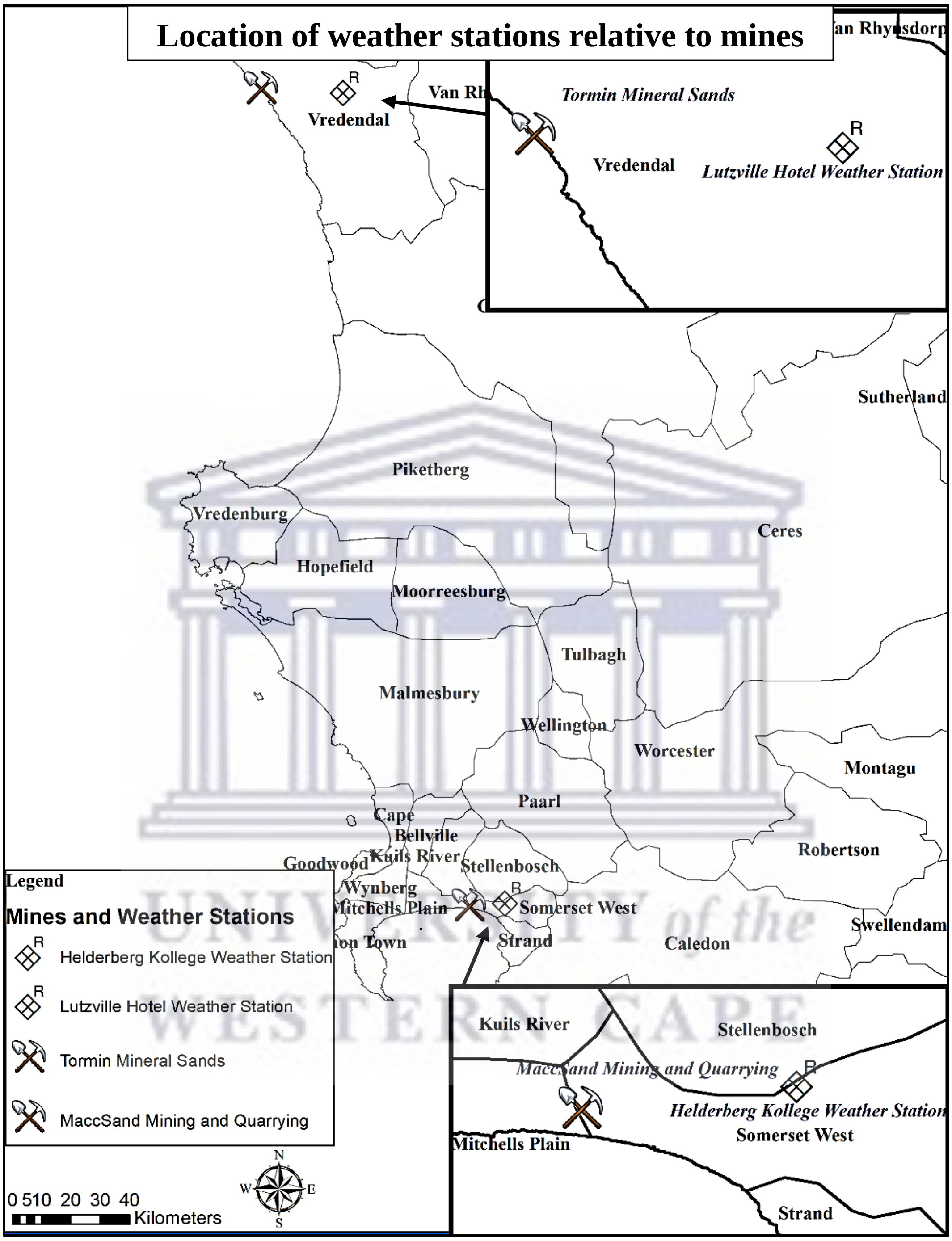

Figure 5.3: *Locations of Weather Stations relative to the Tormin Mineral Sands and MaccSand Mining and Quarrying mines. (**Source:** ArcMap V. 10.8.2)*

Figure 5.3 illustrates the locations of the weather stations used for the rainfall data in this study relative to its distance to the mining sites. As shown in Figure 5.3, the weather stations are in close proximity to the mining sites showing that the rainfall data in mm should be quite accurate for these locations.

Rainfall data is important in relation to the vegetation indices (NDVI and SAVI), because a decrease in rainfall would affect vegetation and would thus not be related to the mining practices. This study thus considered whether the annual rainfall had an impact on the vegetation at the study sites. The main source of water for plants is rain, but rainfall does not ensure a healthy crop, as factors such as water intake by plants, soil texture, topography, and soil evaporation influence the water intake as well (Geneti, 2019). Furthermore, plants also need light, plant nutrients, which this study did not investigate for the Strandveld species since it was beyond the scope of the study. The rainfall data also did not consider mist or fog within an area (Kumar et al., 2015), such as in Lutzville, yet this mist/fog may be sufficient for vegetation growth in this region. Descriptive statistics was used to calculate the sum of the annual rainfall data provided by the South African Weather Service, and this data was then graphed.

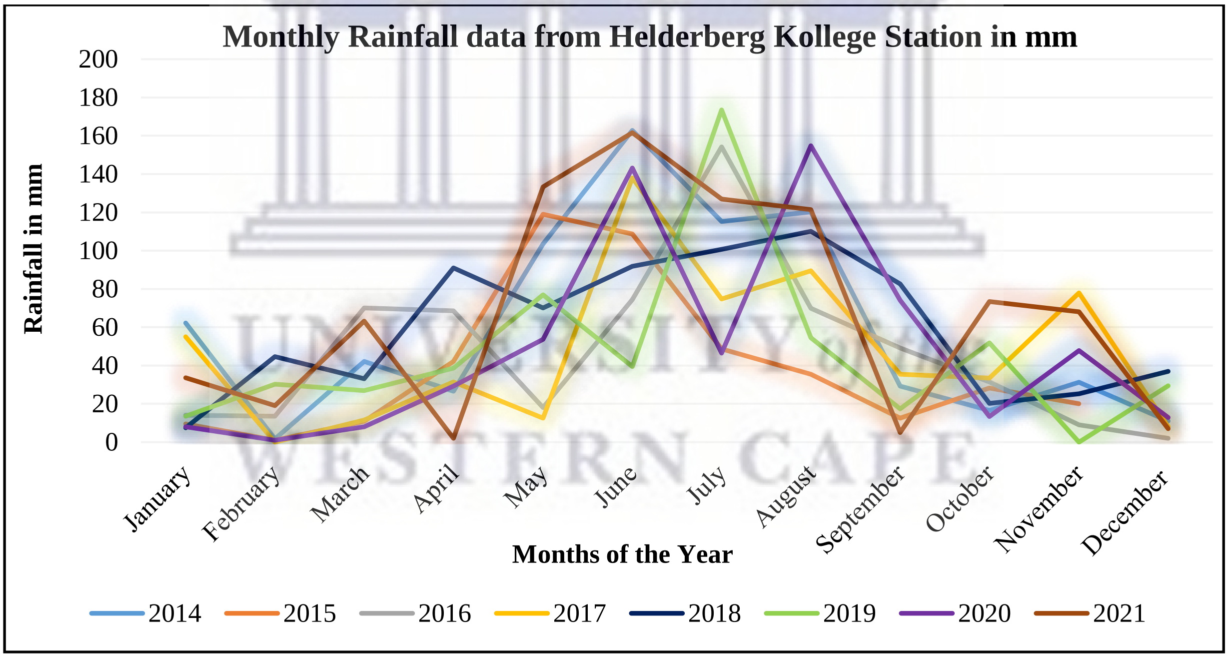

Figure 5. 4: *Monthly rainfall data in mm for the Helderberg Kollege station, 2014 to 2021. (**Source**: Requested and adapted from SAWS)*

Figure 5.4 shows that in 2015, there was a decline in rainfall in Cape Town. According to Muller (2018), in 2013 there was 1250mm of rainfall and this declined through to 2017, resulting in 700mm of rainfall in Jonkershoek. Toale and Molfetas (2019) state that the Cape

Town drought had affected Cape Town since 2015 and was triggered by an El Niño, and, thus, some areas in the Western Cape had not received rainfall since 2014. It was found that 2015-2017 marked the lowest annual rainfall in Cape Town since 1933 (Wolski, 2018). The wettest month in Cape Town is July, with an average of 132 mm of precipitation, and February is the driest month with 18mm of precipitation (Weather and Climate, n.d.).

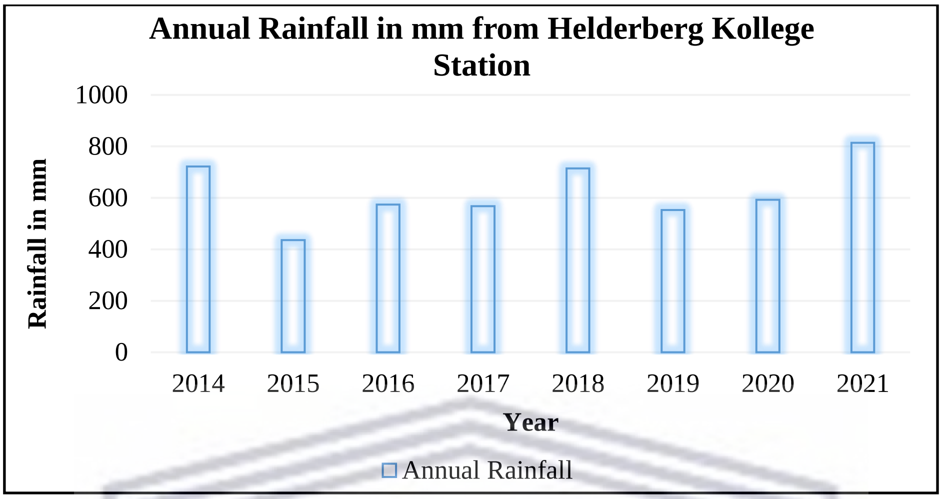

Figure 5. 5: *Annual rainfall in mm for Helderberg Kollege, 2014 to 2021. (**Source**: Requested and adapted from SAWS)*

The data collected at the Helderberg Kollege Station does however not corroborate these numbers by Muller (2018), as the totals of Helderberg Kollege Station can be seen in Figure 5.5 and are less than what was stated in the article. Furthermore, the average annual rainfall in South Africa is 464mm, and since 1996, the rainfall in Cape Town fell within the normal percentage, except for 2017, which recorded less than 75%, the average rainfall for the year (South African Weather Service, 2023). This does however illustrate that in 2015, the rainfall within the Helderberg areas fell below the average rainfall for the country in 2015, 2016, 2017, 2019 and 2020, the annual rainfall was quite low in the Helderberg area. This of course is associated with the severe drought Cape Town faced in 2017 and 2018 (Ziervogel, 2019). The Cape Flats Dune Strandveld, which is found near Macassar, needs 350mm to 560mm annual rainfall (Communitree, n.d.).

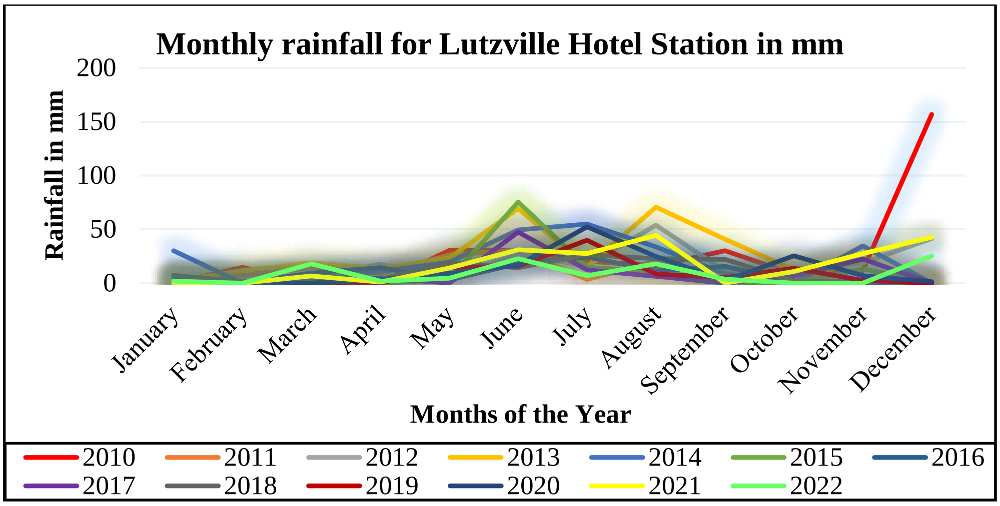

***Figure 5.6**: Monthly rainfall data in mm for Lutzville Hotel Station, 2010 to 2022. (**Source**: Requested and adapted from SAWS)*

Figure 5.6 shows the rainfall for the Lutzville Hotel Station from the South African Weather Service. When comparing Figures 5.5 and 5.7, showing the rainfall patterns for Helderberg versus Lutzville, there is much less rainfall in the town of Lutzville. The annual rainfall along the West Coast ranges from 100-300mm per annum (Akoon. n.d.), and the rainfall in the Matzikama Municipality ranges from 20-290mm per annum (Matzikama Municipality IDP, 2019).

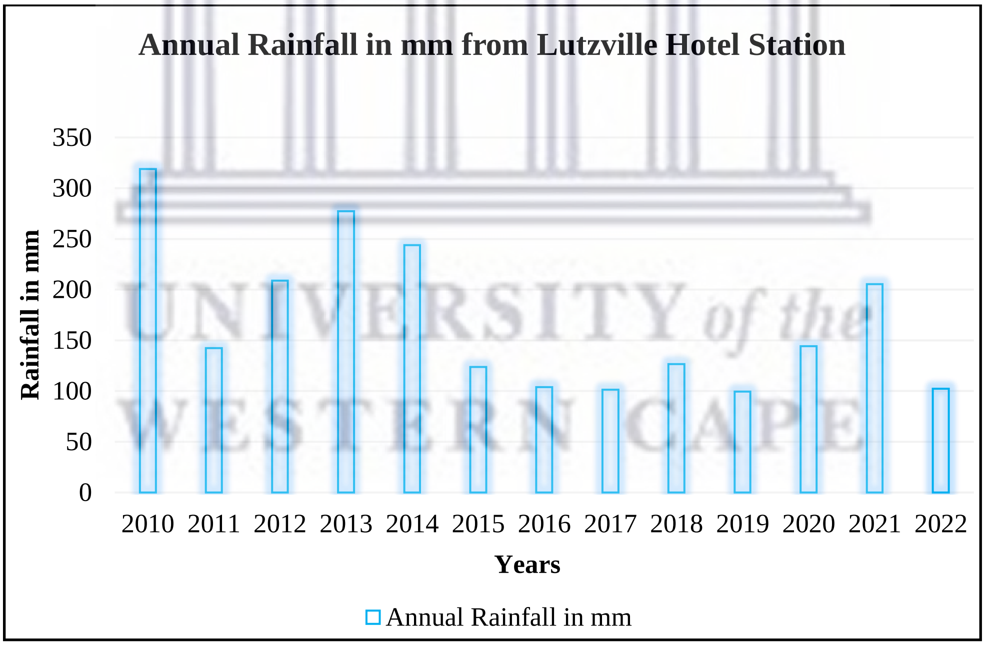

***Figure 5.7**: Annual rainfall in mm for Lutzville Hotel Station, 2010 to 2022. (**Source**: Requested and adapted from SAWS)*

As shown in Figure 5.7, the annual rainfall for the years 2010 to 2022 fell below the average rainfall in mm for South Africa, and thus did not meet the average of 278mm (CSIR, 2014), except for 2010 in which it exceeded this amount. From this rainfall data, it can be deduced that irrespective of the inconsistency of rainfall and the little rain in the area, Strandveld vegetation still thrives within the area, showing that it does not need huge amounts of rainfall to flourish (Eccles, 2000). This is demonstrated by Figure 5.6, which shows that the annual rainfall falls within the average rainfall amount for the Matzikama Municipality (Matzikama Municipality IDP, 2019). It can however be seen in Figure 5.6 that from 2015 to 2020, there was a significant decrease in the amount of rainfall in Lutzville, which was attributable to the drought in the Lower Olifants River region (Pienaar et al., 2018).

5.4 Vegetation Density Assessment

The assessment of vegetation densities pre-and post-mining is used to reflect on the spatial extent to which rehabilitation, in the form of vegetation regrowth as a proxy, was successful. The types of vegetation present at the study sites are shown in Figures 5.8 and 5.9.

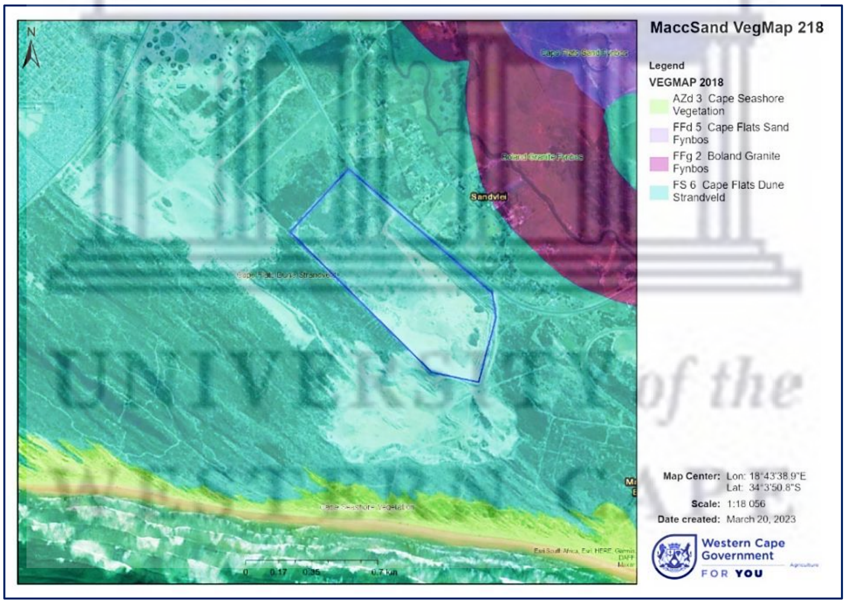

***Figure 5. 8**: Vegetation types near MaccSand Mining and Quarrying Mine. (**Source**: CapeFarmMapper, 2022)*

Figure 5.8 shows that the predominant vegetation type found near the Macassar area is the Cape Flats Dune Strandveld, followed by the Boland Granite Fynbos vegetation type. The vegetation found along the coastline is Cape Seashore Vegetation, which is typically grassy, herbaceous, and somewhat small shrub-like vegetation (Mucina et al., 2006).

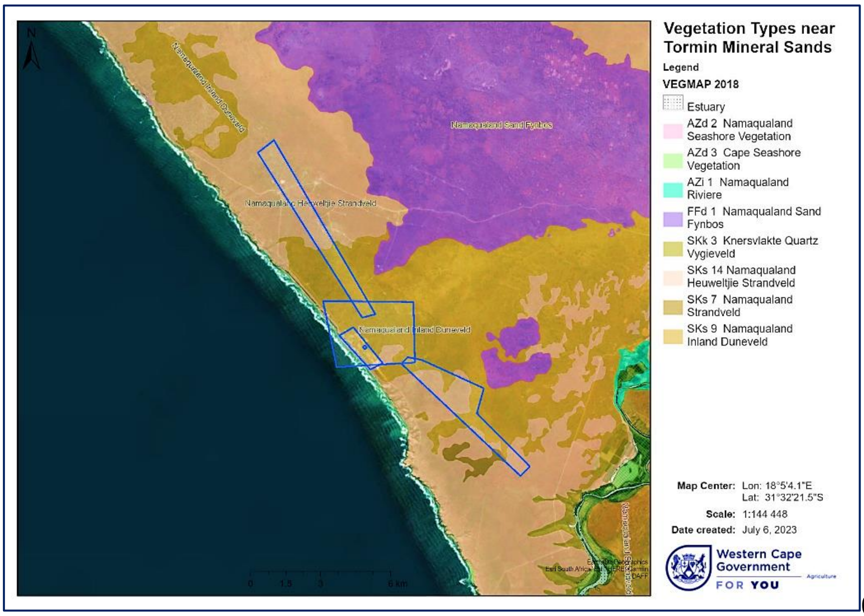

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Figure 5. 9: *Vegetation types near Tormin Mineral Sands Mine. (**Source**: CapeFarmMapper, 2022)*

Figure 5.9 shows that the predominant vegetation near the Tormin Mineral Sands Mine is Namaqualand Strandveld and Namaqualand Heuweltjie Strandveld. The other vegetation types in the area include Namaqualand Sand Fynbos. Namaqualand Heuweltjie Strandveld is a low shrub, dominated by leaf-succulent shrubs and Namaqualand Sand Fynbos is dominated by Cape reeds occurring between scattered shrubs (CES, 2019).

5.4.1 Normalised Difference Vegetation Index (NDVI)

NDVI is used as an index to simplify remotely sensed data and is one of the most popular indices for vegetation density. The NDVI is useful owing to its ability to define vegetation and vegetative stress, and this is appealing to those doing research in commercial agriculture and land-use studies (Huang et al., 2020). This is done by using the reflectance patterns of green vegetation obtained from satellite imagery (Gandhi et al., 2015). The NDVI has been widely used to examine relationships between spectral variability and changes in vegetation growth rate. It is also useful in determining the production of green vegetation, among other uses (Gandhi et al., 2015). The NDVI was used for MaccSand Mining and Quarrying to showcase whether rehabilitation was happening, and whether it was effectively occurring or not, in areas where mining had stopped. Furthermore, it was used to show the extent of mining activities in the area. These NDVI images were cross-referenced with Google Earth images to determine accuracy.

The land classes and range for the NDVI results are shown in Table 5.4.

Table 5. 4: Land class and range used for NDVI

LAND CLASSES AND RANGES FOR NDVI IMAGES	
Range	**Land class**
0	Water
0-0.2	Barren land/ built-up/ rock/ sand
0.2-1	Vegetation

Table 5.4 shows that the range used encompasses all the vegetation, whether healthy or not, into the same category, as the aim of the NDVI is to show the extent of the vegetation at the study sites, and not whether the vegetation is healthy or not. These images simply show the presence or absence of vegetation.

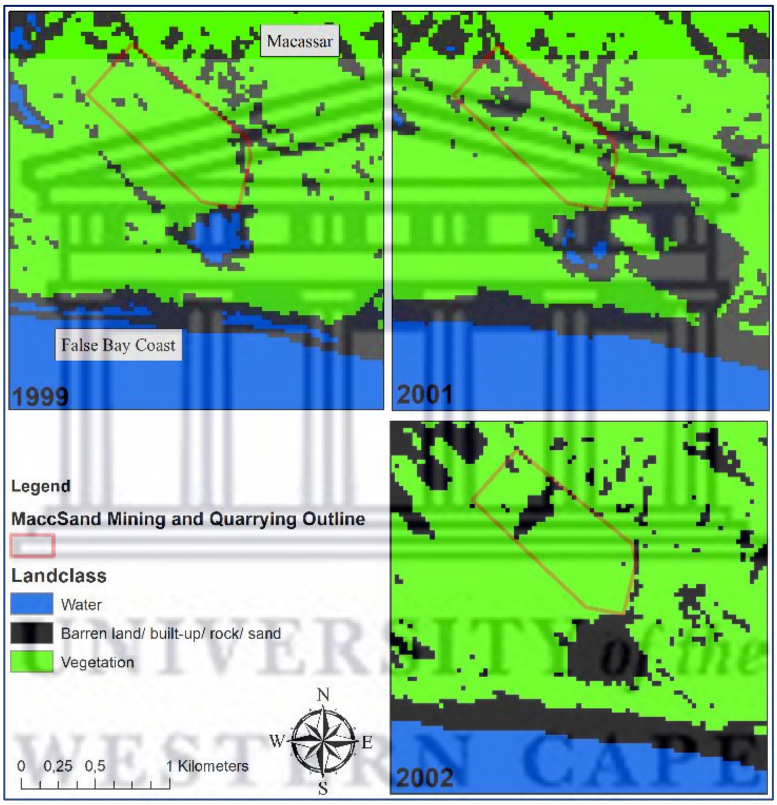


Figure 5.10: *MaccSand Mining and Quarrying Mine NDVI, 1999 to 2002. (**Source**: USGS (https://earthexplorer.usgs.gov/) and ArcMap V.10.8.2)*

Figure 5.10 shows vegetation density before and after operations began at MaccSand Mining and Quarrying. As seen in the first image of 1999, the entire mine location was practically covered in vegetation. One year after operations began, it is seen that there was less vegetation in 2001, as mining operations had begun in 2000. Table 5.5 shows detailed decrease in the frequency of vegetation within the Macassar area, after mining operations began at MaccSand

Mining and Quarrying. Table 5.6 shows that from 1999 to 2001, there was a 5% decrease in vegetation extent within the outlined area near Macassar.

Table 5. 5: Vegetation extent near MaccSand Mining and Quarrying Mine in 1999 and 2001. (Source: ArcMap V10.8.2)

VEGETATION EXTENT NEAR MACCSAND MINING AND QUARRYING MINE

Year	Vegetation frequency	Coverage Percent
1999	5994	57.65
2001	5471	52.6

In 2002, there appears to be an increase in vegetation, which could be due to the increase in rainfall experienced in 2001 and 2002, as shown in Figure 5.11. It could, however, also been because of attempted rehabilitation from MaccSand Mining and Quarrying, but this could not be corroborated with satellite images.

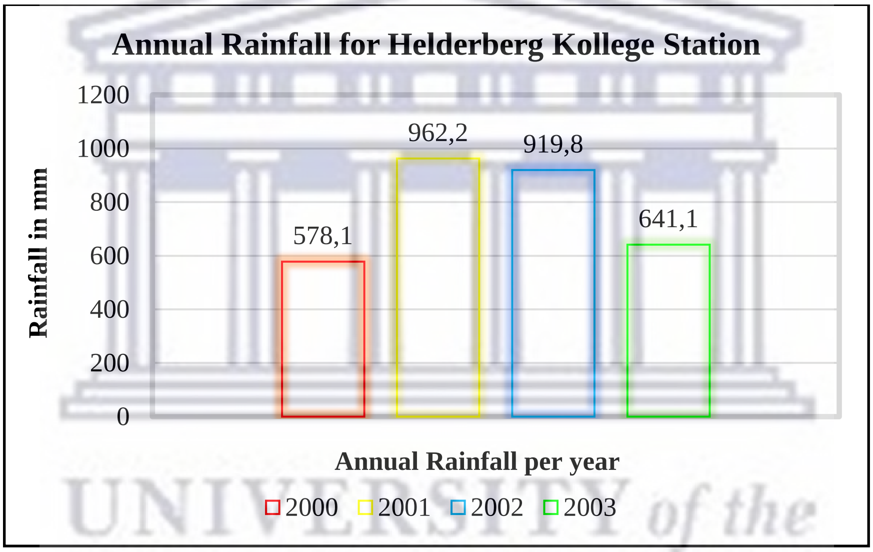


***Figure 5. 11**: Annual rainfall in mm for Helderberg Kollege Station, 2000 to 2003. (**Source**: Adapted from SAWS)*

Figure 5.11 shows that in 2001 and 2002, there was a significant increase in the annual rainfall within Helderberg and surrounding areas, under which MaccSand Mining and Quarrying falls. The Cape Flats Dune Strandveld found in the Macassar area needs 350mm to 560mm annual rainfall (Communitree, n.d.).

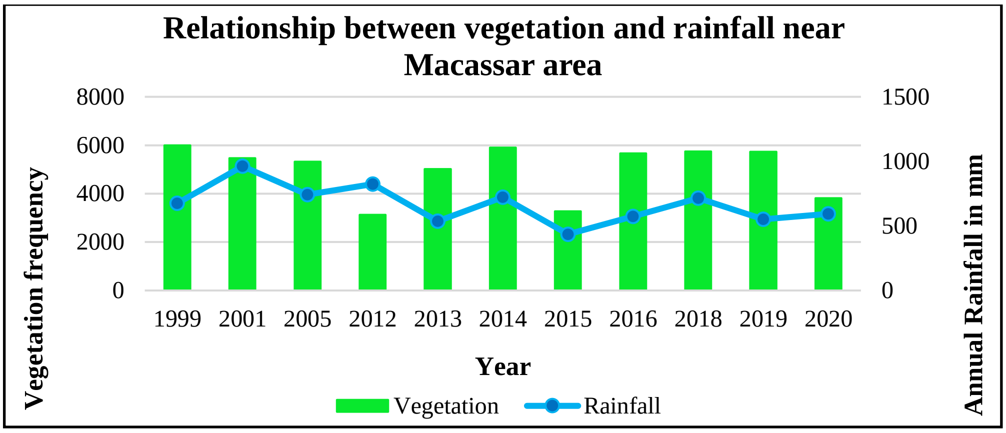


Figure 5. 12*: Relationship between the vegetation extent and annual rainfall in Macassar area, 1999 to 2020. (****Source****: ArcMap V.10.8.2 and SAWS)*

Figure 5.12 illustrates the relationship between vegetation extent and annual rainfall data for the Macassar area. When calculating the Pearson correlation coefficient (r), it indicates that there is no correlation between the vegetation extent and annual rainfall based on the data. The correlation coefficient is 0.187, indicating a very low positive correlation between the two variables (Schober et al., 2018). The Pearson correlation ranges from -1 to 1, indicating a positive or negative correlation between two variables, with 0 indicating no relationship. On one hand, positive correlation indicates that when one variable increases or decreases, so does the other; on the other hand, a negative correlation indicates that when one variable increases, the other decreases (Mondal and Mondal, 2016).

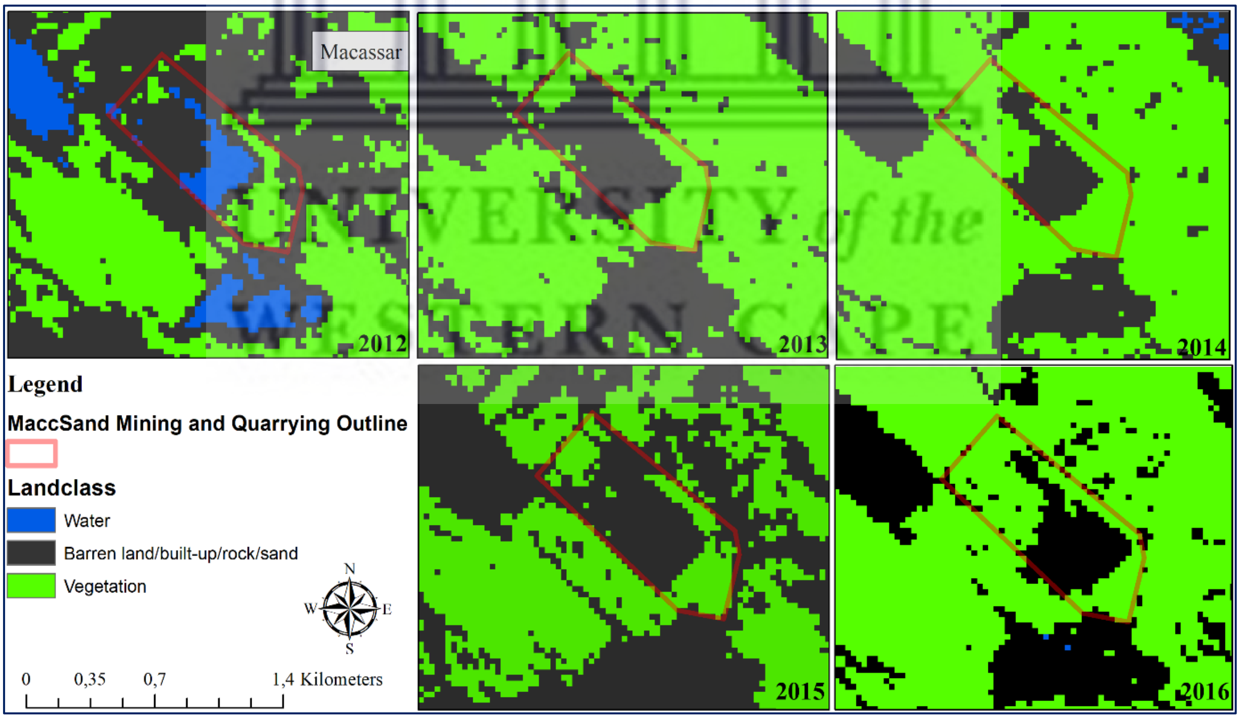


Figure 5. 13*: NDVI for area near MaccSand Mining and Quarrying, 2012 to 2016. (****Source****: USGS (https://earthexplorer.usgs.gov/) and ArcMap V.10.8.2)*

Figure 5.13 shows that in 2012, there was significant vegetation lost at the site, and in 2013 and 2014, there was significant regrowth. In 2015, a decline in vegetation can be seen and in 2016, the vegetation extent once again increased. In 2012/2013, MaccSand Mining and Quarrying was shut down owing to the court case previously mentioned. This would indicate that in the absence of mining operations, there was significant vegetation growth in the area, and once MaccSand Mining and Quarrying resumed operations, there was a decrease in vegetation in the area. Figure 5.14 shows the exact vegetation frequency and decrease that occurred in the years 2012 to 2016.

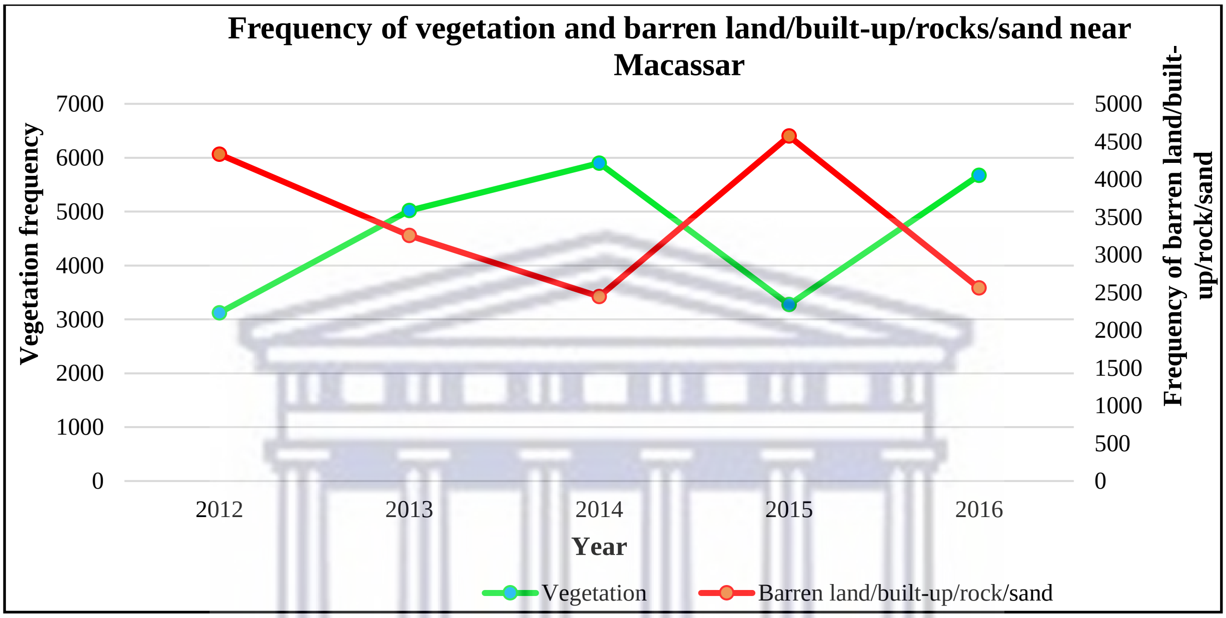


Figure 5. 14: *Extent of vegetation and barren land/built-up/rocks/sand near MaccSand Mining and Quarrying Mine. (**Source**: ArcMap V.10.8.2)*

Figure 5.14 illustrates the relationship between the vegetation frequency and the frequency of barren land/built-up areas/rock/sand. The frequency creates a table from the attributes, which include all attribute fields, and sums each unique value. This frequency is based on how many times the pixel for each attribute occurs on the map (ESRI, n.d.). The y-axis value represents the sum of pixels for the vegetation frequency and the barren land/built-up area/rocks/ sand frequency.

There is a Pearson correlation (r) of -0.988 between the decrease in vegetation and the increase in barren land/built-up areas/rocks/sand in the area. This illustrates that there is a strong negative correlation between the two variables, indicating that one variable directly influences the other (Schober et al., 2018). In the Macassar area, in 2012, there was an increase in frequency of vegetation from 3121 to 5019 in 2013, and a further increase in 2014 to 5900.

This shows an increase in frequency by 1898, indicating a 60% increase in vegetation frequency, and an 89% increase in vegetation frequency from 2012 to 2014. During the 2012 to 2013 period, MaccSand Mining and Quarrying was closed due to the regulatory issues mentioned earlier. It can be deduced that the mine closure allowed for the vegetation in the area to grow back. This is validated by the vegetation frequency in 2015, which saw a decline in vegetation growth from 5900 to 3273, showing a 44.5% decline in vegetation extent as seen in Table 5.6.

The overall changes in vegetation extent can be seen in Table 5.6, which illustrates the vegetation increase and decrease compared to the previous years, illustrating the percentage of increase or reduction.

Table 5. 6: Percentage increase or decrease in vegetation extent, 1999 to 2020. (Source: ArcMap V.10.8.2)

PERCENTAGE CHANGE OF VEGETATION FREQUENCY FROM 1999 TO 2020		
Year	**Vegetation frequency**	**Percentage change from previous year**
1999	5994	0
2001	5471	-8.7%
2005	5316	-2,8%
2012	3121	-41%
2013	5019	60%
2014	5900	17%
2015	3273	-44%
2016	5670	73%
2018	5748	-1.3%
2019	5734	-0,24%
2020	3812	-33,5%
2022	5411	41%

Table 5.6 illustrates that in 1999 to 2001, there was an 8.7% reduction in vegetation near Macassar, and this dropped further, having a 41% reduction in vegetation extent in 2012, from the year 1999 prior to operations. However, from 1999 to 2020, there was a 36% total reduction in vegetation extent within the area near Macassar; however, in 2022, there was a 41% increase from 2020, resulting in an 9.7% decrease in vegetation extent within the area from 1999 to 2022.

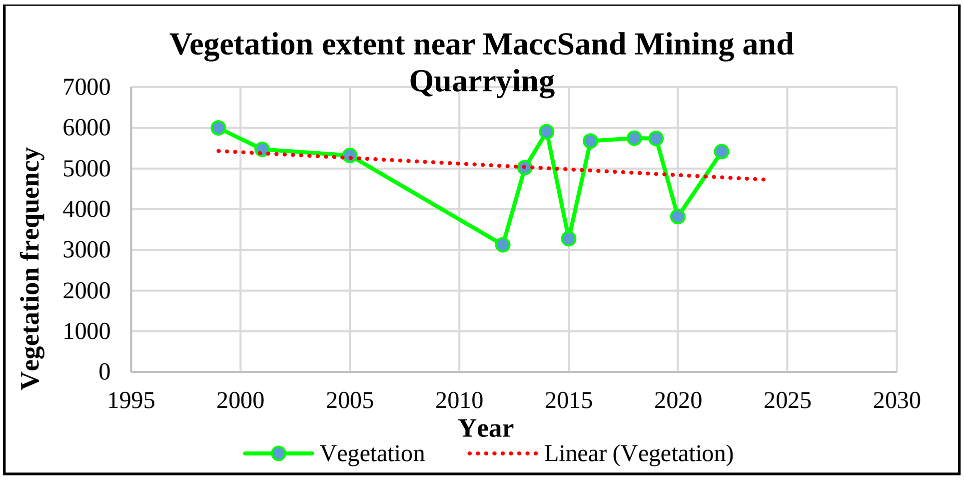


***Figure 5. 15**: Vegetation extent in Macassar 1999 to 2022, illustrating a linear prediction for vegetation loss in future. (**Source**: ArcMap V10.8.2 and Excel)*

Figure 5.15 illustrates vegetation increase and decrease near MaccSand Mining and Quarrying from 1999 to 2020. After mining operations began in 2000, there was a slight decrease in vegetation [8.7%] as per Table 5.6. Afterwards, there appears to have been barely any vegetation loss between 2001 and 2005, presumably due to MaccSand Mining and Quarrying mining the section of sand which was cleared of vegetation in 2001. However, from 2005 to 2012, there was a 41% decrease in vegetation in the area, and afterwards, there was an increase in vegetation until 2014. During this time, as mentioned previously, MaccSand Mining and Quarrying was shut down, but it was also shown in Chapter 4 that rehabilitation is in fact occurring at the site, which would explain the up and down trend of the overall vegetation growth within the area. Figure 5.15 also illustrates a linear trend line for future vegetation extent in the area, and this trend indicates that by 2024, there will be a slight decrease in vegetation extent in the area if similar conditions persist.

The Argus (2013) conducted an interview with a mine management member of MaccSand Mining and Quarrying in which it was stated that MaccSand was shut down, but other mines within the area were allowed to continue operations. This interview also addressed the inequalities and unfairness faced by different sand mining companies in Macassar. The mine manager member also stated that since operations began, City of Cape Town officials had been trying to shut the MaccSand Mining and Quarrying mine down, and threats had been made when reports were filed against other mining companies in the area (The Argus, 2013). These claims were also addressed by RSP4 and RSP7 in the interviews conducted for this study.

5.4.2 Soil-Adjusted Vegetation Index (SAVI)

SAVI is similar to the NDVI, except that it considers the reflectance of soil in an area and attempts to minimise the influence of the brightness by using a soil adjustment factor. The soil adjustment factor is "L" in the equation, meant to reduce soil interference (Huete, 1988), which is used for more semi-arid areas (Vani and Mandla, 2017). The vegetation found along the West Coast is different strains of Strandveld vegetation, and the specific vegetation found surrounding the Tormin Mineral Sands mine is Namaqualand Strandveld. When interpreting satellite imagery, this vegetation is low and shrubby and blends in terms of its colour rendition, into its surroundings. For this reason, SAVI was used to assess the extent of vegetation cover in the area, rather than the health of the vegetation itself. The Namaqualand Strandveld is dark in colour and sometimes brown, and the areas in which it grows may even appear barren (Protect the West Coast, 2023a). This can be seen in Figure 5.16.

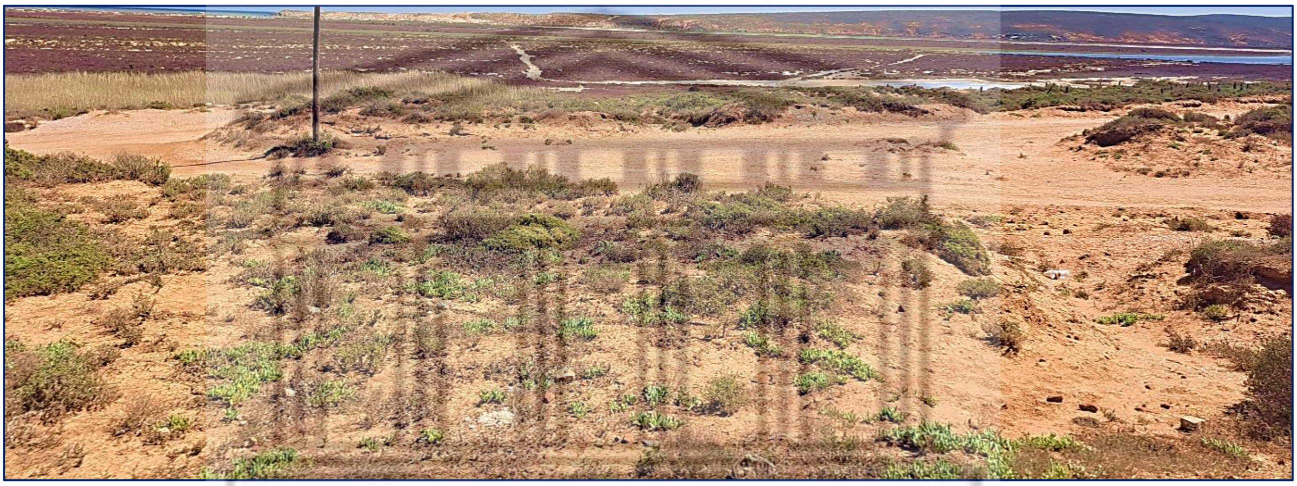


Figure 5. 16: *Strandveld vegetation along the West Coast, taken near the coastal town of Papendorp*. (***Source***: *Author)*

Figure 5.16 was taken near Papendorp, approximately 20 km from the MSR Tormin Mineral Sands Mine. As Figure 5.16 shows, there is vegetation; however, the vegetation is low and shrubby, which would be classified as bare ground or unhealthy vegetation by the NDVI index. For this reason, the NDVI would be an unsuitable index to use to assess the vegetation extent for arid or semi-arid areas, which is why SAVI was used instead. The West Coast areas are categorised as arid to semi-arid (Akoon, n.d.), thus corroborating the suitability of using the SAVI for the area. The categories used for SAVI are shown in Table 5.7.

Table 5. 7: Land class and range used for SAVI.

LAND CLASSES AND RANGE CHOSEN FOR SAVI IMAGES	
Range	**Land class**
0	Water
0-0.2	Barren land/ built-up/ rock/ sand
0.2-1	Vegetation

These ranges were chosen as the focus of the study was not the health of the vegetation, but only the density and locations of vegetation. For this reason, all vegetation was categorised into the range of '0.2 to 1'; whereas typically low NDVI would be 0.1 or less, a moderate NDVI would range from 0.2 to 0.5 and a high NDVI would be categorised as 0.6 and more (Taufik et al., 2016).

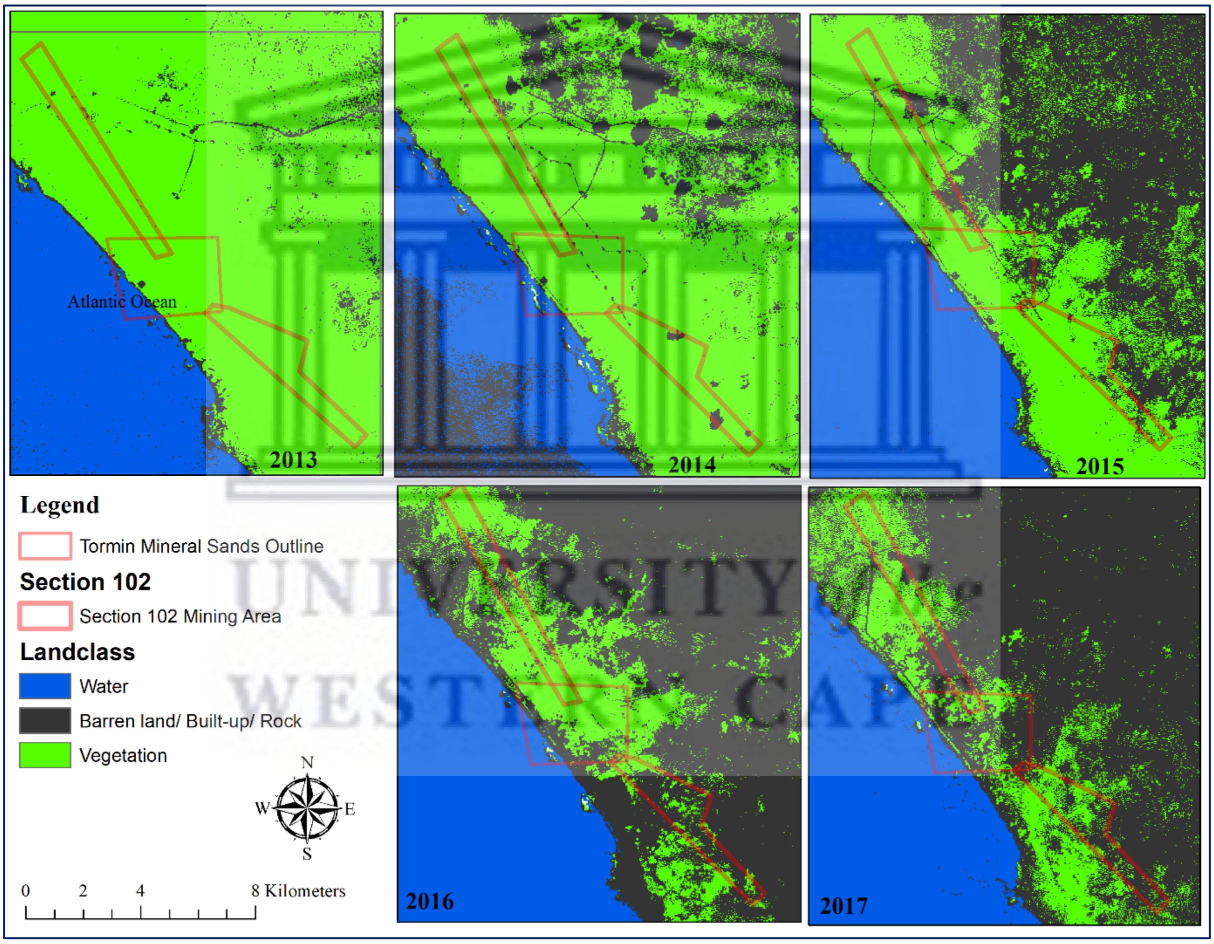
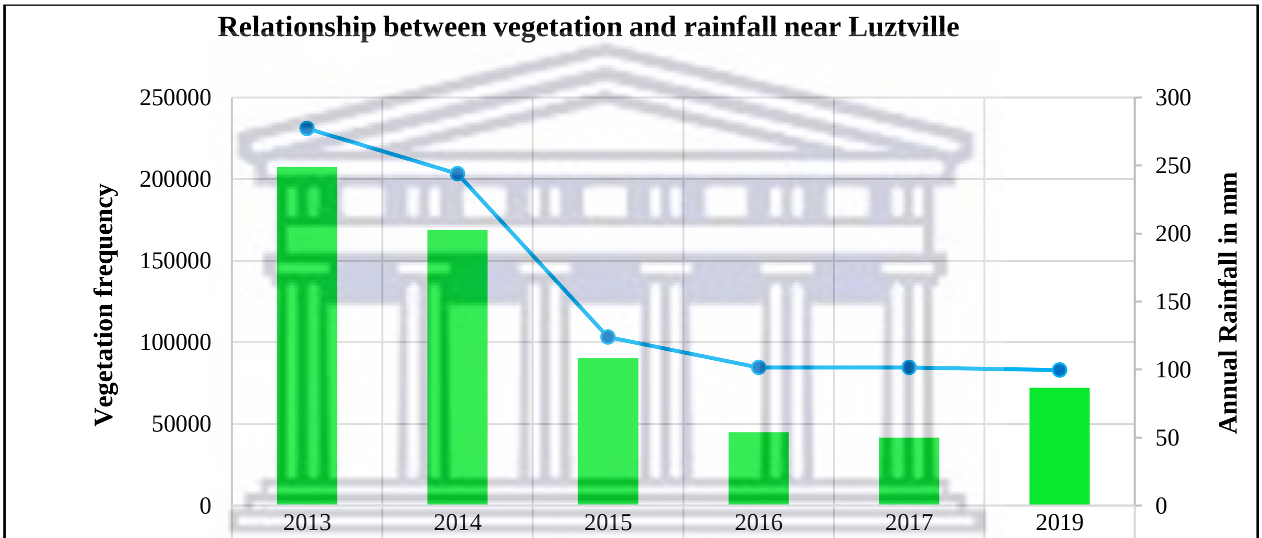


Figure 5. 17: *Vegetation density for the Tormin Mineral Sands Mine and surroundings, 2015, 2016, 2017 and 2019. (**Source**: USGS (https://earthexplorer.usgs.gov/) and ArcMap V.10.8.2)*

Figure 5.17 illustrates that from the year 2013 to 2017, there was a substantial decrease in vegetation near Lutzville and the MSR Tormin Mineral Sands Mines. This decrease in vegetation can be attributed to the drought in South Africa in the years 2017 and 2018, as the years preceding 2018 began to see a decline in precipitation before it was declared an official drought (Muller, 2018).

Afterwards, in 2019, there was an increase in vegetation and rainfall as shown in Figure 5.18, illustrating that the rainfall within the area impacts on the vegetation, as reduced rainfall appears to correlate with vegetation loss. However, after 2019, there was another significant decline in vegetation within the area, and a massive increase in the Tormin Mineral Sands built-up area, as they bulldozed vegetation to access more sand dune in the area. The specific numbers are shown in Figure 5.18.



	2013	2014	2015	2016	2017	2019
Vegetation	207465	168893	90495	44941	41542	72290
Rainfall	277,2	243,9	123,8	101,4	101,4	99,6

Figure 5. 18: *Relationship between vegetation and rainfall in the Lutzville area. (**Source**: ArcMap V.10.8.2 and SAWS)*

Figure 5.18 illustrates the rainfall from 2013 to 2019, showing that there was a significant decline in rainfall since 2013, with 100mm less annual precipitation in 2015, which decreased further in 2016 and 2017. As noted earlier, this period was associated with a drought in South Africa in 2017 and 2018 (Ziervogel, 2019). Figure 5.18 illustrates that there is a positive correlation between the vegetation frequency and rainfall, holding a Pearson correlation (r) of 0.979. This signifies that there is a strong linear relationship between the two variables and the annual rainfall impacts the vegetation frequency in the area (Schober et al., 2018). This means that when there is a decrease in rainfall, there is a reduction in vegetation within the area. It is, however, important to note that the rainfall averages fell within the average range for the West Coast areas, which would indicate that the reduction in rainfall during the drought season is questionable as the reason for the vegetation extent reduction.

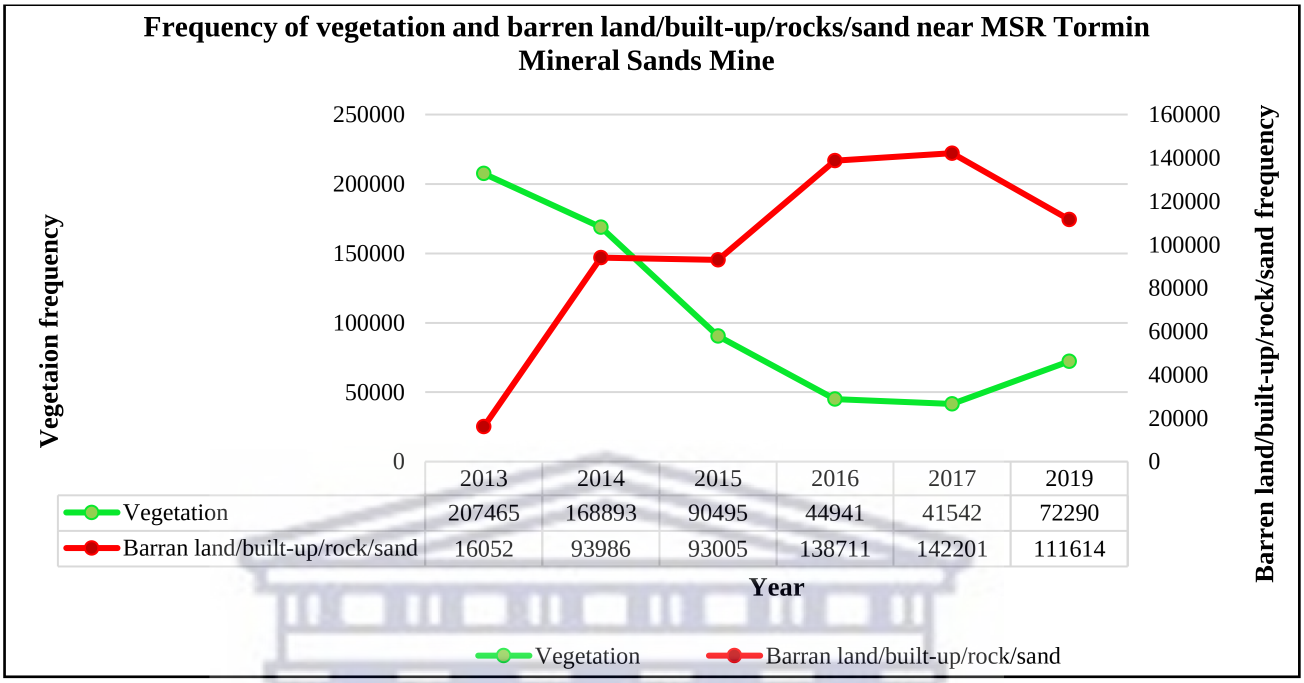


Figure 5.19: *Extent of vegetation and barren land/built-up areas/rocks/ sand near Lutzville.* ***(Source****: ArcMap V.10.8.2)*

Figure 5.19 illustrates the relationship between the frequency of vegetation and barren land/built-up/rocks/sand near the MSR Tormin Mineral Sands Mine. There is a very strong negative correlation between the two variables, with a Pearson correlation (r) of -0.931, indicating that when one variable increases, the other decreases (Schober et al., 2018).

Figure 5.19 shows that from 2013 to 2017, there was a substantial decline in vegetation near Lutzville, decreasing from a frequency of 207465 to 41542, decreasing in frequency by 79.98% in a span of four years. It is also seen that since mining operations began, the vegetation extent has declined annually, but there was a 42% increase in vegetation from 2017 to 2019.

There is a correlation near Lutzville between rainfall and vegetation growth, but also between the extent of barren/built-up areas/rock/sand and vegetation within the area. This indicates that changes in weather patterns would affect vegetation in the area, and so would built-up areas, making it difficult to make a deduction regarding the extent to which Tormin Mineral Sands is responsible for the vegetation loss, and to which extent the rainfall had an impact. However, the extent of the mine itself had an impact on the vegetation extent within the area, as it has extended enormously since beginning operations in 2013, as shown and discussed in Chapter 4. This indicates that it may simply have been a coincidence that when the Tormin Mineral Sands Mine began operations, a drought also befell Cape Town.

Table 5. 8: Vegetation change, 2013 to 2021. (Source: ArcMap V.10.8.2 and Excel)

VEGETATION FREQUENCY CHANGE FROM 2013 TO 2021		
Year	**Vegetation extent**	**Percentage change from previous year**
2013	207465	0
2014	168893	-18,59
2015	90495	-46,41
2016	44941	-50,33
2017	41542	-7,56
2019	72290	74,01
2021	5281	-92,69

Table 5.8 illustrates the extent of vegetation near Lutzville from 2013, prior to mining operations to 2021. It illustrates that there has been a constant decline in vegetation extent since 2013, with an increase in vegetation from 2017 to 2019 by 74%, although this is still 65% less vegetation in the area than from 2013. This indicates that from 2019 to 2021 alone, there was a 92% decrease in vegetation extent in the area, resulting in a 97% loss in vegetation from 2013 to 2021.

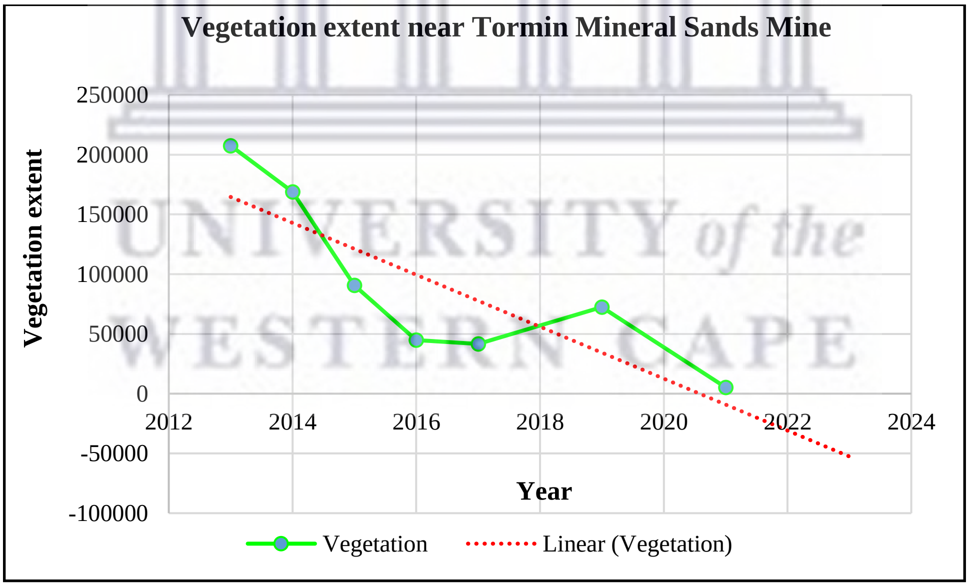


Figure 5. 20: *Vegetation extent near Tormin Mineral Sands Mine, 2013 to 2021, with a linear trend line showing predictive future vegetation.* ***(Source***: *ArcMap V.10.8.2)*

Figure 5.20 illustrates the progression of vegetation near Lutzville from 2013 to 2021. It shows that there has been a constant decrease of vegetation within the area since mining operations began in 2013. Figure 5.20 also illustrates a linear prediction for future vegetation extent, and the prediction is that there will be no vegetation left near Lutzville by 2022. This prediction is not accurate, as there is currently still vegetation near Lutzville. The trendline does, however, speak to the impact that the Tormin Mineral Sands Mine has had on the vegetation along the West Coast near its mining operations.

5.5 Chapter Summary

When comparing the MaccSand Mining and Quarrying Mine to the Tormin Mineral Sands Mine, it is apparent that overall, MaccSand Mining and Quarrying has a lesser impact on the surrounding and adjacent vegetation. Furthermore, it has been shown that there is an attempt at rehabilitation by MaccSand, whereas a questionable attempt can be seen from the Tormin Mineral Sands Mine.

The decline in vegetation near Macassar is not linear, and the extent of vegetation is miniscule when compared to that of the area where Tormin Mineral Sands operates. The decline in vegetation along the West Coast has practically been a constant linear decline, while the mine has increased its extensions and operations along the West Coast. MaccSand Mining and Quarrying has not extended their current site within the 23 years they have been operational, and they have managed to work within the same parameters. However, the Tormin Mineral Sands Mine has extended by more than double their mining area from their original site approval in a timespan of only ten years (MRC, n.d.). There has been immense pushback from interested and affected parties pertaining to the Tormin Mineral Sands development, yet approval to extend its mining operations have continued to be granted by the officialdom. The civil society lobbying groups against the Tormin Mineral Sands Mine include a range of professionals, including botanists, environmental activists, and lecturers from UCT (Protect the West Coast, 2023b).

The above addresses the conservation-development polemic, as the approval of extension suggests that development and revenue from sand mining are considered more important than conservation of the West Coast and its endemic species. Although the Strandveld vegetation near the Tormin Mineral Sands Mine is Least Threatened, it is an endemic species and is only found in the Namaqualand's of the Western Cape (Masson and Reuther, 2018).

It was found that there is a direct correlation between the vegetation extent versus the extent of built-up areas/barren land/rocks/sand. This illustrates that the more development occurs near the study sites, the more vegetation will decrease in these areas. Along the West Coast near Lutzville, in 2019, there was a 65% reduction in vegetation in the area overall from 2013 to 2019, and near Macassar, there was a 9.7% reduction in vegetation from 1999 to 2022. This means that in a timespan of ten years, the West Coast area near the Tormin Mineral Sands Mine has seen a 65% decrease of vegetation, and in 23 years, there has been a 9.7% decrease near Macassar since MaccSand Mining and Quarrying began operations. Notably, MaccSand Mining and Quarrying has two neighbouring sand mines which could be contributing to vegetation loss as well, and the extent of vegetation loss due to MaccSand Mining and Quarrying specifically is thus difficult to ascertain. Although there are three mines in the Macassar area, there is still a 55.3% less decrease in vegetation than the Tormin Mineral Sands Mine. This illustrates the immense impact the MSR Tormin Mineral Sands Mine has on the West Coast. These statistics would also indicate that overall, the mining operations near Macassar are fairly environmentally sustainable, with rehabilitation definitely occurring, while the Tormin Mineral Sands mining operations seem environmentally destructive. As the NDVI or SAVI of the broader spatial footprint of the two study areas indicate that there is a decrease in vegetation, it can perhaps be argued that there may be other factors which contribute to the vegetation extent other than these specific mines and their activities.

CHAPTER 6: DISCUSSION

6.1 Introduction

The previous discussions and results in chapters 4 and 5 conveyed polemics which are presently surrounding coastal mines. This study's aim was to document and analyse the polemics, the varied impacts, and socio-economic desirability associated with continued sand mining operations at the chosen sites. To achieve this aim, it was broken down into five objectives, namely: To analyse the polemics using an SES approach; to document spatial-temporal changes to the environment using GIS applications; to capture the opinions of authorities, as well as that of I&APs, and to provide a synthesis of whether the continued mining operations and extensions of mining activities are socio-economically and environmentally desirable. The extent to which these objectives were met is discussed in this chapter.

6.2 The SES approach

The Socio-Ecological Systems approach is rooted in that human society and ecological systems are interconnected, and this approach provides insight into complex environmental problems (Refulio-Coronado et al., 2021). The interconnectedness of human society and ecological systems is clearer along the West Coast, as these coastal communities rely on fishing as a source of livelihood. These coastal communities are also predominantly low-income areas with high unemployment rates. Negative impacts on the coastline thus directly affect these communities who rely on the ocean for their livelihoods, such as the Papendorp and Doringbaai communities. It has been alleged in the interviews that the fish species have been affected by the mining practices of the Tormin Mineral Sands Mine, as they are mining not only in the ocean, but also just North of the Olifants River estuary near Papendorp. This alludes to the conservation-development theme, as the residents in these communities have a more sustainable relationship with the ocean from which they primarily make a living (Nayak et al., 2021). Nayak et al. (2021) are of the opinion that sustainable subsistence necessarily involves conservation practices. Mining in coastal areas such as the West Coast will therefore essentially impact on relationships highlighted by some respondents.

A relationship with humans and the environment can also be found with the sand dune systems along these coastlines. The coastal dunes are formed through natural ecological processes, and they offer natural protection against sea surges, tsunamis, etc. (Martínez and Psuty, 2004). The mining of coastal dunes puts coastal communities at risk of flooding (Rangel-Buitrago et al., 2023). A relationship between humans and the coastal dunes is evident in Macassar near the MaccSand Mining and Quarrying Mine, as residents in Macassar have erected informal developments on these coastal dunes systems. These dunes are now home to communities in Macassar, and the sand mining operations receiving an extension to mine dunes more inland in Macassar would result in the displacement of these residents (Yuku, 2023).

There have been attempts to bridge the gap between human development and environmental resources using the SES approach by means of the sustainable development goals, but this approach is extremely complex and dynamic, and finding a solution is extremely challenging (Zhang, 2023). The future of humanity depends on linking the prosperity of people and that of the planet. This linkage imposes a fundamental dilemma, that of human development versus the environment and its resources (Zhang, 2023). This directly relates to the conservation-development polemic which was identified through the results. The SES approach therefore provides a framework for understanding the many challenges prevalent in this study and how the ongoing polemics and contestations associated with coastal zone sand mining in the case study areas can be understood.

6.3 Themes in study

The themes reflect the operational/management polemics and environmental contestations, associated with the continued operations of these mines, and this is then contextualised and augmented by the results derived from the GIS applications. This allows for a further analysis of SES interrelationships and associated challenges that exist in the case study areas. The themes which emanated from the study are conservation-development, inter-competent authorities' disagreements, rehabilitation-development, civil society lobbying groups, and officialdom-information sharing polemics. These polemics encompass the contestations not only between land uses within the area, but also between different parties involved.

6.3.1 Conservation-development

The conservation-development polemic was addressed multiple times during the interviews and was also illustrated in the GIS applications. This polemic encompasses issues surrounding the concept that conservation and development at these sites is not occurring conjointly, and there is contestation about whether the land should be used for conservation purposes or for development purposes in terms of sand mining operations.

Furthermore, a difference in opinion arose during interviews among interested and affected parties, with, on one hand, pro-mining stakeholders, who stated that they held no objection to sand mining operations in the area and that the extraction of needed commodities such as sand and job opportunities should be more important than the species within the area. On the other hand, anti-sand mining stakeholders have insisted that sand mining operations need to be done sustainably, with community involvement and further extensions of these mining corporations not condoned. The I&AP interviewees from the West Coast believed that the species within the area are significant to the community and Tormin Mineral Sands should be held accountable for their destructive methods having noticeably destroyed significant flora within the area.

The DMRE was supportive of sand mining companies in the interview, holding the stance that no negative impacts associated with sand mining operations could be thought of. This was contested by DEADP, who argued that there was an array of negative impacts associated with sand mining companies on the environment and there was uncertainty pertaining to whether conservation or development was more important. This stems from the fact that sand is a much-needed commodity and is thought of as the 'gold of the Western Cape' by DEADP. Yuku (2023) states that the DMRE has recently announced its intention to preserve the Macassar dunes into a nature reserve and has pushed for the three mining companies in Macassar to uphold their responsibility to the socio-economic needs of the community. DMRE has also stated that the mining companies in Macassar are all compliant with the Environmental Management Programmes Environmental Authorizations (Yuku, 2023), which is corroborated by the satellite imagery obtained for MaccSand Mining and Quarrying, although the neighbouring sites were not included within the scope of this study, and their environmental compliance can therefore not be spoken to from a GIS perspective.

Coastal sand mining companies' rehabilitation needs to be enforced to achieve sustainable development. The first step towards sustainable development is the competent authority enforcing regulations and confronting mining companies who mine outside their respective zoning rights. The second step would be to take the necessary measures when a mining company does not adhere to environmental legislations such as NEMA and the MPRDA and issue fines and make arrests when necessary.

6.3.2 Inter-competent authorities' disagreements

The competent authority and commenting authority need a mutual understanding and agreement in relation to mining rights, complaints, etc., as the conflict between the competent and commenting authorities limit the possibility for sustainable development. This polemic is directly related to the conservation-development and rehabilitation-conservation polemic, because when those in charge are in conflict and mining corporations know, regulatory inconsistencies erupt, and this can result in the failure of an entire system (Schyns and Schilling, 2013).

This polemic establishes itself throughout the interviews, as there was very little which the competent and commenting authority agreed on. The only topic which was agreed on from both parties is that the environmental legislation within the Western Cape is excellent. Afterwards, the differing opinions arose. The different opinions first emanated when enforcement of relevant legislation was the issue. The competent authority stated that enforcement was happening, and it occurs regularly, whereas DEADP challenged this notion, stating that enforcement of legislation was lacking. The DMRE also had no recall of negative impacts associated with sand mining companies to speak of, whereas DEADP provided a list of negative impacts, such as the destruction of vegetation, species loss, getting sued or bribery involved, unlawful operations and impacts of wetlands and the water table. The DMRE representative was evasive towards the interview questions as mentioned in Chapter 4.3, whereas the one from DEADP answered all questions asked, and gave additional background or related information to what was asked. This once again showcased the difference between the governing departments.

One of the DEADP representatives directly addressed this polemic as well, stating that there was conflict between the DMRE and DEADP departments because of differing opinions and because of the competent authority overruling decisions from DEADP. This overruling was evident in a court case where DMRE stood in favour of the Tormin Mineral Sands Mine, after DEADP's Green Scorpions searched the mining site for evidence of environmental degradation. The DMRE did not sanction this search as the competent authority declared that all evidence found at the site be destroyed (Yeld, 2017). According to Kings (2017), the objective of the minerals department is to expand mining and mines, and compliance by these mines is onerous. It was declared that the environmental department was a headache for mining and that you may stand at the gate of an unlawful mine, but nothing could be done due to lack of jurisdiction. It was stated that this 'one environmental system' would only make things worse, and this is evident in the case of the Tormin Mineral Sands Mine (Kings, 2017). This event illustrates the statement by Schyns and Schilling (2023) that when those in power disagree, mining companies take advantage of the turmoil, resulting in inconsistency and may lead to the failure of the entire system. This event demonstrates that the system itself, due to the competent and commenting authorities' conflict, has been compromised and is possibly failing. This bothersome, as Schyns and Schilling (2023) state that destructive leadership can cause irreversible damage and effects to an entire system.

6.3.3 Rehabilitation-development

When a development is proposed and an EIA is required, there needs to be a section in the EIA related to what happens to the mining site once it is decommissioned. This is usually a rehabilitation strategy. For sand mining companies, it is possible to rehabilitate during operations as you clear a section of vegetation at the site, mine it, and once completed, you move onto the next section and rehabilitate the previous section. It is the Environmental Compliance Officer's (ECOs) job to ensure that this rehabilitation is occurring, and no rules or regulations have been broken by a mining company. These ECO investigations are meant to be done regularly (DFFE, 2020). If the ECO does not adhere to the rules and regulations, the environment will ultimately suffer. This calls into question the importance placed on rehabilitation versus conservation and what is deemed more important within an area. As mentioned in Chapter 3, both mining sites are surrounded by CBAs, yet there is a lack of protected areas offering protection to these species, addressing the conservation-development polemic. This also suggests that development within the area is prioritised over rehabilitation and conservation.

It can thus be argued that the mining corporations in Macassar were approved before EIAs were implemented within South Africa in 1998 (DEA, n.d.). This is presumed as MaccSand Mining and Quarrying received approval in 2000, and one of the neighbouring mines has been active since 1963 (AfriMat, 2011). Since the implementation of EIA and NEMA regulations, environmental legislation has been amended and implemented within South Africa. The MPRDA then came into effect in May 2004, integrating stakeholders and interested and affected parties into the procedure to serve the interests of the industry as well as the country (Stevens, 2013). This is significant, as it suggests that development had been originally approved prior to the relevant environmental regulations' implementation. This may also be why there have been no new visible developments along the False Bay coast in Macassar since the MPRDA came into effect in 2004.

By contrast, the Tormin Mineral Sands Mine began operations in 2013, after relevant environmental legislations were amended and implemented. Since then, there has been immense extensions from the mining company, destroying endemic vegetation. These extensions have been approved by the DMRE despite multiple contestations from civil society lobbying groups, and there is no visible evidence in the satellite imagery that rehabilitation is occurring at this site. It was however stated by a representative of the Tormin Mineral Sands Mine that there is a nursery onsite which is home to endemic vegetation for reintroduction. This could not be corroborated since a site visit was not achieved, nor with GIS, as there is no visible introduction to date.

6.3.4 Civil society lobbying groups

Civil society lobbying groups opposed to these sand mining companies have been created with the goal of halting these developers from extending or opening new mining sites. There are civil lobbying groups for both the Macassar and West Coast areas. These groups believe that the sand mining companies are destroying the endemic species within these areas and that these companies do not consider the communities they operate in or support their respective communities. These civil lobbying groups raise awareness related to sand mining companies and the negative impacts associated with them.

The civil society lobbying groups for the West Coast have faced backlash from the Tormin Mineral Sands Mine, having faced multiple SLAPP suits and a fear of the mining company and their resources. This directly relates to the officialdom-information sharing polemic which encompasses scare tactics to silence others. These civil society lobbying groups have spoken at conferences, created groups within their respective communities in opposition to the mining company, in the context that workers were allegedly dismissed, and SLAPP suits pursued. Despite these SLAPP suits and threats from the Tormin Mineral Sands Mine, these civil society lobbying groups continued their pursuit of awareness and are still active today, under the name "Protect the West Coast".

Currently, there has been pushback against the MaccSand group from interested and affected parties pertaining to the MaccSand Mining and Quarrying Mine attempting to level a dune near Khayelitsha where people reside. MaccSand alleged that they were simply attempting to make the dune more secure so that it would not collapse on the informal houses built on the dune system, but the residents alleged that MaccSand was mining too close to their homes, resulting in their homes and belongings being covered in sand (Lali, 2023). MaccSand has applied to start a sand mining operation in Strandveld, which the residents in the community are unhappy about, and officialdom has deemed that approval for the site would not be granted (Vuso, 2021). This had led to civil society lobbying groups in protest against MaccSand company (Van Der Fort, 2022) who called themselves “We Are Strandfontein”. A representative of MaccSand Mining and Quarrying has however stated that anyone is welcome on the premises of the MaccSand Mining and Quarrying Mine, adding that the mine had nothing to hide. They alleged that they adhered to all mining regulations and were very proud of their rehabilitation attempts and successes.

The civil-lobbying groups for both MaccSand Mining and Quarrying, and the Tormin Mineral Sands mine take the stance of anti-sand mining. These groups’ goal is to halt mining operations in the respective areas. These pro- and anti-mining parties illustrate that the management of these mining sites is extremely important, and management is an issue in sustainable development.

6.3.5 Officialdom-information sharing (scare tactics)

There have been multiple court cases and allegations against the Tormin Mineral Sands Mine surrounding unfair dismissals, threats and SLAPP suits geared towards interested and affected parties bad mouthing the company. This has led to fear within the nearby communities as there has also been a murder case which has been alleged to be related to the MSR Tormin Mineral Sands Mining company as discussed in Chapter 4. The scare tactics most used by the Tormin Mineral Sands Mine is SLAPP suits in which the mining company claims defamation and sues the mining activists (Steyn, 2021). Another scare tactic used by the Tormin Mineral Sands Mine has also been alleged unfair dismissals following miners protesting for improved workplace conditions (Gontsana, 2015). Yet another tactic allegedly used by the Tormin Mineral Sands Mine is harassment of activists by community members and unknown attackers resulting in isolation of anti-mining activists. This harassment is prompted by the mining company inferring that the mine is a socio-economic benefit to the community it operates in or near, and that these anti-mining activists are undermining the potential economic benefits (HRW, 2018).

Notably, there have been no allegations made against MaccSand Mining and Quarrying pertaining to any scare tactics or threats from the company. It has however been alleged that threats have been made towards the employees of MaccSand Mining and Quarrying company from other sand mining companies in the area, as well as from authorities. A kidnapping case has also been alleged, although the company is unsure who was responsible for the scare tactic. Further threats have been alleged by MaccSand Mining and Quarrying against the officialdom, stating that there have been mortar bombs placed onsite at MaccSand Mining and Quarrying with officials threatening the mine workers directly (Yeld, 2013). These allegations could not be corroborated and followed-up on as this was beyond the scope of the study. It is however evident that there have been multiple alleged occurrences involving threats towards the MaccSand Mining and Quarrying Mine, and these threats have involved the officialdom and neighbouring mines.

6.4 MaccSand Mining and Quarrying Mine versus Tormin Mineral Sands Mine

When consulting all the evidence obtained through the questionnaire surveys, interviews, community meetings and GIS applications, it is apparent that overall, the Tormin Mineral Sands Mine is way more destructive than the MaccSand Mining and Quarrying Mine. The Tormin Mineral Sands Mine appears to have no rehabilitation strategy in place with continuous destructive extensions along the West Coast. MaccSand Mining and Quarrying does however attempt rehabilitation, mining in sections, and the overall impact on the surrounding environment has been miniscule from what the satellite images show. However, the allegations that rehabilitation is insufficient at both mining sites does hold truth to it. For the Tormin Mineral Sands Mine, it is evident that rehabilitation, if any, has been unsuccessful and insufficient. For MaccSand Mining and Quarrying, rehabilitation does occur, but the vegetation type that is rehabilitated differs from the original vegetation type in the area. It can however be argued that an attempt at rehabilitation, even if not the same species, is better than no rehabilitation at all. According to the representatives for MaccSand, the species which are planted for rehabilitation are Strandveld and Fynbos, and the rehabilitation per section takes one year.

MaccSand Mining and Quarrying was also very willing to grant an interview pertaining to their mining practices and rehabilitation on site, whereas Tormin Mineral Sands did not respond to any of the attempts made for an interview. The lack of willingness from Tormin Mineral Sands to allow site visits was also made apparent during interviews with different interested and affected parties. Furthermore, DEADP directly made mention of the Tormin Mineral Sands Mine in relation to their destructive nature and lack of adherence to procedure and legislation. To highlight the contrasts between the Tormin Mineral Sands Mine and the MaccSand Mining and Quarrying Mine, evidence has suggested that the MaccSand Mining and Quarrying Mine is more environmentally sustainable than the Tormin Mineral Sands Mine. MaccSand Mining and Quarrying is more willing to address contestations concerning the mine and accept interviews pertaining to their mining operations. The Tormin Mineral Sands Mine administrative staff do not respond to emails, and they do not answer phone calls on the numbers provided by the company website. When this was raised in the stakeholder engagement meeting in Doringbaai, the fault was placed on connectivity and internet connection in the area, to which an I&AP stated that due to the length of active operations along the West Coast, poor connectivity cannot be a sufficient excuse. It is evident that these contestations are specific to coastal sand mining companies, and inland sand mines face different challenges, with preference for inland sand mines as they have a lesser impact than coastal sand mines (Osterkamp and Morton, 2005).

6.5 Research challenges and limitations

Although the study is not reflective of what may exist in other mining operations in coastal areas, it provides some detailed case-study insights into ongoing contestations and argumentative polemics on both sides of the pro-and anti-mining divide. There were also practical methodological limitations, specifically regarding the questionnaire survey. These questionnaires were completed online but should have been collected in person. This would have ensured that all questions were fully understood and answered to the best of the respondents' ability. This was not possible due to the one study site's distant location and the fact that a site visit was not allowed by the Tormin Mineral Sands mine.

The Tormin Mineral Sands Mine was not visited, resulting in a lack of information pertaining to the specifics of the area itself, as well as the absence of an interview. This limitation surrounds the fact that the opinion of a mine representative could not be fully ascertained, as the stakeholder engagement meeting was not a formal interview, and the interview questions in Appendix A3 were not addressed.

The last limitation in this study is the freely accessible Landsat images accessed via USGS. There are satellite images which cannot be used due to cloud cover, or issues such as blurred lines through the imagery. There was also a limitation obtaining satellite imagery for specific dates, as they were not available on the USGS website.

CHAPTER 7: CONCLUSION

7.1 Summary of key findings

The key findings surround the contestations of land use within coastal areas. These contestations include conservation areas, development, and rehabilitation of vegetation. These contestations are rooted in the SES approach, as it would require sustainable development and sustainable management as solutions. Furthermore, polemics surrounding what is more important arose - development or environmental protection?

The overall viewpoint on the case study of sand mines situated along coastal areas, is exceedingly negative, with the standpoint that these mining companies are not environmentally desirable, despite the economic desirability. Furthermore, it has been found that the I&APs believe that the mining companies are not providing social or socio-economic benefit. It has been stated that the enforcement of environmental legislation and ECO compliance checks are lacking at these mining companies, with DEADP corroborating these claims.

There is apparent conflict between the DMRE and DEADP departments, the competent authority, and the commenting authority respectively. This conflict has caused uncertainty among enforcement of legislation, and this is largely because of a lack of legislation that encompasses this 'one environmental system' (Kings, 2017), illustrating that neither DMRE nor DEADP may do site inspections or warrant searches without the approval of DEADP, DMRE, and DWS (DFFE, 2014).

When comparing the satellite imagery for MaccSand Mining and Quarrying with that of the Tormin Mineral Sands Mine, it was apparent that the Tormin Mineral Sands Mine has a much larger impact on the environment than MaccSand Mining and Quarrying. There has been a 65% reduction in vegetation extent near the Tormin Mineral Sands Mine since operations began in 2013, whereas MaccSand Mining and Quarrying has had a 9.7% reduction in vegetation extent since operations began in 2000. This would suggest that the concerns surrounding the Tormin Mineral Sands Mine are valid, and those surrounding MaccSand Mining and Quarrying are questionable. However, it is noticeable in the satellite images that the vegetation type at MaccSand Mining and Quarrying differs from 2000 to 2022 and a representative working at the mine confirmed that different vegetation is introduced during the rehabilitation process.

7.2 Conclusion

Sand mining is a concern as sand is being extracted at an accelerated pace and on a substantial scale. Sand mining operations are surrounded by social, environmental, and economic problems and concerns. Globally, sand mining is done in opposition to the opinions of interested and affected parties, as well as laws, which has resulted in gangsterism related to sand mining (Rangel-Buitrago, 2023). This is evident in the case study areas as well.

The entire basis of these polemics is rooted in the Socio-ecological systems approach, as the underlying issues involve humans and the environment. The solution to these issues is to achieve sustainable development with collaborations between the sand mining companies, environmental activists, the civil society lobbying groups and authorities. All parties should cooperate with one another to ensure that the needs of those involved are being met, as well as the needs of the environment, encompassing sustainable human development (Sangha, 2015).

The Tormin Mineral Sands Mine has had a considerable impact on the West Coast in a timespan of ten years, which is extremely alarming, as MaccSand Mining and Quarrying, together with two other sand mining companies, have had much lesser impact in the past 23 years. This illustrates the concern associated with the Tormin Mineral Sands Mine and illustrates that the concerns surrounding this mining company are justified. It can thus be argued that based on the evidence, sustainable development is not what MSR is striving for, and it is not desirable to allow Tormin Mineral Sands to continue operations with the current environmental degradation that can be seen, regardless of its economic benefits. On the other hand, based on the evidence, it can be argued that it would be desirable for MaccSand Mining and Quarrying to continue mining operations, as their environmental impact has not been devastating, possibly indicating that sustainable development may be a goal of the company.

The original aim and objectives of this study were largely met as polemics were analysed; GIS applications were used to ascertain the spatial-temporal changes at the mining sites; the opinions of both authorities and interested and affected parties were captured, and whether the environmental and socio-economic desirability of continued operations and extensions were synthesised. There was, however, lack of opinions ascertained from the officialdom due to the DMRE representatives' evasiveness and the inability to secure an interview with a representative of the Tormin Mineral Sands Mine. The information obtained has documented and analysed the polemics, varied impacts and desirability associated with continued sand mining operations at the chosen study sites.

The recommendations illustrate that sand mining is an international problem and this study has addressed it within a South African context. It is evident that more research on the topic of sand mining in the Western Cape needs to be conducted. Sand mining polemics appear to be endless, and it is important to find sustainable and viable solutions to these problems.

7.3 Recommendations

7.3.1 Improved governance and management of sand resources

According to Zhang (2023), human systems change rapidly, and this change necessitates the SES approach to adapt with these changes. The ultimate task for humanity is to overcome the transitions which are largely caused by mankind. It is less about pursuing the best practice, and more about exploring the best fit or approach to these changes. UNEP (2022b) created a list of ten recommendations to avert a crisis in the sand mining sector. These recommendations are underpinned by sustainable management practices. These recommendations are international, and many can be related to the findings in this study. The recommendations by UNEP (2022b) which are related to the study are discussed below.

UNEP (2022b) states that the importance of sand as a resource, and its function in critical ecosystem services, as well as its importance in the protection of deltas and coastal zones should be acknowledged. Sand dredging in marine environments has also been identified as a major problem, as it impacts on biodiversity and fisheries. This can be seen with the Tormin Mineral Sands Mine operations, which occur on the beaches along the West Coast, allegedly impacting on marine resources. Specific management systems are needed within these coastal communities. It is recommended that sand on beaches be preserved, and this would be the most cost-effective strategy (UNEP, 2022b) due to the vital role that sand dunes play in protection against sea surges, sea level rise, and protection of inland communities (Apitz, 2012).

Furthermore, UNEP (2022b) states that research models can be developed which monitor demand over time which considers population growth, urbanisation trends, infrastructure development, climate change adaptations, and the uptake of alternative materials. The demand and supply in different geographic locations should also be considered, to address the best management system which also considers the environmental and socio-economic outcomes (UNEP, 2022b). This directly relates to the findings of this study, as it underpins the socio-economic impact on the coastal communities along the West Coast who are dependent on marine resources for their livelihoods. It also relates to the residents in Macassar who reside on these dune systems (Graham and Ernstson, 2012).

UNEP (2022b) addresses the social, political, and economic dynamics involved with sand extraction in its second recommendation. The recommendation is that sand resource governance and decision-making need to include interested and affected parties related to the sand mining sector to see reform. It is stated that this reform will be challenging and will impact large numbers of people. In Chapter 4, I&APs stated that they were unhappy with the mining practices occurring, as these were unsustainable and there was lack of community investment. This recommendation would thus give a voice to these community members and have their suggestions incorporated into the mining sector's regulations, giving the nearby communities a sense of authority about what is occurring near their communities/towns and its regulations. UNEP (2022b) further recommends that the reform includes using new materials as an alternative to sand, implementing safer mining practices for the workers and upgraded equipment to ensure safety. This will also include identifying sustainable practices in the extraction of sand, with incentives for structural and sustainable changes in the supply chain (UNEP, 2022b). In Chapter 2, an alternative to sand was discussed, in the form of ore-sand specifically as a viable substitution for this commodity (Golev at al., 2022; UNEP, 2022a).

The third recommendation by UNEP (2022b) concerns educating people and changing education systems geared towards a regenerative and circular economy. This education is meant to include sustainable practices for sand, in the extraction, application or deployment of alternatives in the sector. Large-scale mining corporations should have infrastructure in place that ensures that there will not be unexpected damage to ecosystems over time (UNEP, 2022b). The lack of education related to mining practices was addressed in Chapter 4 during an interview with a community member in Lutzville. It was stated that there is a lack of education within the community connected to sand mining operations and its regulations. A participant at the stakeholder engagement meeting in Doringbaai also alluded to the idea of environmental education related to sand mining operations. It is thus imperative that nearby and affected communities receive education related to sand mining operations as well, to ensure that the mining practices are sustainable.

The fourth recommendation by UNEP (2022b) pertains to strategic and integrative policies and legal frameworks which support responsible sand sourcing and management, with sand alternatives. To achieve this, national and sub-national laws will need to be in coherence. It is thus imperative to analyse the old and current legislature, to establish and reinforce administrative bodies with regulatory authorities to create and enforce strategic levels of decision-making that affects the demand and flow of materials. The monitoring and statistics of these materials need to be improved. The policies and legal complexities should also be simplified to ensure that all parties understand (UNEP, 2022b). This recommendation by the United Nations has also been addressed within the study, as there is a 'one environmental system' which was implemented in South Africa in 2014, and legislation has not been adapted to suit this new system (Kings, 2017). Strategics and integrative policies are thus required within the Western Cape.

The fifth recommendation by UNEP (2022b) underpins the governance and management of resources. These resources need to be mapped and understood to recognise existing interests and who should be in charge must be considered, such as whether the rights should lie under private, community, or government ownership. A comprehensive national, enforceable legal framework for mineral rights is needed that controls access to sand resources. A royalty levy should be applied to mine companies which fully recover the national sand resource management costs. A framework for sand extractions should recognise and balance the interests of government and sustainable sourcing of the materials. Furthermore, it is stated that this framework should be independent from the mineral rights framework (UNEP, 2022b). This recommendation is relevant to the Western Cape as there is allegedly a lack of cooperation between the competent and commenting authorities. The MPRDA and NEMA predominantly governs the environmental legislature, but there is allegedly a lack of enforcement (Watson and Olalde, 2019). Regulations outside these frameworks would thus be beneficial to ensure sustainable extraction of materials. A royalty levy should also be implemented within the mining sector, which promotes and supports sustainable mining companies and practices.

UNEP (2022b) recommends the incorporation of sustainable management of sand resources, and this may be achieved through careful and thorough balancing of the available quantity and quality of sand compared to the rapidly changing societal and economical needs. Strategic planning is needed to identify both short-term and long-term availability while protecting the natural capital. There is a need for Geological Survey Organisations to coordinate with government and policy, to build databases which allow the monitoring of sand resources, especially within isolated areas where data is difficult to obtain. Furthermore, the EIA should become more holistic for larger sand mining corporations, with the ability to identify its impacts on the environment, as well as on human health and welfare. Traditional and local knowledge should be captured to safeguard the valuable ecosystem services which these local and traditional people rely on for their livelihoods (UNEP, 2022b). This study used geographical information systems in coordination with opinions ascertained from I&APs and authorities to assess the environmental and socio-economic impacts of sand mining at the case study areas. It was also deduced that the local communities hold knowledge on the surrounding environments and this recommendation would thus be reasonable for this study. An incorporation of mixed methods was used in this study, and the recommendation is that mixed method approaches be used to achieve sustainable development in the sand mining sector in the Western Cape.

According to UNEP (2022b), the next recommendation addresses the identification of practices to minimise the environmental impact that infrastructure has on altering the natural pathways of sand. There are also high-quality sands which should be reserved for the ecosystem services which require it to function and should only be extracted for limited purposes to reduce the impact on the ecosystem service it provides. An example is silica sand. Silica sand should be reserved for industrial applications over construction applications, and marine deposits along the coast should be prioritised for long-term coastal resilience rather than extraction, which represents short-term benefits. This should be introduced at the Tormin Mineral Sands Mine, as the company's mining operations occur directly on the beaches, impacting on the natural ecosystem services within the area. It is recommended that building with nature is achieved (Spalding et al., 2014). It is also recommended that an international regulatory framework be introduced which has a common vision and enhances the coverage of environmental issues about sand resources, with specific guidelines and international standards (UNEP, 2022b). It is important to have one regulatory framework, as in the Western Cape, there is an array of departments, and national and provincial legislation which must be adhered to for a mining right. Multiple departments and governments have caused confusion within the mining sector and causes inconsistencies and conflict within the sector. This was seen with LUPO and the MPRDA, when MaccSand Mining and Quarrying was closed due to zoning inconsistencies, having obtained zoning rights from the MPRDA which is the national legislation, but needed zoning rights from LUPO as well, which is the provincial legislation (SAFLII, 2011).

The next recommendation by UNEP (2022b) is responsible sourcing of materials. This relates to corporations using ethical, sustainable, and socially conscious sourced materials. The construction material and supply chains should also be more transparent with the sand resources, as this can assist proactive planning for the sustainable criteria of sand extraction to be considered (UNEP, 2022b). This is an important recommendation, as there is a lack of transparency within the Western Cape in terms of mining activities, not only with the mining companies, but also with the officialdom. The officialdom tends to be evasive during interviews and avoid answering questions (Allsop, 2022; Parliament of South Africa, 2009) and as discussed in Chapter 4 of this study.

The last applicable recommendation by UNEP (2022b) is ensuring the restoration of degraded ecosystems after a sand mine is decommissioned, which has directly or indirectly contributed to the degradation. There is need for implementation of compensation mechanisms for remaining losses and to promote natural-based solutions for restoration. This restoration will be towards affected rivers, coastal systems, and land systems. There is lack of rehabilitation within the Western Cape, as DEADP stated in the interview that they were not aware of many mining companies in the Western Cape which rehabilitate during operations. It has also been discovered that there is a higher chance that a mine is abandoned than decommissioned due to the rehabilitation requirements before a mine may be closed (Mpanza et al., 2021). The sand and aggregate mining sectors must fully consider the biodiversity and ecosystem services with the four stages of mitigation, namely avoidance, minimisation of impacts, restoration and offsetting with the amplification and enhancement of benefits of the mine and restoration projects for biodiversity and ecosystem services (UNEP, 2022b).

These recommendations work in collaboration with the sustainable development goals, which is another United Nation Environment Programme (UNEP) initiative aimed at achieving sustainable development and management. More on the SDGs follows.

7.3.2 Sustainable Development Goals (SDGs)

SDGs are a blueprint of interlinked objectives aimed at creating peace and prosperity for people and the planet. The SDGs are a global initiative comprising 17 goals, as shown in Table 7.1.

Table 7. 1: The 17 Sustainable Development Goals. (Source: StatsSA, 2019)

17 Sustainable Development Goals	
1. No poverty	10. Reduced inequalities
2. Zero hunger	11. Sustainable cities and communities
3. Good health and well-being	12. Responsible consumption and production
4. Quality education	13. Climate action
5. Gender equality	14. Life below water
6. Clean water and sanitation	15. Life on land
7. Affordable and clean energy	16 Peace, justice and strong institutions
8. Decent work and economic growth	17. Partnerships for the goals
9. Industry, innovation and infrastructure	

There are six of the Sustainable Development Goals which can be directly applied to the study areas. These include goals 8, 9, 10, 11, 12, and 17. With the achievement of these six goals, there may be an indirect impact on goals 1, 2, 3, and 4. Each goal has different targets and indicators within it which need to be met. How these goals relate to the study sites is discussed below.

7.3.2.1 Goal 8: Decent work and economic growth

This goal relates to the objective of creating job opportunities for youth (UNEP, 2015). The sand mining companies should employ people who reside near the mining companies and should attempt to hire as many youths as possible. Employment within the nearby communities could thus address the SDG goals 1 and 2 by reducing poverty and hunger within these communities. Providing employment opportunities within these communities can also impact SDG 3 and 4 by improving the health and well-being of residents in nearby communities, and by making it possible for the youth to gain an education.

7.3.2.2 Goal 9: Industry, innovation and infrastructure

This goal relates to funding projects that provide basic infrastructure (UNEP, 2015). These sand mines can thus donate sand to construct infrastructure such as roads in informal settlements and towns. This infrastructure would thus make it easier for the residents of rural towns to access transport, making mobility easier.

7.3.2.3 Goal 10: Reduced inequalities

This goal is aimed at assisting marginalised and disadvantaged communities (UNEP, 2015). The study sites chosen are both found in marginalised, disadvantaged communities and can thus strive to support these communities as the SLP requires. This goal correlates to goal 8, as employment opportunities will promote economic growth as well.

7.3.2.4 Goal 17: Partnerships for the goals

This goal relates to the mining companies lobbying the government to boost development financing (UNEP, 2015). These mining companies can thus arrange with the respective government departments to assist them with meeting and achieving the Sustainable Development Goals.

The sustainable development goals work mutually with the achievement of improved governance and management of sand mining sites. Although these are international goals, they can be applied at provincial, national, and local levels within the Western Cape.

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IMAGES

Google Earth Pro images

Source	Year	Coordinates	Satellite	Resolution	Link
Google Earth Pro	**MaccSand Mining and Quarrying**				
	2009	-34.060468, 18.730997	Landsat; Copernicus	600 m	https://www.google.com/maps/place/MACCSAND+Mining+%26+Quarrying/@-34.0603609,18.7283736,17z/data=!3m1!4b1!4m6!3m5!1s0x1dcc4bcb5a554a7b:0xb7158a5df258b99c!8m2!3d-34.0603609!4d18.7309485!16s%2Fg%2F11d_9fbb2c?entry=ttu
	2011		Landsat; Copernicus	600 m	
	2023		Airbus	1km	
	2023		Airbus; Maxar Technologies; TerraMetrics	1 km	
	2023		TerraMetrics; Airbus	800m	
	Tormin Mineral Sands				
	2013	-31.551035, 18.090934	CNES; Airbus	800m	https://www.google.com/maps/place/MSR+Tormin+Mine/@-31.5510201,18.0887344,17z/data=!3m1!4b1!4m6!3m5!1s0x1c314d0694d9389b:0xb23deb52f9b4f4d8!8m2!3d-31.5510201!4d18.0909231!16s%2Fg%2F11b7l2hn3g?entry=ttu
	2013		CNES; Airbus	200m	
	2016		CNES; Airbus	200m	
	2021		Landsat; Copernicus	500m	
	2022		CNES; Airbus	200m	
	2022		Airbus	800m	
	2023		CNES; Airbus	5km	
	2023		TerraMetrics; Airbus; Maxar Technologies	1km	

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SOFTWARE AND APPLICATIONS TO USED

Programmes used for Maps and GIS work

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Coordinate data

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Spatial Data

DIVA-GIS. Ver 7.5. https://www.diva-gis.org/

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GLOSSARY

Active mine: A mine which is actively and currently conducting mining activities on land (Law Insider, n.d.)

Benthic Fauna: species living in shallow waters, and therefore directly impacted by sediment changes (Cowie and Woulds, 2012)

Decommissioned Mine: A decommissioned mine is when a mining and mineral process operation ends, resulting in the removal of all equipment and facilities associated with the mine, and which will no longer be of use in future (Kauppila, n.d.).

Endemism: endemism refers to the taxon of a species which is limited to specific areas and can naturally be found in this space. These species only occur in specific areas or regions and cannot be located elsewhere (Daru et al., 2020).

Frequency: The frequency provides a summary of the number of occurrences for each land class used, illustrating the extent of each land class on the map, based on its unique field number (Pawar et al., 2022).

High turnover: this relates to the rate at which a species' composition changes within a predefined space or gradient (Minachilis et al., 2023). This means that within a given area, there are multiple variations of one species.

Littoral zone: The shallow area of an area of a lake or pond that has a down-slope (Brittanica, 2019).

Mesic: characterized by, relating to, or requiring a moderate amount of moisture (Merriam-Webster, n.d.-b)

Perennial species: A plant that persists for many years, with strong growth completing life cycles all within the same year (Brittanica, 2023).

Polemic: A piece of writing in which a person strongly attacks or defends a topic. It is usually a controversial topic (Cambridge Dictionary, n.d.).

Sclerophyllous: a type of vegetation adapted to long periods of dryness and heat (Bussotti et al., 2014).

SLAPP suit: A SLAPP suit is a lawsuit meant to silence protesting and prevent negative criticism by citizens (Snow, 2009).

SLP: A social and labour plan is part of a mining right meant to assist and uplift communities in which a mining corporation operates, by means of developing the communities, employment opportunism, etc (DMRE, 2010).

APPENDIX A: INTERVIEW QUESTIONS

1. INTERVIEW QUESTIONS FOR I&AP/STAKEHOLDER GROUPS

These interviews will be semi-structured, and questions will be asked regarding a topic and follow-up questions will be asked based on the answers given.

Q1. Is it acceptable with you if I record this conversation?

Q2. What is your standpoint regarding the Tormin Mineral Sand Mine operations occurring along the West Coast Beach?/ What is your standpoint regarding the Maccsand CC mining operations that are occurring along the Macassar coast? Why do you feel that way?

Q3. What do you believe are the positive impacts associated with sand mining? And what do you believe the positive impacts of the Tormin Mineral Sands/ Maccsand Mining and Quarrying Mine may be?

Q4. What do you believe are the negative impacts associated with the sand mining industry? And what do you believe the possible negative impacts are associated with the Tormin Mineral Sands/ Maccsand Mining and Quarrying mine?

Q5. Has the Tormin Mineral Sands/ Maccsand Mining and Quarrying mine impacted your livelihood in any way? If so, what was the impact?

Q6. When the Tormin Mineral Sands/ Maccsand Mining and **Q**uarrying mine was built, do you believe that there was sufficient/enough stakeholder engagement which took place? Please explain your answer.

Q7. Do you believe that there are any off-site impacts of the sand mining operations? If yes, elaborate on these impacts.

Q8. What do you think about rehabilitation of the mining sites after they have closed down?

2. INTERVIEW QUESTIONS FOR COMPETENT AUTHORITIES SUCH AS THE DMRE AND DEADP

Q1. Is it okay if I record this conversation?

Q2. What is your job title and the company which you work for?

Q3. How long have you been working for this company?

Q4. What do you think about the legislation regarding sand mining within South Africa?

Q5. If a sand mine is approved to operate, what regulations need to be upheld during operations?

Q6. In your opinion, what are the positive impacts associated with sand mining?

Q7. In your opinion, what are the negative impacts associated with sand mining?

Q8. If there are any apprehensions regarding the sand mining operations with stakeholders, what is the procedure undertaken to resolve these issues?

Q9. What do you believe is the extent of the impact that sand mining operations may have on surrounding and adjacent vegetation?

Q10. What is the rehabilitation procedure set in place specifically for sand mining companies? What happens if these regulations are not met? / How is rehabilitation enforced for sand mining companies?

Q11. How many sand mining companies, more or less, are rehabilitating while their operations are active?

Q12. Does rehabilitation work the majority of the time? If yes or no, what is the success rate of rehabilitation after a sand mine is closed or abandoned?

Q13. Is the protocol in place to ensure the least amount of damage to the surrounding dune systems as possible? If yes, what is the protocol?

3. QUESTIONS FOR TORMIN MINERAL SANDS AND MACCSAND MINING AND QUARRYING MINE OWNERS

Q1. Do I have permission to record this conversation?

Q2. What is your name and position at the mine?

Q3. What year did you apply for the approval to build the sand mine? When did you get approval for the mine?

Q4. How long have you been operational?

Q5. Were there any difficulties you faced during your EIA? If so, what were these difficulties?

Q6. Since opening the mine, what adversity (if any) have you faced relating to the mining operations, stakeholders, etc.?

Q7. What do you believe are the positive and negative impacts associated with sand mining?

Q8. Are there any negative impacts your mine may have or has had on surrounding or adjacent vegetation? If yes, elaborate. What did you do to remedy the situation or mitigate said impacts?

Q9. What are some of the off-site impacts associated with sand mining?

Q10. What rehabilitation strategies do you have in place to ensure successful rehabilitation?

Q11. How many sand mines do you own within South Africa? How many of these mines are located within the Western Cape?

APPENDIX B: QUESTIONNAIRE SURVEY QUESTIONS

Survey (interview) questions for stakeholders/affected parties/residents associated with the Tormin Mineral Sands/ Maccsand Mining and Quarrying mines/

Opnames (onderhoud) vrae vir belanghebbendes/geaffekteerde partye/inwoners wat verband hou met die Tormin Mineral Sands/Maccsand Mining and Quarrying mines

Please be advised that all information derived from this survey will be used in the thesis of Jaydeen Pretorius. All participants will be treated anonymously (names will not be mentioned and any information which may compromise the integrity of participants will be excluded). If needed, consent to use a participant's information will be asked at the end of the survey. / *Let asseblief daarop dat alle inligting wat uit hierdie opname verkry word, gebruik sal word in die tesis van Jaydeen Pretorius. Alle deelnemers word anoniem behandel (name word nie genoem nie en inligting wat die integriteit van die deelnemers kan benadeel, sal uitgesluit word). Aan die einde van die opname word, indien nodig, toestemming gevra om die inligting van 'n deelnemer te gebruik.*

Q1. Where do you reside? / *V1. Waar woon u?*

Q2. What is/was your length of stay at your current residence? / *V2. Wat is/was u verblyfduur in u huidige woning?*

Q3. What is your interest in the mine (Tormin or Maccsand)? / *V3. Wat is u belangstelling in die myn (Tormin of Maccsand)?*

Q4. What are the positive impacts of the mine (Tormin/Maccsand)? / *V4. Wat is die positiewe gevolge van die myn (Tormin/Maccsand)?*

Q5. What are the negative impacts of the mine (Tormin/Maccsand)? / *V5. Wat is die negatiewe gevolge van die myn (Tormin/Maccsand)?*

Q6. Have you physically visited the mine in person already? Explain your answer. / *V6. Het u die myn al persoonlik besoek? Verduidelik jou antwoord.*

Q7. If your answer to Q.6 is **YES**, please record your impressions of: / *V7. As u antwoord op V.6 JA is, teken u indrukke op van:*

(a) The scale/size of the mine / *Die skaal/grootte van die myn*

(b) The nature of the mining operations / *Die aard van die mynbedrywighede*

(c) The removal/transportation of materials mined / *Die verwydering/vervoer van ontginde materiaal*

Q8. Did you participate in any stakeholder/Interested and Affected Party (I&AP) engagement before the mine was established? / *V8. Het u deelgeneem aan enige betrokkenheid/belanghebbende en geaffekteerde party (B&GP) betrokkenheid voordat die myn gestig is?*

Yes/ *Ja*	No/ *Nee*

Q9. If your answer to the previous question (Q8), is **YES** what was the nature of the stakeholder engagement and who conducted it? / *V9. As u antwoord op die vorige vraag (V8) is, **JA**, wat was die aard van die betrokkenheid by die belanghebbendes en wie het dit uitgevoer?*

Q10. Do you think that the stakeholder engagement was sufficient in regards to providing enough information on the project and did it help stakeholders/I&APs understand the process, procedures, legalities, etc.? / *V10. Dink u dat die betrokkenheid van die belanghebbendes voldoende was om genoeg inligting oor die projek te verskaf, en het dit belanghebbendes/B & GP's gehelp om die proses, prosedures, wettighede, ens. te verstaan?*

Q11. If your answer to Q10 is **NO**, why did you not participate in the stakeholder engagement? / *V11. As u antwoord op V10 **NEE** is, waarom het u nie aan die betrokkenheid van die belanghebbendes deelgeneem nie?*

Q12. Do you know anyone who participated in the stakeholder/I&AP engagement of the Tormin Mineral Sands/ Maccsand mining and Quarrying mine? / *V12. Ken jy iemand wat deelgeneem het aan die belanghebbende/ I & AP -betrokkenheid van die Tormin Mineral Sands/ Maccsand myn- en steengroefmyn?*

Yes/ *Ja*	No/ *Nee*

Q13. If your answer to Q12, is **YES** what was/is your relation to the person/organisation that participated? / *V13. As u antwoord op V12 is **JA**, wat was u verhouding met die persoon/organisasie wat deelgeneem het?*

Friend/ *Vriend*		Employer/ *Werkgewer*	
Family member/ *Familielid*		Civil society group/ *Die burgerlike samelewingsgroep*	
Colleague/ *kollega*		Other (please specify)/ *Ander (spesifiseer asseblief):*	

Q14. What is your opinion on the processes of rehabilitation of the physical environment and flora species which may have been lost, after the mine closes down? / *V14. Wat is u mening oor die prosesse van rehabilitasie van die fisiese omgewing en flora spesies wat moontlik verlore gegaan het nadat die myn gesluit het?*

CONSENT ARRANGEMENT / TOESTEMMINGSREËLING

I hereby provide consent to Jaydeen Pretorius from the University of the Western Cape to use this information in her research, knowing that it will be kept anonymous and that only the information provided will be used. I also confirm that all the information provided is true. / *Ek gee hiermee toestemming aan Jaydeen Pretorius van die Universiteit van Wes - Kaapland om hierdie inligting in haar navorsing te gebruik, wetende dat dit anoniem gehou sal word en dat slegs die gegewe inligting gebruik sal word. Ek bevestig ook dat alle gegewens waar is.*

______________________________ ____________________

Signature/ *Handtekening* **Date/ *Datum***

APPENDIX C: LIST OF PARTICIPANTS

	Interviewee	Code of Study	Position/ Affiliation/ Interest	Year
INTERVIEWS	DMRE	RSP1	Department of Mineral Resources representative	2022
	DEADP 1	RSP2	Department of Environmental Affairs and Development Planning representative	2022
	DEADP 2	RSP3	Department of Environmental Affairs and Development Planning representative	2022
	MaccSand 1 & 2	RSP4 and RSP5	Representatives from MaccSand Mining and Quarrying mine (workers)	2022
	Activist	RSP6	Community member in Lutzville	2022
	MaccSand I&AP	RSP7	Community member in Macassar	2022
	Botanist 1	RSP8	Botanist	2022
	Botanist 2	RSP9	Botanist associated with sand mining operations	2022
STAKEHOLDER ENGAGEMENT MEETINGS		RP1	Presenter at SLP Meetings	2023
		RP2	Farmer	2023
		RP3	Educator in the area	2023
		RP4	Researcher	2023
		RP5	Lecturer from UWC	2023
		RP6	Community Member – Construction worker	2023
		RP7	Community Member	2023
		RP8	Community Member – Council member	2023

APPENDIX D: WEIGHBRIDGE ALLEGATIONS

Interviewer: Is that the only negative or is there more?

RSP4: No, there's lots. He can tell you.

Respondent: Ja, and what other negatives are there, uhm…

RSP4: The negatives do not have to be specific to your mine, it can just be sand mining in general.

RSP5: No look. They have a issue here with – they brought this from Pretoria – with sand blowing in Khayelitsha. Now look at these areas. They have a mine there (in Khayelitsha) adjacent to Khayelitsha, they don't approach them, they approach us. Now they send these people, these white people, they send them notices: "Look here, we gonna come and talk to you about this issue" six weeks in advance. They came 20 minutes, before they came here they said "Listen here, in 20 minutes, we'll be at your site for investigation." And then 5 minutes later, they pop in and ask you for documentation that you don't even know of. So, we provide and everything, at the end of the day, they were happy with our whatever we gave them. The way we manage things to suppress dust and to, the wind blowing and all that. But the others, they don't even, it's fine because they white. If you white, you right. That's how it is unfortunately in Cape Town. City of Cape Town do an inspection on mines, I don't know whatever year, but my brothers out here now, they check whether you have a toilet, whether the toilets working and how do you manage it and all these kinds of things, if it's clean and all these kind of things, if it's enough for the people that work here; they don't do it there that side. You can go there now. You'll see, they don't care, it's fine, but they do it here and they inspect the buildings, everything. There they had a weighbridge built 55m up in the air right. It's dangerous with the downward slope., the weighbridge, they cast concrete 20m long, 1m by 1m to have the weighbridge fitted on its, so that it can carry what, 20 ton and 30 ton trucks. Fine. They said these people don't need plans to do it because I don't know, maybe it's because they white. That other man will talk about it when he gets here.

RSP7: Yes I forgot. Let me tell you this. You know if you wanna build a house nah, you must mos submit a plan or a veranda or whatever, the City is so over this. They built a weighbridge – a concrete structure – on a 50m hill. You saw the trucks coming in here nah, now those trucks are being weighed on there – on a hill. There's no EIA, there's no engineering plan. When I questioned that to [redacted] in the meeting, he said in front of the deputy mayor "No, there's no problem with that."

APPENDIX E: MaccSand I&AP ALLEGATIONS

Interviewer: And then what do you think about rehabilitation of mining sites after the close down?

RSP7: If it is done properly, like you see here what's happening here (at MaccSand), then it's right, but if you look here and you look there [showing neighboring mining sites] and the other places, there's, that's not rehabilitation. I mean, I was there a couple of weeks ago by AfriMat. We literally found cement, rubble, with a City official, [redacted] that saw it. I'm still waiting for [redacted] to come, [redacted] to come out. When we came to the meeting with [redacted] with [redacted], he denied everything. He said, but then we were by a different place. Rubble was tipped in the hole because I remember back in the day, that hole was so high, people drove quadbike there. When I went there a couple of weeks ago, it was level with rubble, but the City of Cape Town wanna fine you for rubble. So what they do is, they come in with their trucks, what do you call it, I'm gonna say a sail (a cover); they come in, they tip it in the hole, they drive out with sand. You won't find a single topsoil there on that mine because they sell it. I'm not sucking this stuff out of my thumb here, this is true.

Interviewer: Is there anything else you would like to add?

RSP7: Because they white. No, it is true. That is what I ask [redacted]. And I asked the mayor to come and you know what the mayor, I will show you on my WhatsApp what the mayor send me: that the owner of MaccSand is driving this belt? For AfriMat to be closed and I told him that is serious allegations he is making. Is it because they are a white company? This is two white companies here man that is getting away with murder. Now you tell me, when a judgement comes out and it includes everyone, that the City of Cape Town have the right now, if you apply at the DMR for your license and zoning, the zoning must go together with your license. These people are closed while they are now waiting for zoning, for 18 months, but they [neighbor mines] can operate, and they can operate. I've got the emails to prove to you from the officials that told me "No, they going to close them." How many years? That was 2016, we now where? We went through covid already, they operated. They just went to the court and said "No" and the court said "No, they can carry on". The City didn't even appeal it. Now again I'm mos asking you, write that down "It's because hulle's wit." Please don't make it anonymous. Write my name there. You can put my cell number also there. My email, whatever. You can put there.

Interviewer: Thank you. Is there anything else, or that's it? You fine with that?

RSP7: Yes I forgot. Let me tell you this. You know if you wanna build a house nah, you must mos submit a plan or a veranda or whatever, the City is so over this. They built a weighbridge – a concrete structure – on a 50m hill. You saw the trucks coming in here nah, now those trucks are being weighed on there – on a hill. There's no EIA, there's no engineering plan. When I questioned that to [redacted] in the meeting, he said in front of the deputy mayor "No, there's no problem with that." So I said "Okay, then I will build a house without a plan. How can you build a concrete structure without a engineering plan?" there's the thing. The servitude road. The deputy mayor was sitting, and he was shocked. They 50m away. The City paid for that entrance, but they 50m away. The servitude must run like this according to the City's map, there's a straight, they don't have a problem. Write there. [redacted] official said "that Urban Mobility don't have a problem with it." And I asked the mayor himself Jordan Hill, to come out and see. He said "No, it's not necessary because why, AfriMat, there's nothing wrong there." Dai's mos corruption man. Skryf daar "Dai's corruption." Ek sê so. You must expose this people. The same with this thing next door. He is putting a bulldozer on the green belt. That's not even allowed. So I ask him, I went in there and I asked him "What are you doing?" I took [redacted] till there and I asked him "Where's your topsoil?". They also have a weighbridge. They say "No, we pushing topsoil". I Said "There's no topsoil! You sold it to me man." So, somebody's paying somebody. Write there "Somebody's paying somebody" Ek sê. Not this people, I say so. Baie skryfwerk. But ek is op recording mos, is fine.

Interviewer: I will have to transcribe that as well.

RSP7: Anything else that you wanna know?

Interviewer: No, I am good.

RSP7: Oh ja, no. write this also. Sorry man, I forgot. Here by R300, Power Construction was mining there for 3 years illegally. They take the sand, they supply a City contract. I sent Eddie Andrews, deputy mayor the photos and councilor [redacted], and [redacted], write [redacted], they did nothing until I forced them. They supply stolen sand to a City contract. So they stopped them now only. Now if you go here in Khayelitsha, deep in Khayelitsha, you will see so a loadetjie, there in also, then there's van Boom also that's mining illegally in Mitchells Plain, but nobody's doing nothing. But when a person of color apply, then there's so many problems. But they tell you you must report, whistleblowing. But now, where's

JP smith with all the rubble that's been tipped here because he know the rubble has been tipped here, then it's fine. We even contacted him for law enforcement to come out here to them. They say they came here, apparently there was no weighbridge built, the weighbridge is for many years there, so where were you. Because the law enforcement they don't have, hulle'tie kennis van die goed nie man. Issie mos nie [inaudible] wat stuur toe nie man, you must know what you talking about. And this councilor here, this man, [redacted] he was also in the meeting with Eddie. Here didn't say one thing. He don't even come, he wasn't even here when the inspection was here. Useless man. Sorry that I raise my voice now, but it's emotional because you struggle with these people for years and years. If you try to go the legal route, then you get problems, but if you go illegal, there's no problem. So, who wants something? But the City works for you. No, they only work for certain people. If you white, they work with you. Anything else that you want to know? I just wanna calm down, ek wil gou bitejie my water drink. Then whatever you wanna ask, ask me.

Interviewer: Okay.

[Someone in background: encroachment to the sea]

Respondent: Ja, here by AfriMat. They on the beach. On the beach man! If you stand by Strand beach nah, you can see AfriMat. If you go now to Macassar beach, just drive around there, you will see they on the sea. Because you know why they getting away with it? Because nobody can see what's going on behind this hill. Olympic. That time with [redacted] was chased away here. I was part of that. The late [redacted] was still standing with a loud ailer??? I was there, Cape Talk was there. Then [redacted] joined with AfriMat. Now they are again there. So, for how long can you then mine? For years. And only that piece. They mine there. You know how mining works? You must mine in blocks then you must rehabilitate. I dare you to go there, you will see they mining there, they mining there, they mining there, but you don't see any topsoil; you will literally see gravel that's been brought in.

Interviewer: [sighs] that's illegal.

Respondent: It's illegal! My point, man! It's illegal! [redacted] saw it with his own eyes, he almost cried.

Interviewer: But then, they're supposed to have an EAP or ECO come to the site every few months-

Respondent: no, they say they did. They saw nothing wrong. They were never here, they lying. Because I almost fought with the mine manager there, they didn't want the City official to enter. Then a motorbike was driving pass us while they were mining. [redacted] was standing and saying "This is not right". I say "Yes. Look, it's not right." And then they came to take photos of me because I'm standing there, I say "Yes, take photos of me." [redacted] didn't bring it up. We brought it up in the meeting then they canceled the meeting because the deputy mayor said "This doesn't make sense." So, we either gonna come here on a site visit in October because he was now going overseas, I don't know where is he going instead of coming here, but I challenged the mayor to come. He doesn't wanna come. Write down, I'm not done with him, I will get him here. How can a mayor, a mayor man, make such an allegation on Whatsapp? And I told him "I will inform this company what you saying." He said "Go ahead." Did you write that? You can give me your WhatsApp, I will forward it, that whole conversation. I wasn't rude to him, but he mustn't talk such stuff.

Interviewer: I will give you my number.

Respondent: yes, you must.

[Friendly conversation unrelated to interview]

Respondent: Oh ja, I forgot to tell you, but this neighboring mine. This wasn't even the original entrance, they were supposed to come in there by Khayelitsha side. Then I want to tell you, the [redacted], his name is [redacted], the manager of [redacted] here, the Wastewater Plant. He put in a complaint because the sand on them is blocking - and that's a City owned building – the pumps, that's why they got continuous sewer plant problems because of them, but I'm glad they fired [redacted]. But I will give you a statement from that man, from [redacted].

Interviewer: And then City also did nothing?

Respondent: No. You see, they contracting under the City of Cape Town. And he said that he tried so many times, who can I contact because this man is arrogant – [redacted]. I've been trying with this people for so long and I thought this is gonna be a new administration, a new mayor, make a lot of promises, maar die wit man is maar nog altyd daar. I told you I'm gonna say it like it is. This is how I see it. But you know what they did with that Atlantic Foundries. They allowed them a 100-year lease in council, but it's a sand mine. They had no problem with it. When it was mentioned to them, they said "No, there's nothing wrong with it." So that people can for 99 years, they can lease the ground and mine for 65 000 a month. Because it's a white company. I dare you. You go put in a application now, you will see all the feedback because what happens is, your EMP will be sent to the City of Cape Town; all their departments. It's just negative because there's a certain flower that grows there, I dunno, it's gonna cure hunger, I dunno. That flower is more important than giving somebody a job. This people don't employ locals. This thing don't employ locals. This [MaccSand] is the only company that employ locals from here. Niks social events. We got nothing! For years, we got nothing. I'm asking for a load, they won't give it. Not a single cent. A man died on AfriMat's mine. The loader, because he didn't mine properly, the loader, a bulldozer fell and crushed the man's head. He's still operating. I told their NB, he was here because he want to open a concrete plant. I told him "You don't have a good track record, what happened to that man?". He couldn't answer me. Now they wanna give a million rand for wi-fi for the whole area. Wat moet ek met wi-fi maak? A million rand vir hoeveel jaar? We want all those years! Invest here. Did nothing. They say no, they give to Macassar. Wat- where? What do they give? Sorry for shouting now man, I apologize. It's just I'm getting a little emotional here. I must take a moment. Give me a moment.

Anything else you wanna know?

Interviewer: No, I was done a while ago, but you can continue.

Respondent: Okay, but the sites that I'm telling you. You mos have a car. Drive till there by Mitchells Plain, you will see van Boom is mining there. If you drive Bydenpaal right up, not here, because this is a legal mine that's right here opposite sewer, if you go further between the hokkies, you will see there's a hill there. There's somebody busy there, but there's nothing, nothing wrong with that. Net corrupt officials in die City man. No, you know what shocked me? [redacted], I told [redacted] I'm gonna get Carte Blanche out with him, he took me like this and he said "No, Sir. Trust me. You don't know me, I will-" he come in the meeting, he say he saw nothing wrong. So I most had to jump up and say "But jy lieg mos nou omdat die mense wit is." I can't help it if he's white, but dis die waarheid. Because I told him "It seems like you taking something here because you covering up. Not even a single thing you see wrong." So, where were we? So, we told him then if we knew, we would've brought the sea sand and smuit dit hie op die tafel because I mean, he's then the one that picked it up and say "This is not right." But they still operating. They are operating illegally man because they were not granted zoning. I was one of the appellants, but I wasn't informed. Write that down. Please write it down. And I even told the mayor I was one of the appellants, that’s why I want to speak to him, he just ignore me.

APPENDIX F: SPECTRAL AND SPATIAL CHARACTERISTICS OF THE USED SATELLITE SENSORS WITH ACQUISITION DATES.

SATELLITE SENSOR	SCENE ID	PROJECTION	DATUM	DATE ACQUIRED	PATH	ROW	BANDS USED
	SAVI images used for Tormin Mineral Sands Mine						
LANDSAT_8	LE71750842013216ASN00	UTM	WGS84	2013-08-04	176	082	(NIR) – Band 5 (Red) – Band 4
	LC81760822014170LGN02			2014-06-19			
	LC81760822015157LGN01			2015-06-06			
	LC81760822016160LGN01			2016-06-08			
	LC81760822017130LGN00			2017-05-10			
	LC81760822019184LGN00			2019-07-03			
	LC81760822021157LGN00			2021-06-06			
	NDVI images used for MaccSand Mining and Quarrying						
L7_ETM	LE71750842012006ASN00	UTM	WGS84	2012-01-06	075	084	(NIR) – Band 4 (Red) – Band 3
	LE71750842013216ASN00			2013-08-04			
	LE71750841999306AGS00			1999-11-02			
	LE71750842001311EDC00			2001-11-07			
	LE71750842005130ASN00			2005-05-10			
LANDSAT_8	LC81750842014195LGN01			2014-07-14			(NIR) – Band 5 (Red) – Band 4
	LC81750842015038LGN01			2015-02-07			
	LC81750842016185LGN01			2016-07-03			
	LC81750842018254LGN00			2018-09-11			
	LC81750842019257LGN00			2019-09-14			
	LC81750842020004LGN00			2020-01-04			
	LC81750842022297LGN00			2022-10-24			