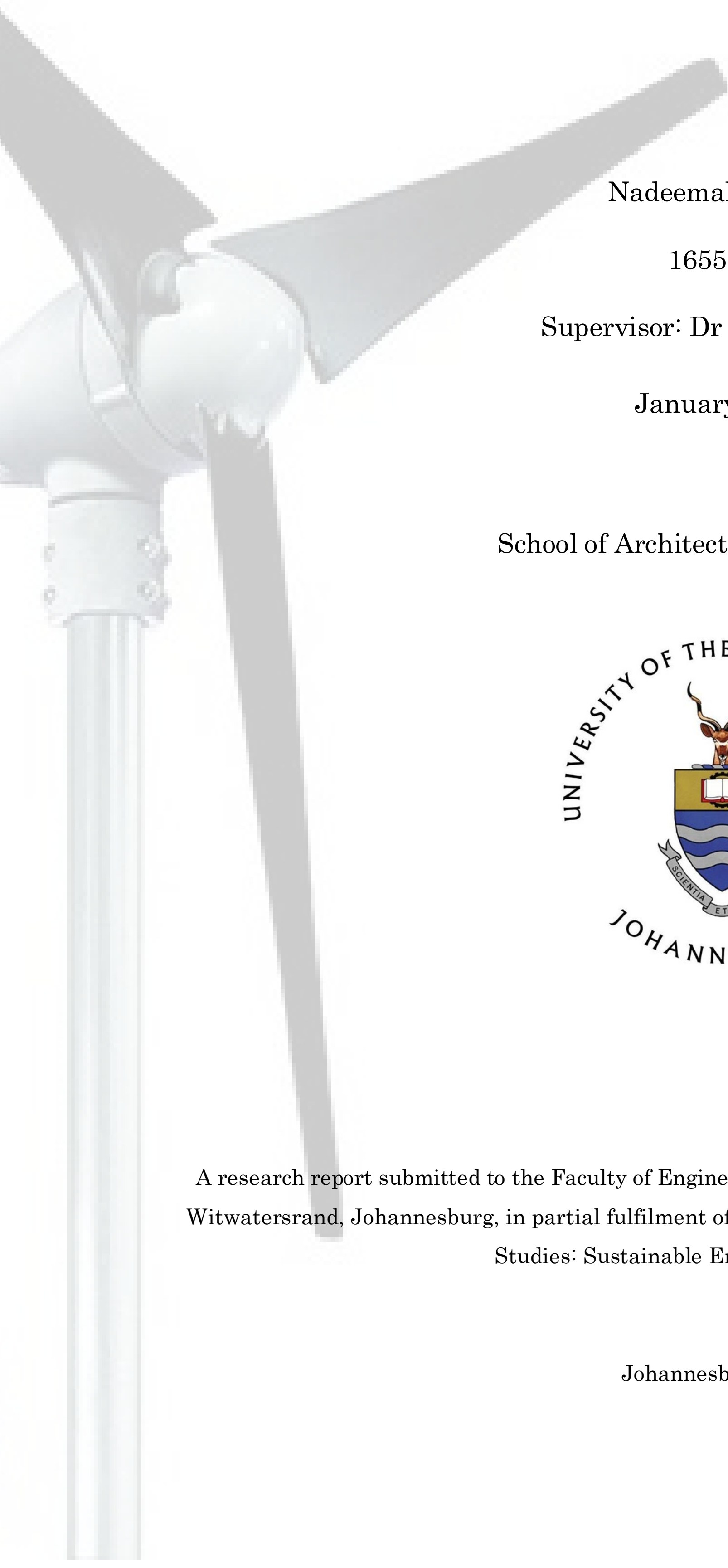
The negative impact of wind turbines on wildlife in South Africa



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Declaration

I, Nadeemah Docrat, hereby declare that this research report is my own unaided work. It is being submitted as part of the requirements to attain a Masters of Urban Studies in Sustainable Energy Efficient Cities with the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

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(Signature of Candidate)

…**10**… day of …**January**… year…**2023**…

Abstract

Wind energy has an exponential growth rate across the world and is seen as the most efficient and reliable source of renewable and green energy technology. However, its negative impacts include the destruction of wildlife habitats and ecosystems and are the cause of many birdlife fatalities. National environmental legislation and assessments provide the basis on which environmental protection and conservation are achieved and as such will be reviewed to identify the level to which avian protection against wind turbines is ensured. This research report aims to investigate the relationships that exist between wind turbines and their subsequent negative effects on avifauna mortality and to understand if environmental legislation reduces the negative impacts caused by wind turbines on avifauna. This is done in the case study area of South Africa and the Western Cape province. Qualitative, exploratory methods will be used in the collection of secondary data. Through the identification of three diurnal raptors most affected by wind turbines in the Western Cape and through the review of two wind farms EIA reports in the Western Cape province, it is evident that wind turbines do negatively affect avian species and contribute to their mortality. Furthermore, whilst environmental legislation underpins the protection and conservation of the natural environment in the country, environmental assessments have the most important role in ensuring the protection of avians and wildlife against the negative impacts that wind turbines present.

Keywords: 'green' and renewable energy, wind turbines, avian mortality, environmental legislation & assessments, wildlife conservation

For my mother,

Taheerah Docrat

Acknowledgements

This past year has been my most challenging year yet. It has made me realize my strength but has also revealed who the most important people are in my life and who I could not have survived without.

To my mother – Taheerah Docrat. Throughout my life, you have been there for me when I needed it the most. But in this past year, you became the support system that I needed to be able to continue and finish my Master studies. You continuously listened to my hardships, gave me advice and continued to stand by me when I wanted to give up on myself. During those tear-filled and heart-wrenching days, you became my rock and my inspiration to keep moving forward. In everything that I do, I will always continue to try and make you proud.

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List of Acronyms & Abbreviations

BAWESG	Birds and Wind Energy Best-Practice Guidelines
BNEF	Bloomberg New Energy Finance
CAGR	Compounded annual growth rate
CBA	Critically Biodiverse Areas
CO_2	Carbon dioxide
COP26	26th United Nations Climate Change Conference
CR	Critically endangered
DFFE	Department of Fisheries, Forestry, and the Environment
DoE	Department of Energy
EIA	Environmental Impact Assessment
EN	Endangered
ESA	Ecologically Support Areas
EWT	Endangered Wildlife Trust
GHGs	Greenhouse Gases
GPS	Global Positioning System
GW	Gigawatt
GWEC	Global Wind Energy Council
HAWTs	Horizontal axis wind turbines
IBAs	Important Bird and Biodiversity Areas
IBAT	Integrated Biodiversity Assessment Tool
ICT	Information and Communication Technology
IEM	Integrated Environmental Management
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
IUCN	International Union for Conservation of Nature
LC	Least concerned
MD	Moderately depleted
MDGs	Millennium Development Goals
MW	Megawatt
NBA	National Biodiversity Act

NBSA	National Spatial Biodiversity Assessment
NBSAP	National Biodiversity Strategy and Action Plan
NEMA	National Environmental Management Act
NEMBA	National Environmental Management Biodiversity Act
NGOs	Non-governmental Organisations
NPAES	National protected Areas Expansion Strategy
NT	Near threatened
OECD	Organization for Economic Cooperation and Development
PPA	Power Purchase Agreement
PV	Photovoltaic
REDZ	Renewable Energy Development Zones
REIPPP	Renewable Energy Independent Power Procurement Programme
SACN	South African Cities Network
SANBI	South African National Biodiversity Institute
SAWEA	South African Wind Energy Association
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SO_2	Sulphur dioxide
TWh	Terrawatt-hour
UNIDO	United Nations Development Organisation
VAWTs	Vertical axis wind turbines
VIA	Visual Impact Assessment
VRE	Variable Renewable Energy
VU	Vulnerable
WEF	Wind energy facility
WWF	World Wildlife Fund
YoY	Year-over-Year
WM	Wind Measurement Masts

Chapter 1 (Introduction)

"Without habitat, there is no wildlife. It's that simple." - Fresh Quotes

1.1. Introduction

Nature and its elements are important for human survival and continue to provide 'natural capital' that underpins countries' economies and their social and physical development over the years. As cities continue to become industrialized, the impact that development has had on the natural environment asserts the need to develop alternative methods that will allow for the continued expansion of cities without negatively impacting the natural surroundings. The increasing realization of neglect of the environment over the past several decades has inevitably coincided with the various physical and technological developments of cities and the development of various spheres that make up the space that we live in. It is widely acknowledged that destruction has been caused, but little consideration is given to the essential aspects that sustain our being and bring forth the need to be more inclusive of sustainable practices for the future.

Sustainability has become an important concept in the development of cities and strives toward creating city spaces that not only mitigate climate change but incorporate the conservation of resources and the development and use of new technologies. Sustainable practices in urban development include green buildings, alternate and renewable energy, and the use of renewable materials. However, renewable and sustainable practices bring forth the negative issues that then depend on alternate thinking and measures to mitigate these issues.

The growth of the population and the high rate of urbanization in cities has meant an increase in pollution stemming from the industrious use of fossil fuels to generate electricity for industrial and personal consumption. However, due to increased realization of the harmful effects that carbon dioxide (CO_2) has on ecosystems and human health, alternate solutions have been sought to offer 'green' and clean methods of producing energy that is less damaging and which reduces CO_2 percentages that are released into the environment. This not only incorporates the 'greening' of alternate methods to generate electricity but also the use of sustainable means (technology, raw materials, and the use of the natural environment) to ensure the reduction of CO_2 emissions released by various contributing factors (i.e.: commercial and industrial buildings, vehicles and society).

Cities have, thereby, 'evolved' to be incorporative of sustainability models and smart technology which prioritizes the protection of the natural environment whilst still allowing for development and growth. Similarly, the increased introduction of various kinds of renewable energy generation in cities presents the benefits of having clean and better-quality air, improved living spaces and forms a basis for transitioning to low carbon-based economies that have less reliance on fossil fuels.

In conjunction with renewable energy, the generation of electricity using wind turbines presents the opportunity to generate electricity using natural elements (wind) with the wind industry having increased by 53% in 2020 (GWEC, 2021). The differential that exists between onshore and offshore wind turbines relates to the amount of energy produced – offshore wind turbines can generate at least two times more electricity due to the undisturbed wind currents that exist out at sea. However, although wind turbines are the fastest and most notably used form of green energy, the question arises as to what the implications are on the natural environment and surrounding wildlife. It is 'common' knowledge that the blades of the turbines kill birds due to the blades disrupting their flight pathways and that the placement of the turbines is based on topographical and geographical locations. As such, extra care needs to be taken in understanding how surrounding flora and fauna are affected by the placement and during the operational phase of the wind turbines.

As the generation of renewable energy, through wind energy, grows in South Africa, it becomes important to understand the relationship that exists between operational wind turbines and the surrounding environment. Not only has wind energy become an important concept and practice in countries around the world, but because of the expected 3% growth in the South African wind energy market (MordorIntelligence, 2021), it is being seen as the backbone of 'sustainable, green' energy generation in cities. Wind turbine infrastructure present adverse environmental impacts that are not always considered. This research seeks to investigate the renewable energy sector, specifically energy generation through wind turbines, and the negative impact that wind turbine infrastructure has on the environment.

1.2. Problem statement

The Intergovernmental Panel on Climate Change Report has stated that "*the global surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered. Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in* CO_2 *and other greenhouse gas emissions occur in the coming decade*" (IPCC, 2021:18). Not only does this report further reinforce the notion of the negative implications of past environmental transgressions, but it has allowed the public to fully comprehend the need to move towards a greener and more sustainable city. COP26 became an important platform to discuss the crisis highlighted in the IPCC report. However, many believe that the conference did not address the larger issues at hand and did not present adequate responses and mitigation plans on how countries would ensure drastic reductions in CO_2 to reduce the increase in average global temperatures (Reay, 2021).

As renewable energy usage increases globally to mitigate and reduce the impacts of climate change and the use of fossil fuels in energy generation, countries adopt different energy production methods that align with, inter alia, their country's topography and climate. However, wind energy has become more globally used, as it is the most established, efficient and cleanest form of renewable energy source (Acciona, 2020). The wind industry is expected to grow globally at a compounded annual growth rate (CAGR) of 5.2 - 5.4% (2020 – 2027) and 8.5% between 2020 – 2024. This translates to a 54% increase in wind energy installations according to the Global Wind Energy Councils Report (GWEC, 2021:44).

In South Africa, the wind energy industry boasts the largest market on the continent (Mostafaeipour, et al., 2020) with an installed capacity of 2.4GW and operational capacity of 2.1GW stemming from 25 wind energy facilities and more than 961 wind turbines as of Quarter 1 2019 (SAWEA, 2018; van Zyl, 2019). It is forecasted for the industry to grow at a CAGR of more than 3% between 2022-2027 with an estimate that the wind electricity generation capacity could reach 12 Terrawatt-hour (TWh) in 2025 and 81 TWh in 2040 (MordorIntelligence, 2021). However, South Africa was highlighted in COP26 as being heavily reliant on coal (Reay, 2021). With this, the need to shift away from the dependency presented by using coal and onto renewable energy has become an important topic. The country initially responded by introducing a '*supportive policy and legislative framework to exploit the excellent local renewable energy resources'* (SANEDI, 2022) in 2003, but South Africa's Department of Statistics stated that in 2016, coal energy still accounted for 85% of all electricity generated (Akinbami, et al., 2021). These statistics convey the large growth that still needs to happen within the energy sector to become more sustainable.

Protecting the South African landscape and all its flora and fauna has become pivotal as cities become more urbanized. Not only does South Africa have a large range of land and ocean biomes but the various ecosystems that are home to endangered and endemic species further promote South Africa to be deemed the most beautiful country in the world in 2022 (Pennington, 2022). The wildlife is, thereby, not only important for the South African tourism industry but is further important for the protection of endemic wildlife that lives on this landscape.

By introducing wind energy as a renewable energy source in the country, the turbine structure transgresses the landscape and disrupts the natural behaviour of animals in the area. Within a period of 4 years (2014-2018) in South Africa, over 800 endemic birds were killed by colliding with wind turbines (Bega, 2020). Recent research further shows that at least 36% of these birds are birds of prey (Murgatroyd & Amar, 2021), which contribute significantly to the longevity of various ecosystems and habitats. As demand for renewable energy in Africa and South Africa continues to grow, so does the risk to endemic biodiversity, especially birdlife.

Although environmental organizations - *Bird Life South Africa*, *the Endangered Wildlife Trust* and *Wilderness Foundation Africa* - track and create a voice of concern for birdlife mortality rates, the lack of strong and effective implementations of environmental assessments and policies has meant that wind farms may be able to emerge without fully complying with necessary assessments, negatively impacting native and endangered flora and fauna.

1.3. Aim & Rationale

This research is important because it compares the increase in alternate and renewable energy, wind energy, in cities with the negative impact that such infrastructure has on externalities that are not usually considered by laypersons, such as bird mortality rates. Although mortality of birdlife can be attributed to factors such as poisoning, persecution, mortalities linked to human infrastructure (powerlines, fences, roads), loss of habitats and the destruction and disturbance of nesting areas (BirdLife South Africa, 2020), wind turbines contribute to the number of bird fatalities, especially as the wind energy industry emerges, and provides an area to be investigated. This research will focus on the negative impacts that wind turbines have on birdlife (i.e.: mortality) and will include a review of national environmental policies and assessments. This is because environmental policies and assessments hinder ecological degradation and further promote the sustainable use of natural resources to achieve social, economic and ecologically sustainable development and provide a framework to understand the sustainable operational use of wind turbines.

The aim is to, therefore, use the case study area of South Africa and the Western Cape province, to understand if said environmental legislation reduces the negative effects and impacts caused by wind turbines on birdlife. This research *does not* intend to measure the correlation between wind farms and avian mortality rates and thus presents an avenue for future research.

1.4. Objectives

a. To understand the complexities and level of wildlife, habitat and ecosystem loss due to turbine infrastructure (kinds of flora and fauna loss, percentages etc.).
b. Review how policy (NEMA, NEMBA etc.) and assessments (EIA, SEA, Avifaunal Impact Assessments etc.) have limited and/or advanced the development of wind turbines and ensured the protection of birds.
c. Review if wind energy production is truly sustainable for the future of South Africa's renewable energy generation production.
d. Compare wind farms within the Western Cape, to each other, and understand the differences that exist in the operations of turbines and how this has impacted surrounding birdlife.
e. Understand if newer policies and assessments have made a positive or negative impact on birdlife mortality rates.

1.5. Research question

Have South Africa's environmental policies and assessments reduced the negative effects of destruction and mortality of birdlife caused by wind turbines?

1.6. Sub-questions

1. How have Environmental Impact Assessment (EIA) and related policies (Strategic Environmental Assessment (SEA) etc.) ensured the protection of wildlife in wind farm areas and their surroundings?
2. What alternate measures have been introduced in wind farming areas to limit the threats posed on wildlife, habitat and ecosystem loss by wind turbine structures?
3. Do alternate wind structures exist that can be implemented in or around cities that reduce the overall distance, expenditure and threat that existing turbines have in outlying areas?
4. Is energy generation through wind turbines sustainable in the long term for cities and wildlife?

1.7. Research Methods

This research will be a qualitative study that is inductive, cross-sectional, and which employs a case study strategy incorporative of wind farms in the Western Cape. The literature explored will be comprised of secondary data which include information being extrapolated from academic journals, websites, international and national environmental reports, as well as relevant organizations and NGOs. Grey literature, such as environmental policy and assessments will also be used and will create the legal premise of understanding the kind of environmental goals and wildlife protections that the country is aiming towards.

Semi-structured interviews, with purposively selected professionals from birdlife and environmental protection organizations (Birdlife South Africa and Endangered Wildlife Trust (EWT)), were set to happen. However, interviews were not conducted due to no availability of said professionals, and reliance was then placed solely on the gathering of secondary data.

1.8. Limitations and Challenges of the Research Report

a. Not being able to conduct interviews with professionals from various organizations due to no availability, no communication or permission being granted by them. This made reliance on secondary data more pronounced and did not enable additional professional and knowledgeable insight into the matter.

b. Access to data (EIAs) on specific wind farms in South Africa is hard to find, which has led to only a few wind farm environmental assessments being reviewed.
c. Accessing data on South Africa's wind energy market is limited, making reliance on a few sources more prominent and which did not all have the information needed.
d. Accessing statistical material relating to flora, fauna and bird mortality rate proved hard to find and/or access as permission is required to access databases from bird protection organizations and NGOs. Acquiring approval takes several weeks.
e. Outdated data on birds due to surveys only being conducted every few years and updates are not available during the time between reports.
f. Relevant data on wind farms in the Western Cape are scattered with sources having outdated information. More time was spent trying to correlate and validate the information found.

1.9. Ethical Considerations

Ethical considerations play a vital role in research even if this research is primarily conducted via desktop study. This research does not include sensitive matters and/or vulnerable groups. The necessary procedures have been followed to obtain ethical clearance from the School of Architecture and Planning at the University of the Witwatersrand. This research report, thereby, includes honest interpretations of desktop collected data, including environmental policy and assessments, and not ignoring and/or being biased toward a source of data that conflicts with another source. Furthermore, juxtaposing views are noted which further elates the different opinions of authors.

1.10. Chapter outline

Each chapter heading is a quote that narrates with the content of the chapter. Some resonate with the environment whilst others resonate with a deeper sense of self that should have the reader questioning themselves and their stance on being environmentally aware. Sometimes all we need is a quote, a simple choice of words, to question ourselves and our activities.

<u>Chapter 1 (Introduction)</u>: **"Without habitat, there is no wildlife. It's that simple."** - Fresh Quotes

The introductory chapter covers a variety of aspects and highlights the degradation that has occurred within the natural environment because of technological advancement and because many countries around the world rely on fossil fuels to generate electricity. Associations are made between sustainability and the emergence of renewable and alternate energy, especially wind energy. The chapter introduces climate change issues and why renewable energy is seen as the way forward, especially in South Africa. The issue surrounding wind turbines and bird mortalities is introduced. Furthermore, the chapter is inclusive of the research question and sub-questions, research methods used in this research and limitations and challenges faced whilst conducting the research.

Chapter 2 (Literature Review): **"None of us can change our yesterdays, but all of us can change our tomorrows"** - Colin Powell

Chapter 2 is a literature review. It identifies and explores concepts, theories and arguments which provide the basis to answer the research question. The literature explores and develops an understanding of sustainability and the protection of the environment, cities and sustainable development and renewable energy. It dwells deeper into understanding wind energy, the impact that wind energy has on wildlife and corresponding environmental policies and assessments. Chapter 2 forms the foundation of this research by allowing comprehension of pivotal arguments and concepts before immersing into succeeding chapters and arguments.

Chapter 3 (Context): **"I cannot change the World. But I can change the world in Me"** - BONO

Chapter 3 outlines the study context area of this research. This chapter examines the context of wind energy in South Africa and provides an understanding of how wind energy disrupts wildlife and birdlife in South Africa and the Western Cape province. The chapter further outlines national environmental legislation and assessments that are said to enact the protection of birdlife in the country.

Chapter 4 (Findings and Analysis): **"A bird doesn't sing because it has an answer. It sings because it has a song"** - Maya Angelou

Chapter 4 relays the findings and analysis of said findings of this research. The chapter details the identification of red-listed avifauna species in South Africa and the Western Cape province. In-depth information is given on bird species most affected by wind turbines in the Western Cape with wind farms in the Western Cape province being selected for review. Environmental assessment reports of said wind farms are reviewed against national environmental legislation and assessments to answer the main research question.

Chapter 5 (Conclusion & Recommendations): **"What wild creature is more accessible to our eyes and ears, as close to us and everyone in the world, as universal as a bird"** - David Attenborough

Chapter 5 is the concluding chapter which aggregates the content of the research which was covered. More importantly, this chapter provides a summary of the research report and answers the main research question based on the findings and analysis covered in chapter 4. It is further inclusive of recommendations for future research and studies.

<u>Chapter 2 (Literature Review)</u>

"None of us can change our yesterdays, but all of us can change our tomorrows" - Colin Powell

2.1. Introduction

The use of sustainability and 'greening' practices and strategies have become more evident in cities as deeper understandings surround exponential global change and the realization of past unyielding environmental neglect. This engenders the creation of multiple spheres in which various mitigatory projects are carried out as one realizes the vast impact that our everyday lives have on the environment, both directly and indirectly. As a response, not only have policies been developed that target environmental awareness and strategies to overcome past negative discrepancies, but city planning and technologies have further assured the change in governmental and citizen mindset.

The Intergovernmental Panel on Climate Change (IPCC) 2021 Climate Report has stated that the last four decades has been sequentially warmer than any decade since 1850, due to human influence and the increase in greenhouse gases (GHGs). Together with the 2020 World Wildlife Fund Living Planet Report, it is evident that the natural environment has experienced a substantial decrease in bio-diversities and ecosystems, due to the damaging and destructive nature of humans on said environments, owing to pollution and species and resource exploitation. Not only is human greed a contributing factor to the loss of the natural environment, but many people still do not know about the issues due to a lack of education, understanding and willingness to learn and comprehend the issues that surround them.

This chapter identifies and explores concepts, theories and arguments which provide the basis to answer the research question. The literature explores and develops an understanding of sustainability and the protection of the environment, cities and sustainable development and renewable energy. It dwells deeper into understanding wind energy, the impact that wind energy has on wildlife and corresponding environmental policies. Chapter 2 forms the foundation of the research by allowing comprehension of pivotal arguments and concepts before immersing into succeeding chapters and arguments.

The title of this chapter, therefore, resonates that what has happened in the past cannot be undone. It is up to the current persons and youth, to take it upon themselves to implement measures to somewhat offset the negative impacts that past doings have done, especially to the environment. As a combined entity, we can only move forward but moving forward does not entail doing injustice to the surroundings but rather ensues us to move forward to protect the environment so that future generations do not suffer more as the world and communities suffer today.

2.2 Sustainability & the protection of the environment

Present environmental problems were exacerbated by the onslaught of the industrial revolution which caused widespread water and air pollution, reductions and destruction of ecosystems and large percentage increases in global atmospheric temperature (Rafferty, n.d.). However, through this came the added contemporary benefits of technological, socio-economic, and cultural changes and developments, but with the added stress on the environment for its natural resources. The balance between meeting our own needs outweighed the need to look after the environment resulting in an environmental imbalance and the current unsettling affairs associated with climate change.

The initial term and concept of 'sustainability' can be traced to the English farmers up until the 19th Century, where the term was used to describe communities that were supported by sustainable food systems that enabled community and individual self-reliance (Ecological Agricultural Projects, 1990; Kuhlman & Farrington, 2010). This term has made its way into the contemporary world, and in doing so has changed the mindsets of people, communities and governments in the way that people think and act with not only the environment but question the feasibility of doing more with less.

The term 'sustainability' encompasses creating a balance between the environmental, social and economic pillars that propel humanity with the existence of the term being derived from other concepts surrounding (a) development, (b) providing basic human needs to all and, (c) ensuring the protection of the environment for the future (Klarin, 2018). According to Thomas (2004), the concept embeds itself in the constant alterations of society (present, future, and past) and can be noted in international and local statutory and regulatory compliances through which it coincides with the development of our surroundings. Naturally, concern arose with the increased tension between the aspirations of man and wanting a better, more developed life and limitations imposed by nature. Being more sustainable created the desire to achieve a harmonious balance between needs versus resources and development versus the environment. According to Kuhlman and Farrington (2010), the premise argument of sustainability is primarily around human 'welfare' and inter-generational equity, although it accepts that environmental concerns are important. It is also noted that the concept of sustainability has opposing views regarding humankind and the environment: human needs can be adapted to be more harmonious and inclusive of the environment and others which see nature as something that can be conquered and bent to will (Kuhlman & Farrington, 2010). It is through this that the understanding of the three pillars of sustainability needs to be understood and defined.

The three pillars of sustainability include (1) people (social), (2) planet (environmental), and (3) profit (economic) (World Bank, 2016) as shown in Figure 1. Klarin (2018) states that environmental sustainability seeks to maintain the balance of the quality of the environment to ensure the continuation of economic activities and the quality of life of people. Social sustainability endeavours to ensure the balance between human rights, equality, cultural preservation of identity and respect towards other races, religions and cultural diversity (Klarin, 2018) whilst economic sustainability strives to maintain the natural, social and human capital required for everyday living and expenses (Klarin, 2018). Absolute sustainability is accomplished when all three pillars are balanced, however, this encompasses the need to respect and consider the interests of the other pillars. Although the environmental pillar underpins this research, both the social and economic pillars influence environmental sustainability and provide an understanding of how capitalistic and social means underpin either the protection or exploitation of nature.

Figure 1: The 3 Pillars of Sustainability (World Bank, 2016)

The institutional understanding of the term 'Sustainability' stems from the definition used within the United Nations Brundtland Report of 1987 (Our Common Future) – "*Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.*" (United Nations, 1987, p. 16) and will be used as the basis of understanding what sustainability is in this research. This definition emphasises the close relationship that exists between the environment, development and the need for cooperation between environmentalists and developmentalists to not only place the issue of sustainability at an international level, but to ensure the balance between social, economic and environmental needs.

2.3. Sustainability and Development

The concept of 'development' is said to have undergone tremendous change since the end of World War II due to the unprecedented periods of science and technology development and transfer (Remenyi, 2004). It underpinned the growth in mindsets and government strategies, economies and policies. This ensured the exponential growth of information but also in understanding the importance of surrounding environments and the relationships that they have with each other. Development is said to connect to the historic relations between colonialism and imperialism linking development to (a) economic growth, (b) structural transformation, (c) human development, (d) democracy and government, and (e) environmental sustainability (Vázquez & Sumner, 2013); and targeting change to achieve resources and goals (Remenyi, 2004; Klarin, 2018).

Remenyi (2004) states that development is the process of not only improving self-sufficiency and one's quality of life, but together with Klarin (2018) who states that development motivates the adoption of plans, policies, strategies, and activities evident in governmental, private and non-governmental institutions, ensuring a sense of direction and plans to achieve a set of goals.

The United Nations introduced the Sustainable Development Goals (SDGs) in 2012 (Figure 2), to ensure the increase in sustainable development globally, whilst ensuring that development to meet human needs was being done and was incorporative of environmental restraints and limits.

Figure 2: Sustainable Development Goals – South Africa (SA Goal Tracker, 2019)

This research will predominantly relate to SDG 3 (establish good health and well-being), SDG 7 (grow affordable and clean energy), SDG 11 (mobilize sustainable cities and communities), SDG 12 (influence responsible consumption and production), and SDG 13 (organize climate action). These specific SDGs were chosen as they respond to the specific factors and topics that will be highlighted throughout the research and will account for the kind of sustainable development that is happening within the South African space and what it means for future development in the country.

2.4. Cities and Sustainable Development

As of December 2021, statistics given by the Worldometer show the worlds' population exceeding 7.9 billion. The growth of the population and the 55% rate of urbanization (The World Bank, 2020) in cities has meant an increase in pollution, stemming partly from the use of fossil fuels to generate electricity for industrial and personal consumption. Whilst cities have been seen as beacons of opportunity that offer employment and a better quality of life, increased urban migration has meant that more land is being consumed for housing (i.e.: low-density housing) and more energy and resources are needed to support the influx of people into the city.

The OECD (2018) states that urban sprawl has significantly attributed to the increase in CO_2 emissions and pollution, from humans and vehicles, with increased interference and loss of environmental processes and ecosystems. Furthermore, not only have urban areas become more dense, but due to exclusionary housing markets, segregation between different income groups has become more evident inducing trade-offs between work and living lifestyles. This in turn causes higher CO_2 emissions from increased mobility dependency on transportation and further leads to increased environmental pollution in densely populated areas where municipal services are not operational or evident.

In a country such as South Africa, which predominantly uses coal for electricity generation and where electricity is needed for the functioning of society, housing segregation has meant that not everyone has access to electricity, thereby, relying on alternate means of providing energy for domestic use (i.e.: burning of wood, paraffin etcetera). This imparts that alternate, safer and more sustainable energy generation needs to be developed for those that do not have access to electricity. It is a way for South Africa to be more sustainable, less reliant on coal and to adequately comply with international sustainability policies to safeguard a more sustainable country by adopting alternate and renewable means and technologies. The South African Cities Network (SACN) has been manifesting the ideals of creating a sustainable city in South Africa by focusing on variables surrounding water management, climate change, sustainable energy, and waste management to project the way forward for future sustainable developments within the country.

2.4. The introduction of renewable energy

Urban areas account for more than half the worlds' population (The World Bank, 2020), with cities consuming 65% of global energy demand and accounting for more than 70% of greenhouse gas emissions (IRENA, 2016; The World Bank, 2020). Dependency on fossil-fuel generated energy has increased and has meant that to meet the rising needs of the population, alternate measures need to be developed that will decrease dependency on non-renewable resources. Renewable and green energy sources have paved the way as it has the potential to meet the above goals and addresses SDG 7.

Renewable energy provides the solution to meet the developmental and climate objectives of cities. However, the growth of renewable energy greatly depends on each country's and city's characteristics, namely, population growth, growth and demand profiles and climate (IRENA, 2016). The International Renewable Energy Agency (IRENA) (2016) states that emerging economies and developing countries that have a population growth of above 2% will account for 70% of global energy growth by 2030 and will be best positioned to implement energy efficiency and renewable energy technologies to offer solutions for sustainable development, whilst being incremental and cost-effective. Strategies and policy frameworks need to be deployed and implemented based on each city's context. Furthermore, although policies at various municipal levels play a crucial and fundamental role in ensuring effective, smart and sustainable growth, the transition to introducing renewables depends on citizen and governments mind-shifts that consider renewable energy as economic and environmentally sustainable drivers.

More cities are attempting to significantly increase their renewable energy usage by 2050 and use concepts such as carbon neutral, decarbonized or net-zero energy to describe their ambition (Thellufsen, et al., 2020). However, to achieve this, entails not solely relying on the move toward green energy, but includes reducing energy demand through energy efficiency and relying on centralized and decentralized sustainable energy systems (European Green Capital Network, 2020). Renewable energy and sustainability are networked together because they offer the possibility of change in city systems that greatly contribute to the rise in emissions and energy usage, namely, transportation, buildings, and domestic use. Through the implementation of renewable technologies, emissions and energy usage can be reduced by harvesting energy from the environment around us and by using energy-efficient technology.

Renewable energy includes (1) solar, (2) wind, (3) hydro-power, (4) ocean/ tidal, (5) geothermal, and (6) biomass (EDF, n.d.; Shinn, 2018; TWI, 2022) as shown in Figure 3. This consists of not only harvesting different kinds of natural energy, but technological development has meant that more kinds of energy can be harvested on a large scale. Although renewable energy is seen as a positive inclination in combatting climate change and the use of fossil fuels, it still bears negative social, environmental and economic costs (Inspire, 2021). It is, therefore, important to understand the distinguishing factors between renewable energy, green energy and clean energy. Renewable energy is recyclable, clean energy does not produce pollutants and green energy is natural, hence, the cross-over and merging of understandings (TWI, 2022). Renewable energy does not make it sustainable energy nor green energy and its characteristics need to be considered when being chosen and implemented.

Figure 3: Kinds of renewable Energy (Article1000, n.d.)

The advantage of renewable energy is that it offers a low-cost supply of power, creates job and economic opportunities, and can change lives and lifestyles to be more cognizant of the surrounding environment (IRENA, 2016; TWI, 2020). Not only does it reduce CO_2 emissions and air pollution (increasing public health (Ucsusa, 2017)), but it offers greater energy security and resilience to external shocks, presents greater energy access for developing nations (Ucsusa, 2018), has lower energy maintenance requirements and lower reliance on a foreign power supply (EnergySage, 2022). However, the disadvantages are that renewable energy sources cannot always be relied upon (i.e.: weather change) and that it still poses some danger to the environment (i.e.: biomass and nuclear) (TWI, 2020). It further includes higher capital costs in the beginning, limited energy storage capacity, energy sources are geographically limited, it is still not fully 100% carbon-free due to manufacturing, transportation and installation which produces a degree of CO_2 (Terrapass, 2020; EnergySage, 2022) and the renewable energy sites require a lot of space which imposes onto environmental grounds and spaces (GreenMatch, n.d.).

Renewable energy in developing countries and economies exhibit robust opportunities as urbanization relays increased pollution and air quality damage, due to the usage of old energy-heating methods. Increased advances in variable renewable energy (VRE) technologies together with country commitments to reduce GHG emissions, global energy production costs and patterns can be offset (Arndt, et al., 2019) and present advantageous opportunities for countries that have energy poverty (Costa, 2019). These countries, in most instances, have abundant distributed renewable energy sources, have increased energy demand and often have dispersed and large rural populations that have limited or no access to electricity. The opportunity to leapfrog to advanced technologies that are becoming low-cost, reliable and environmentally friendly is best suited to serve these rural communities (Arndt, et al., 2019).

Emerging countries approach renewables as part of the industrialization process because they are clean, offer employment opportunities, respond to economic growth and energy consumption can be managed (Mathew, n.d.; Costa, 2019). Furthermore, Bloomberg New Energy Finance (BNEF) has reported that developing countries have built more clean energy than fossil-fueled, increasing the power-generating capacity in the past several years (Bronstein, 2020). As of 2017, statistics showed that developing countries accounted for 63% of global investment in renewables (Arndt, et al., 2019). Due to wind energy being the fastest growing form of renewable and green energy in the world and South Africa, this specific green energy will be focused on.

2.5. Wind Energy

Wind energy is currently the most efficient and feasible renewable technology available (SEA, 2018). Wind energy is produced by using kinetic energy created by air in motion that hits the turbine blades, causing them to rotate and turn the turbine connected to them. The kinetic energy is changed into rotational energy which produces electrical energy and is produced through either wind turbines or wind energy conversion systems (IRENA, 2011-2022). The amount of power harvested is dependent on the size of the turbine, the length of its blade and, in theory, the speed of the wind which causes the turbine blades to increase rotation, increasing energy generation.

The Global Wind Energy Council (GWEC) Global Wind Energy Report 2021, states that 2020 was the best year in the global-wind industry with a year-over-year (YoY) growth of 53%. This came during a challenging year when the world was faced with the COVID-19 pandemic, emphasizing the resilience of the industry and the potential for the global supply chain to deliver in the coming years. It is expected over the next five years for the industry to have a compound annual growth (CAGR) of 4% with annual installations expected to exceed 110 GW by 2025 (GWEC, 2021). The expected additions are comparable to the existing two-thirds of all current wind installations worldwide, showcasing the significant expansion set to happen over the next five years.

As more countries set targets and commitments to be net-zero/ carbon neutral, it is imperative for a radical and systematic move away from dependency on fossil fuel to a renewable and low-carbon energy solution. Wind energy offers this window of opportunity as it is cost-effective, is a clean fuel source, offers sustainable employment opportunities, is a domestic source of energy, offers sustainable and green energy industry growth (U.S Department of Energy, n.d.), can bring socio-economic benefits and industrial development to local communities (GWEC, 2021), and can keep global warming temperatures below the needed pre-industrial level of 2°C (GWEC, 2021). However, the disadvantages of the wind energy industry include: wind power must still compete with conventional sources due to initial costs, locations are often remote and need to be connected to a supply chain between the city and the wind farm (additional costs), noise and aesthetic pollution, unpredictable weather and wind farms can impact on local wildlife (SolarReviews, 2020). Hence, these factors need to be considered, but are offset by the advantages of using such energy because countries are looking to reduce their fossil-fuel usage whilst benefitting from natural wind energy sources.

2.6.1. Differentiating between onshore and offshore wind farms

Wind farms are located in geographical and topographical locations where the wind is almost continuous and not sporadic (ScienceDaily, 2019). The onshore and offshore wind industry provides greater energy reliability to emerging markets where power demand is growing and provides an alternative to fossil fuels for developing countries. However, this does not limit wind farms to only exist on land and has thus shown how technology has evolved from being limited and constrained.

Offshore wind farms have grown and are said to grow by a CAGR of 31.5% over the next five years because they generate at least two times more electricity due to the undisturbed wind currents that exist out at sea (GWEC, 2021). Not only are offshore wind turbines bigger than onshore wind turbines (Figure 4), making energy production more efficient, but offshore facilities produce energy for longer periods (Liao, 2020), is less intrusive on neighbouring countries and locals and has a neutral impact on their surrounding environment as they are not located in

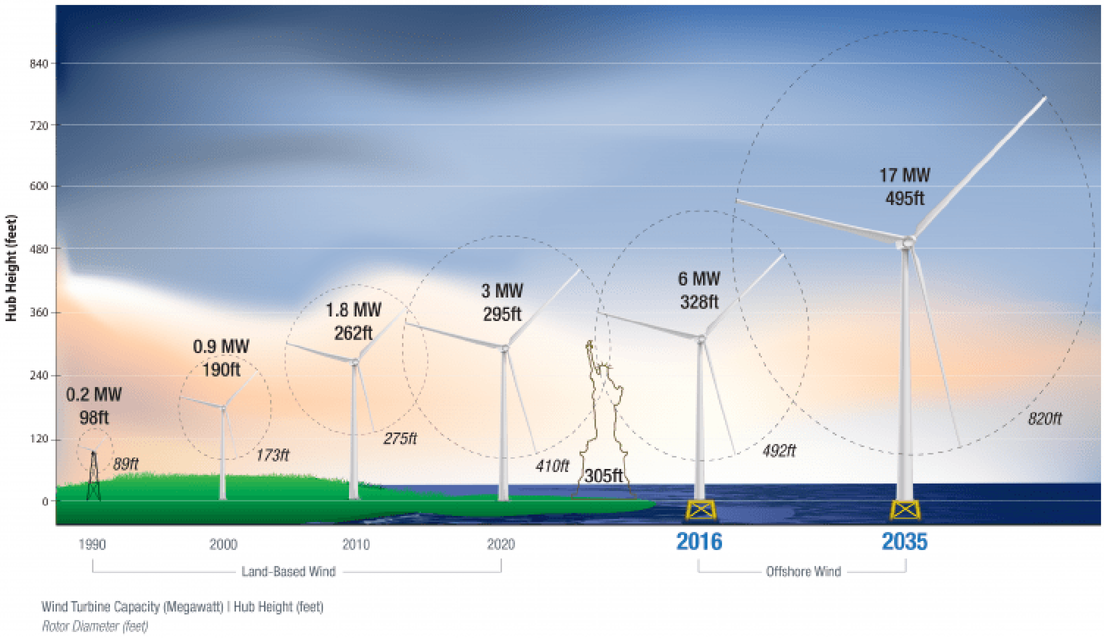

Figure 4: Offshore wind turbines compared to Onshore wind turbines (U.S Department of Energy, n.d.)

shipping lanes or fishing areas (NESFircroft, 2021). The GWEC Global Wind Energy Report (2021) report states that offshore wind technology is vital, as it will provide 10% of the needed carbon mitigation to achieve a 1.5°C pathway by 2050. But, offshore wind farms come at a substantial initial cost in building, operating and maintenance because of their distance from shore (susceptible to oceanic damage), the effects on marine and birdlife are not fully understood as it is fairly new and the farms can be aesthetically negative if located close to shore that are tourism hot-spots (NESFircroft, 2021). However, offshore wind farms are said to take a bigger role in driving global growth in developing markets.

Similarly, onshore wind facilities will increase between 32-58% by 2050 (GWEC, 2021) and is currently the cheapest new source of electricity. Compared to offshore wind farms, onshore wind farms are cheaper and cost-effective (allowing for more compact and mass wind farms), are closer to cities, use less cabling and are quicker to install (Brunel, 2021). Furthermore, onshore wind farms provide long-term positive climate change reductions for biodiversity and can be built on existing farms where the land is still able to be agriculturally viable (EERE, n.d.). However, negatives associated with onshore wind energy stem from the construction and operations affecting local wildlife (i.e. birds, bats, eagles), land usage required, landscapes and sustainable land use (protected areas) (Energy Sage, 2019; EWEA, n.d.), wind predictability and visual and sound pollution (Brunel, 2021).

Onshore wind turbines present adverse environmental threats to both flora and fauna with them having the potential to reduce, fragment and degrade local habitats and ecosystems. Rotating turbines pose a threat to local and migratory birds, eagles and bats. These threats and challenges are not isolated and occur globally, presenting challenges as to how this issue can be minimized and negated without the continued loss of wildlife. Overall, the advantages of onshore wind energy outweigh the disadvantages and provide a lens through which environmental protection can be viewed and investigated.

2.5.2. Kinds of wind turbines

Wind turbines have been used throughout history, the earliest dating to 5000 BC which were used in Ancient Egypt to power ships along the Nile River (The Renewable Energy Hub, 2018). Its use varied in civilizations being used to power irrigation pumps in Babylon and as devices to pump water and grind grain. However, the first known wind turbine that produced electricity was developed in 1887 in Scotland (Shahan, 2014) and paved the way for contemporary wind turbine technology. Whilst turbine technology failed in the beginning, success came from Denmark at the beginning of the 20th Century where windmills were able to produce over 30MW of power, electrifying homes in a sustainable way whilst the rest of the world grew more dependent on fossil fuels for their energy needs (The Renewable Energy Hub, 2018). Since the onslaught of sustainable policies and laws in the late 20th Century, the use of wind turbines has increased together with wind energy and turbine technology, enabling more wind to be harvested and transformed into energy.

There are two basic types of turbines, namely, the horizontal axis (HAWTs) and the vertical axis (VAWTs). The size of the wind turbines varies widely with different locations opting for different sizes and designs that are more compatible with the surrounding landscape and that maximize the harvesting of the wind. The length of the turbine blades is the biggest factor in determining the amount of electricity that a wind turbine generates, small turbines can be home-placed to generate electricity for domestic use and large turbines are often grouped to create wind farms that generate large quantities of electricity that provide power to electricity grids (EIA, 2021).

Horizontal axis turbines are the most common due to their strength and efficiency and have 3 blades that are similar to an airplane's propeller (EIA, 2021). The largest horizontal-axis turbines are 20 storeys in height and have blades that are longer than 30 metres (Hanania, et al., 2020). Hence the base of the tower has to be extremely strong to accommodate the weight of the blades, especially when exposed to strong winds. Due to the blades being perpendicular to the wind, the rotation can generate more power than that of a vertical axis turbine. The design of horizontal axis turbines varies between the towers and blades used with blades varying between a single HAWT, a two-blade HAWT and a three-blade HAWT (Table 1 and Figure 5) (Dolcera, 2011) but is not limited to these designs. The design variations not only account for structural strength but also maximize wind harvesting and energy output.

Table 1: Horizontal axis wind turbine blades (Castellani, et al., 2019)

Single blade HAWT	Two blade HAWT	Three-blade HAWT
Reduces the cost and weight of the turbine but are rarely used due to balance inefficiencies	Requires a more complex design to maintain stability and sustain wind shocks	The most common turbine that has a strong structure and base to withstand heavy windstorms and produces high output

Horizontal axis turbines are more common because they have higher power output, high efficiency, high reliability, and higher operational wind speeds. However, they are difficult to transport and maintain due to their height, they disrupt and negatively affect surrounding environments and have to comply with strict installation and operations regulations (Luvside, 2020).

Vertical axis turbines look like egg-beaters that have blades attached to the top and bottom of a vertical rotor and are less affected by frequent wind direction changes due to the placement of the blades. The turbine is generally installed near ground level but does not perform as well as horizontal axis turbines due to lower wind speeds at ground level, generating little energy (Hanania, et al., 2020). However, this kind of turbine has become more popular to generate localized electricity (The Renewable Energy Hub, 2018) and can be placed in domestic, town or inner-city environments but is dependent on the size as vertical axis turbines can be 30 metres in height and 15 metres wide (Hanania, et al., 2020; EIA, 2021).

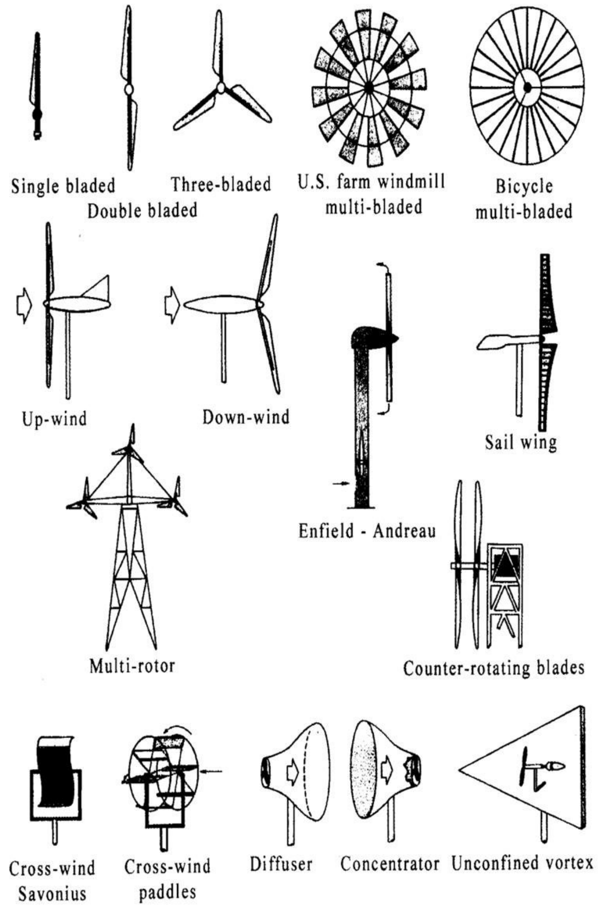

Figure 5: Horizontal axis wind turbine (Castellani, et al., 2019)

The most common vertical-axis turbine includes the Darrieus wind turbine and the Savonius wind turbine, but is not limited to these (Figure 6). Furthermore, vertical-axis turbines produce electricity at low wind speeds, are quieter and have fewer vibrations than horizontal axis turbines, have slower blade speeds which are more bird-friendly, are more aesthetically pleasing, operate at lower noise levels so they can be fitted in urban environments and the wind is generated irrespective of wind direction (ElectricalAcademia, n.d.). But, because of being smaller and closer to the ground, the turbine requires power and a starting motor to start the Darrieus wind turbine, requires pole wiring to maintain position and is not as efficient as a horizontal axis turbine (ElectricalAcademia, n.d.).

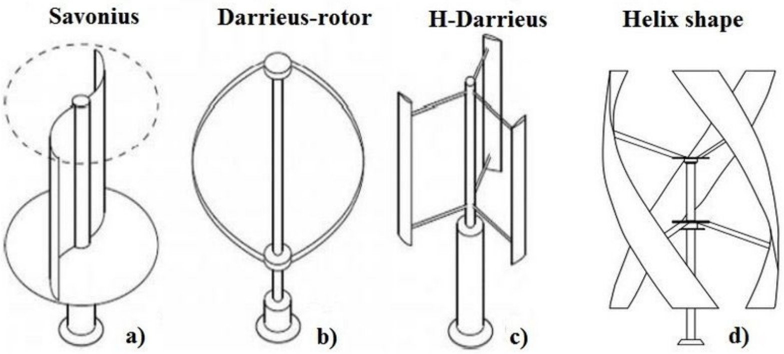

Figure 6: Vertical axis wind turbines (ElectricalAcademia, n.d.)

As technology has advanced so has the design of wind turbines, responding to increasing generation capacity and/or to respond to environmental threats that turbines are said to have on birdlife. The Vortex Bladeless turbine, or 'skybrator' (Figure 7), is a 3-meter-high bladeless turbine that can harness energy from winds by oscillating within the wind range and generates electricity from the vibrations produced (Ambrose, 2021). Not only can this turbine be installed in urban and residential areas, but the main benefit is that the design reduces traditional wind turbine's environmental impact, its visual impact and the cost of operating and maintaining the turbine whilst offering undetectable noise frequencies if fitted in residential areas. Similarly, the introduction of the multi-turbine technology, 'Wind Catcher' (Figure 8), offers a way to harness wind power whilst increasing energy production as it is said to generate five times the energy that a single wind turbine


Figure 7: Vortex Bladeless Turbine (Ambrose, 2021)

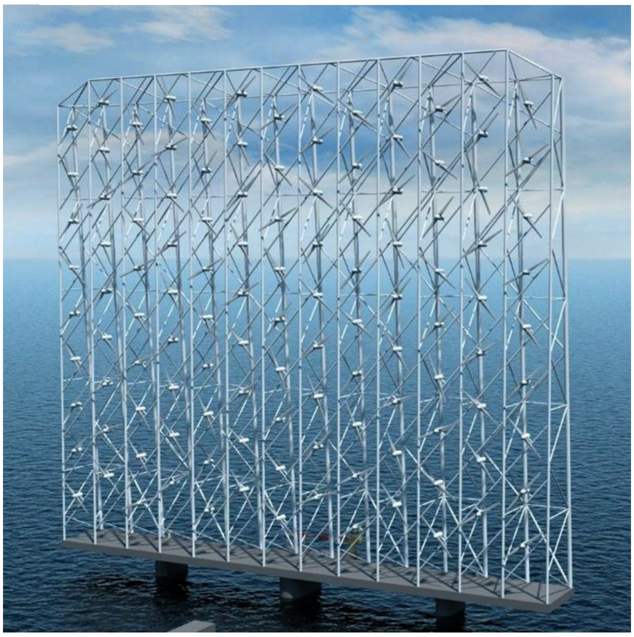
Figure 8: Wind Catcher System Turbine (Sharma, 2021)

produces in a year (Sharma, 2021). As an offshore wind technology design that incorporates 100 small blades on a square grid, it seeks to fully grasp the high-speed winds in outer oceanic waters but does present the question as to the implication of what this means for oceanic and migratory birds. This design technology is only said to appear sometime in 2022.

2.5.3. Wind turbines and sustainability

Given the climate change challenge, all industries are adopting a more sustainable path. As such, the wind industry must ensure sustainable growth as the industry grows. This relates to the lifecycle of wind turbines and its technology that must deploy optimal technology and processes whilst minimizing its waste and decarbonizing its supply chain. A full cradle-to-grave lifecycle assessment has been introduced to show the impact that wind turbines have from the start until the end of its operation (GWEC, 2021). This lifecycle assessment captures the emissions to air, water and land from the wind project that includes stages of manufacturing, transport, installation and decommissioning.

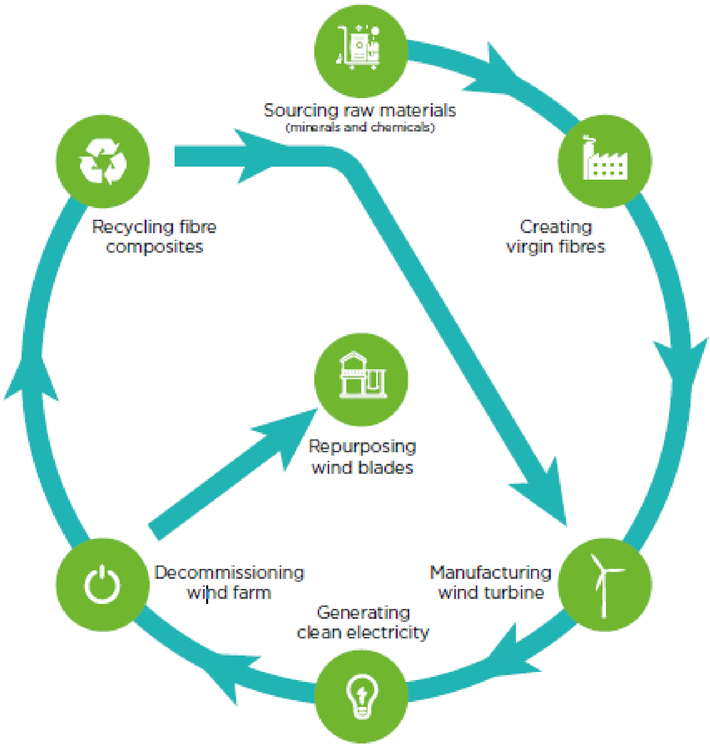

Figure 9: Lifecycle of a wind turbine (GWEC, 2021)

As reported by the GWEC Global Wind Energy Report (2021), the lifecycle analysis shows that the payback period for wind is shorter than coal-based plants and even outdoes hydro and solar generation accounting, based on location (onshore or offshore), for between 5.5 months and 7.8 months. Whilst the manufacturing and installation stages account for the most carbon emissions (90%), more than 80% of the turbine mass material is recyclable material (GWEC, 2021) and once the turbine is decommissioned, the materials can be recycled and used once again as in Figure 9. Furthermore, turbine blades are expected to last for 25 years and whilst repurposing it has been a concern, Denmark has recently shown that blade turbines can be recycled and repurposed into bike shelters or pedestrian bridges (Designboom, 2021) with Ireland going further in experimentation to use turbine blades in skate parks, as stadium bleachers or sound barriers.

This shows that even though wind energy is a green and sustainable way of producing electricity, other phases in the wind turbine lifecycle need to be considered and emissions produced from those operations also need to move to become more sustainable.

2.6. The impact of wind energy on wildlife

Wind energy is regarded as the most 'inexpensive' option for large scale renewable energy (Lima, et al., 2013) and is the reason that the industry is growing at a significant rate. But it is also widely known that wind energy does present adverse negative effects on the environmental, social and economic spheres and is not limited to the environmental sector. Through this, it is important to create a balance between the three sustainability pillars because they all influence and impact each other but focus will be placed on the environmental sphere. Whilst studies on the relationship between energy development and environmental habitats are scarce, it presents the opportunity to investigate and examine what negative effects are known and what could potentially emerge in the future between these two spheres, hence a window for future research.

Onshore wind turbines are documented to encroach on various flora and fauna ecosystems and provide an environmental risk to flying and terrestrial animals which can be seen through increased collision risks to birds and bats and disruption of migratory corridors (Copping, et al., 2020). Through the development of '*energy sprawl*', landscape development further disrupts ecosystems and habitats as road networks, transmission lines and associated infrastructure is built to capture and transport the power generated (Jones, et al., 2015). The development of wind farms and turbines can have either a direct or indirect impact. The direct impact includes wildlife mortality whilst indirect impacts include noise and light pollution, habitat loss and fragmentation, carbon sequestration and water resource impacts (Jones, et al., 2015; Dhar, et al., 2020) with these explanations being given in Table 2.

Table 2: Effects that wind energy has on ecosystem services (Jones, et al., 2015; Dhar, et al., 2020)

Negative Impact on…	Cause
Habitat loss and fragmentation	• Roads, turbine pads, pipelines, transmission lines, meteorological towers, substations and operations buildings
Potential mortality	• Collision, contamination, electrocution by turbines, transmissions lines, roads, buildings and meteorological towers
Noise and light pollution	• Aerodynamic noise associated with wind speed, temporary construction activities, vehicle traffic, and substation and building operations • Light disturbance by shadow flickering
Carbon sequestration	• Loss of carbon sequestration due to the removal of vegetation and topsoil by impermeable surfaces increasing carbon emissions through the loss of biomass

	and increased soil erosion, if only for a short period whilst the flora rejuvenates after construction
Water resources	• Very small or non-existent

Furthermore, vegetation and animal habitats can be impacted by loss and fragmentation with turbines and plants restricting movement and impacting breeding and/or feeding sites and behaviour. As a result, mitigation measures would need to be adopted to lessen the impact and include conducting environmental impact assessments (EIAs), improving structural design (i.e.: slowing rotational speeds), and placement of farms should be in areas with little biodiversity and the halting of power generation during periods of migration and high activity which can reduce fatalities (Dhar, et al., 2020).

Offshore wind turbines, present collision risks for migratory birds, disruption of marine mammal corridors and harm to marine life from the construction of bottom-mounted turbines (Copping, et al., 2020). Migratory birds are particularly threatened by these structures as they often travel in large flocks along a set route and obstacles would not only cause fatalities but may force them to burn crucial energy reserves, diverting their route and abandoning their rest stops (BirdLife International, 2020). Furthermore, additional environmental risks include increased pollution from vessel traffic, the upliftment of seabed contaminants, increased noise pollution and alterations to marine food webs (Bailey, et al., 2014).

As such, policy becomes an important factor in trying to mitigate the negative impacts that wind energy has on the environment because if it did not exist, it would mean the continuous construction of wind farms in biodiverse critical areas and the destruction of native ecosystems and habitats which might not be able to rejuvenate themselves. Whilst wind energy does have an environmental footprint during the construction phase, the operational phase is when the most impact is had on wildlife, specifically birdlife. Thus, the operational phase of wind turbines and the impact that they have on birdlife will be evaluated.

2.7. The importance of bird life in the natural environment

Whilst not always considered to be important in ecosystems and biodiversities, birds' ecological role contributes positively to the protection of societies' economic and social systems. Irrespective of size, birds' functions alternate between pollination, control of insect populations and controlling disease-infested animals (Morante-Filho & Faria, 2017) with specific groups of birds being critical for surrounding ecosystem integrity and human survival (i.e.: ensuring food security and restricting disease). However, a decline in bird populations in areas can be attributed to altered landscapes due to human invasion. This habitat invasion may affect population shifts so that some species grow, some decline and others remain neutral (Morante-

Filho & Faria, 2017). Landscapes need to remain a viable space for birds because if bird diversity declines in a specific ecosystem so decline the maintenance of functions and stability of said ecosystems.

Between 2002 and 2010, the world's biodiversity, which included nearly 10000 species of birds, was declining at a rapid pace (BirdLife International, 2008). Current bird species estimates are around 11000 (BirdLife International, n.d.). Bird species narrate the situation of the ecosystem that it inhabits because they are driven by biogeographic factors and are a natural indicator of the health and quality of the environment. Since 1500, it is estimated that more than 153 bird species have gone extinct due to extensive and expanding habitat destruction, not accounting for loss and fatalities that have been caused by the emergence of renewable and green energy (i.e.: wind and solar). Threatened species are not distributed evenly between bird families with the IUCN Red List stating that one in every eight bird species is threatened with extinction (IUCN, 2008). This befalls mainly larger-bodies species and species that have low reproductive rates (BirdLife International, 2008).

The introduction of renewable energy into the landscape has meant that more fatalities are being caused. However, an international average is not evident but with the U.S recording between 140000 and 500000 bird fatalities in a year, or roughly 5 birds per turbine (Reve, 2020). However, whilst wind turbines do account for bird fatalities, they are not the main cause. As such, bird fatalities can be caused by collisions (window strikes, communication towers, electrocution, cars and wind turbines), poisoning (pesticides, oil spills, lead poisoning, and pollution), predation (hunting, domestic and feral cats and by-catch (getting caught in nets)), disease (Sibley Guides, 2010) and other causes such as starvation, wildfires and toxic gases (Rapp, 2021). Whilst numbers may vary, consensus shows that cats account for the largest number of bird killings estimated between 240-310 billion a year, followed by window collisions with 599 million

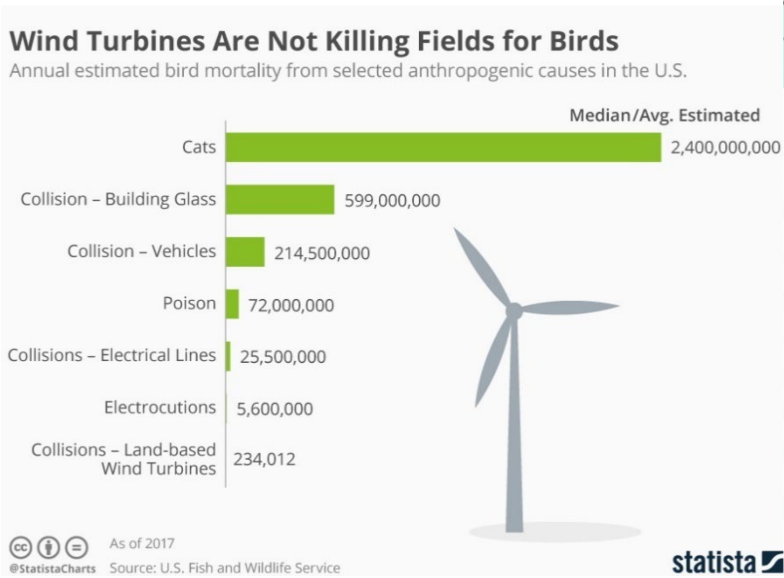

Figure 10 & 11: Causes of bird mortality (Feldman, 2019; Lafleur, 2019) fatalities (Figures 10 & 11) (Feldman, 2019; Lafleur, 2019). Wind turbines are last on the list with rough estimates to be between 234 000 – 57 000 a year. Not only does this show that turbines have a low percentage of bird fatalities than previously thought but it does present a window for research to be done in accounting for how these deaths can be avoided as the wind energy industry grows around the world.

2.8. Conceptual Framework

The literature review has attempted to establish a basis of understanding around the importance of energy generated through wind turbines and the subsequent harm that it brings to not only wildlife but also birdlife. This has led to the initial question of does environmental legislation (policies and assessments) ensure the protection of wildlife as the renewable, alternate and green energy sphere becomes more cognizant in society? Through this question it was realized that relationships do exist between environmental legislation, renewable energy, and wildlife but to which has not been explored as yet in the South African context.

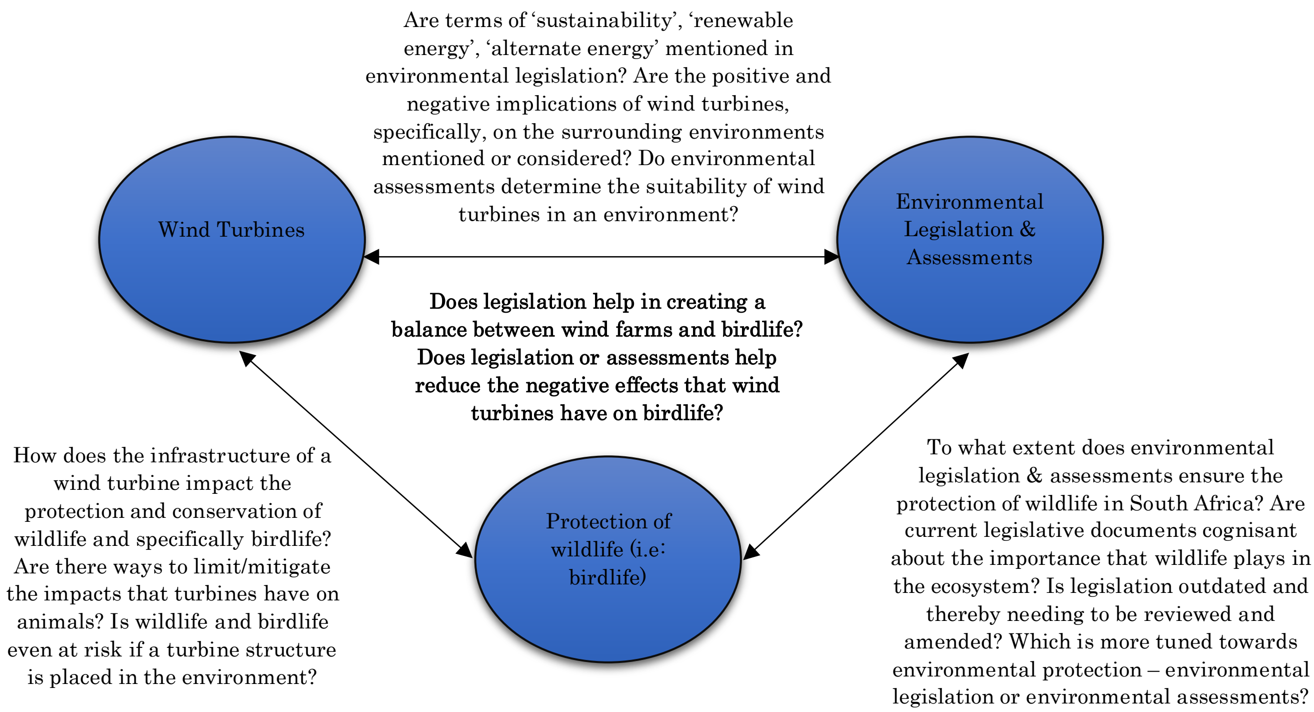

Diagram 1: Conceptual Framework

The contextual framework outlines the basis of trying to understand how each subject area influences each other and more importantly if legislation helps to create a balance between the impacts that wind turbines have on wildlife and birdlife in the areas that they are situated in.

Whilst legislation underpins this study, the identification of wind farms in the country and the subsequent identification of birdlife species affected in those wind farm areas will help to determine the level of impact that is being experienced. As forementioned this study *will not* look at the correlation of wind turbines and bird mortality rates but will rather assess, review and determine if environmental legislation and assessments have tried to mitigate the effects that wind turbines have on identified species of birds in wind farms areas.

2.9. Conclusion

Sustainability and sustainable development have become important concepts and topics in contemporary cities and offer a way to be cognizant of the surrounding natural environment whilst still moving into the future through technological development. Specific focus has been put on renewable and green energy as it has emerged as a major response to combatting climate change and ensuring the reduced dependency on fossil fuel usage for electricity generation.

Wind energy has emerged as the world's fastest-growing green alternative energy source, but with it comes the unfamiliar territory of increased environmental consequences linked to the generation of energy through wind turbines. Because wind energy has adverse effects on surrounding landscapes and wildlife, especially birdlife, with limited data available, it presents an opportunity to further research the negative impacts that wind turbines have through a policy window as it is stated that policy development and strategies are the main factors to ensure environmental protection. It is important to note that this study will focus specifically on the negative impacts that wind turbines have during their operational phase on birdlife in South Africa and *will not* focus on determining the correlation between wind farms and bird mortality rates.

Chapter 3 (Context)

"I cannot change the World. But I can change the world in Me" - BONO

3.1. Introduction

This chapter examines the context of wind energy in South Africa and provides an understanding of how wind energy disrupts wildlife, specifically birdlife in the country. The chapter outlines national environmental legislation and how this is enacted in the protection of birdlife with the growing emergence of the wind industry. Specific focus will be placed on wind farms in the Western Cape province and examined as to whether the operations of these farms, based on national environmental policies, have continued to have negative consequences on birdlife fatalities in the area. Due to environmental and birdlife fatality data being limited, the overall South African context will be used as a foundation in determining the overall impact that wind turbines throughout the country have on birdlife. The chapter provides an opportunity to understand the current atmosphere surrounding wind energy and bird mortality in South Africa and whether national environmental legislation protects birdlife as the industry expands or if a review of policies should be done.

The title of this chapter should evoke emotions about oneself and question whether how we live is sustainable and practical for future generations. As we experience life, we undergo a beneficial transformation, both bad and good, which makes us learn and grow into different people based on those experiences. Similarly, as the world becomes more advanced, we cannot continue to turn a blind eye to the destruction that has been done in the past, especially to the environment. One needs to acknowledge the injustices and develop a better system that continues to evolve with advancement and to which past and emerging issues are addressed (i.e.: policy should continue to evolve with advancement to address emerging issues and should not remain stagnant).

3.2. Renewable Energy in South Africa

South Africa is a large consumer of electricity, with a heavy dependency on coal for electricity generation. South Africa is the worlds' 7th largest coal producer, and this has placed the country among the world's top 10 greenhouse gas emitters in the world (Akinbami, et al., 2021). Since 2007, South Africa has experienced constant periods of load-shedding because of electricity shortages, rising demand and the lack of proper maintenance of coal plants and sub-stations. Due to increased international pressure to become less reliant on coal usage and to reduce CO_2 emissions, together with increased environmental impacts, efforts have been made to diversify energy sources in the country. The Department of Minerals and Energy (n.d.) states that the White Paper on Renewable Energy of 2003 was one of the policy documents that laid the foundation for the promotion of renewable energy technologies in the country and includes the use of solar, hydro technology, biomass, wind and most recently nuclear energy. The large array of renewable and green energy that exists in certain parts of the country presents the opportunity to reduce reliance on coal and has the potential to increase employment opportunities, thus sustainably improving the economy.

To invite private investment into the energy transition, the Renewable Energy Independent Power Procurement Programme (REIPPP) was developed in 2011 with the overall aim to reduce CO_2 emissions, improve electricity generating capacity and use alternate energy for economic development (Akinbami, et al., 2021). It has been a key success in ensuring the development of solar and wind energy in South Africa (SADC, 2015). Furthermore, not only has alternate energy helped in electrifying homes in rural areas and social housing projects (IRENA, 2016), but the increase in alternate energy production, has increased employment opportunities in these green industries. However, according to South Africa's Department of Statistics, in 2016, coal still accounted for 85% of electricity generation in the country with ESKOM generating and supplying 96% of electricity to the country with municipalities and Independent Power Producers (IPP) accounting for 4% (Akinbami, et al., 2021).

Since the onset of the REIPPP; 4 bid windows were evident, which seeks to increase Mega wattage (MW) produced in the country through alternate and green energy. Almost 3.4GW capacity of wind power has been built, attracting R80.5 billion investment into the country and resulting in over 100 wind turbine technicians having been trained and graduated empowering local communities across the country (Ganie, 2021). With the recent release of bid window 5, the country endeavours to add 2,600 MW of renewable energy to the countries grid with the proposed projects set to inject an estimated R50 billion into South Africa's economy, creating 13900 new job opportunities (Smith, 2021). Bid window 5 aims to introduce 1600 MW from onshore wind energy and 1000 MW from Solar PV. This shows the increase in wind energy generation and the importance that wind energy plays in the country with two provinces being ideally located to harvest the strong winds, namely the Western and Eastern Cape. Furthermore, according to the International Renewable Energy Agency (IRENA) (2022), South Africa's installed capacity for wind energy has seen a significant growth trend for onshore wind energy (Figure 12) and is set to grow at a CAGR of more than 3% between 2022 and 2027 (MordorIntelligence, 2021).

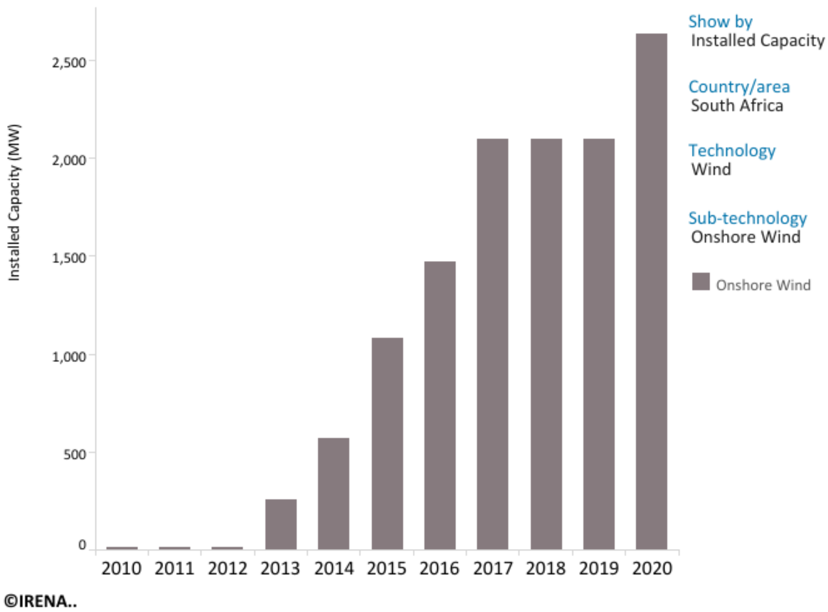

Figure 12: Onshore wind analysis for South Africa (IRENA, 2011-2022)

Whilst it is evident that onshore wind energy is strong in the country, it is estimated that South Africa's offshore potential could reach around 646GW and this presents a viable opportunity for green energy in the future (CREAMER, 2020). However, there are no current policies for offshore wind farms and to extract the benefits, policymakers need to establish regulatory frameworks that account for long-term development and investor potential. This is said to be done through a review of the development of offshore wind in Europe which would increase the pace at which lessons can be learnt.

3.3. South African biodiversity

South Africa has one of the richest biodiversity ranges in the world, being home to 10% of the world's known bird, fish and plant species and over 6% of the world's known mammal and reptile species (Safaris, 2020). This is attributed to the various climates and topography in the country that give rise to nine biomes across the country (Figure 13), each offering distinct habitats and ecosystems. This variety of ecosystems houses endangered and endemic species which has contributed to South Africa being deemed the most beautiful country in the world in 2022 (Pennington, 2022). The protection of wildlife is thereby not only important for the South African tourism industry but for the protection of endemic wildlife that lives on this landscape.

Figure 13: South Africa's nine biomes (vanWilgen, et al., 2020)

3.3.1. Flora

South Africa is home to unique biodiversity with its wealth bringing benefits of clean water, food, medicine, materials, supporting agricultural and fishery production, protection against floods and droughts provides the basis for the tourism industry and offers ample natural space for recreational and cultural activities (SANBI, 2020). According to the South African National Biodiversity Institute (SANBI), 16% of South Africa's plants are threatened with extinction and 5% of plant taxa[1] have increased in threat status between 1990 and 2018, due to increased threats from invasive species, especially in the Cape Floral regions which are home to a high number of endemic plants. Threats to the country's flora include crop cultivation (33%), urban development (20%), habitat degradation due to livestock overgrazing (11%) and drought (SANBI, 2020). Furthermore, due to onshore wind farms having a large land footprint, construction of the turbines would include the removal of vegetation to accommodate the cement bases and road sprawl that could result in subsequent land-use change, habitat loss, fragmentation, land degradation and illegal activities (Kati, et al., 2021). As such, the development of wind farms needs to consider the effects that wind farms can have in areas that are rich in biodiversity and predict consequences that could potentially happen to the environment if it is not able to replenish and rejuvenate itself once the turbines are operational.

3.3.2. Avians (birdlife)

According to the 2015 Eskom Red Data Book of Birds in South Africa, Lesotho and Swaziland, the regions of South Africa, Lesotho and Swaziland have an estimated 856 bird species, of which 132 are listed as regionally threatened in South Africa with the number of species critically endangered having risen from five to 13 since 2000 (Figure 14) (BirdLife South Africa, 2015). These figures, unfortunately, showcase the increasing pressure under which South African biomes are under due to a wide range of human-induced threats including agriculture, mining, urban expansion and afforestation. Only 35% of terrestrial ecosystems are protected in the country (BirdLife South Africa, 2015).

South Africa has between 69 and 160 bird species that are endemic or near-endemic to the country (BirdLife South Africa, 2015; SA-Venues, 1999-2022; IOCongress, 2022-2022) with 185 species that migrate from Europe and Asia to Southern Africa every year (DFFE, 2018),

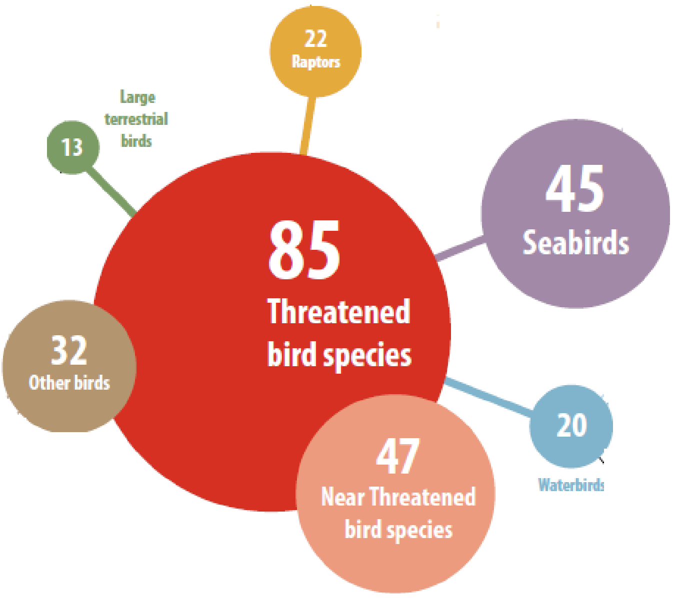

Figure 14: Threatened bird species in South Africa (BirdLife South Africa, 2018)

[1] Plant taxa or taxonomy refers to the science of naming organisms and placing them in a hierarchical structure (e.g.: kingdom, division, class, order, family, genus, species) (USDA, n.d.)

in search of warmer climates and food sources. As aforementioned, different species of birds have different roles to play in the continuation of ecosystems and act as pollinators, pest and disease-controllers (Morante-Filho & Faria, 2017) and maintain ecosystem balance for human survival. Bird threats and deaths within the country are attributed to a vast array of factors, with natural habitat modification, climate change and severe weather accounting for large percentages whilst renewable energy is seen as a medium threat (BirdLife South Africa, 2015).

3.4. The impact of wind energy on South African birds

As reported by Birdlife South Africa (2017), the wind energy industry of South Africa is still relatively new with methods and ways of avoiding bird impacts still being determined and refined as more information and studies are made available. Due to limited information and experience of wind farms in South Africa, information and experience have been imported from other countries to try and understand trajectories that might occur locally. This has resulted in the understanding that the risk of a bird colliding with a turbine can be attributed to particular characteristics of a species or the topography of the area and does not mean that fatalities will happen. This further lends itself to the importance of studying the effects of wind turbines in different areas and regions of the country to determine the impacts that operational turbines have.

Through the monitoring of wind farms post-construction, BirdLife South Africa (2017) estimated an average fatality rate of 2.06 to 8.95 birds per wind turbine per year but with more recent studies being conducted by Perold et al., (2020), which built on the above study by BirdLife South Africa and the Endangered Wildlife Trust (EWT), has shown the estimated collision rate to be 4.6 birds per turbine per year. A lower number of fatalities are recorded during the winter months due to lower bird activity levels, as the region has limited terrestrial bird migration (Perold, et al., 2020). Bird types most affected by wind turbines in the country include diurnal raptors, swifts, songbirds, waterbirds, large terrestrial species, pigeons and doves and other 'near passerines' (tree-dwelling birds) (BirdLifeSA, 2017). However, within a period of 4 years (2014-2018), over 800 endemic birds were killed by colliding with wind turbines (Bega, 2020) with at least 36% of these birds being birds of prey (Murgatroyd & Amar, 2021) which not only contribute significantly to the longevity of surrounding ecosystems and habitats but of whom are listed as vulnerable or endangered.

3.5. Wind Farms in South Africa

South Africa has an installed capacity of 2.4GW and operational capacity of 2.1GW stemming from 25 wind energy facilities and more than 961 wind turbines as of Quarter 1 2019 (SAWEA, 2018; van Zyl, 2019). The Hagemann's Wind Atlas documents that the best regions in South Africa to harvest wind power are in the Western Cape, Northern Cape and Eastern Cape provinces (Akinbami, et al., 2021). As shown in Figure 15, it is evident that South Africa has great potential in harvesting wind energy as the central and western parts of the country have medium to strong annual winds as measured by the wind measurement masts (WM) scattered across the country.

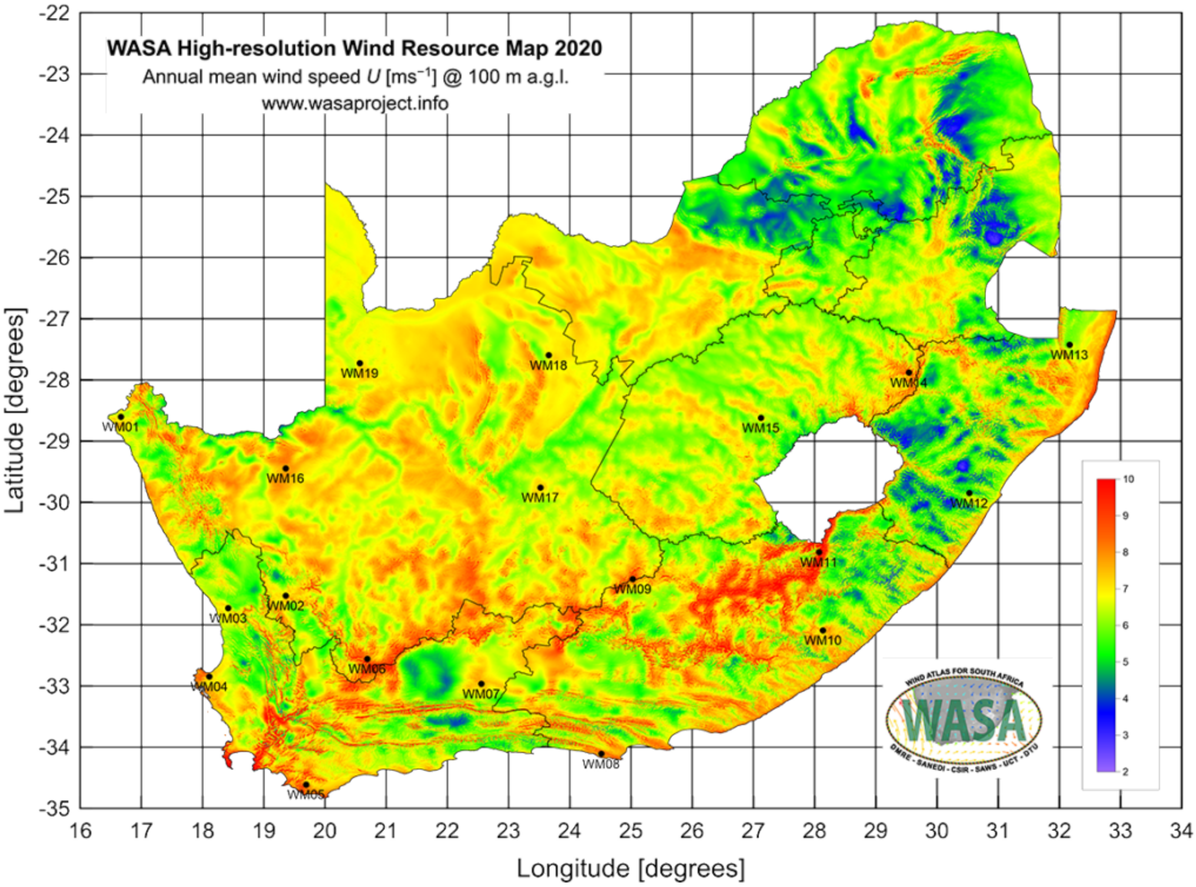

Figure 15: South African Wind Atlas (SAWEA, 2019)

With the dawn of wind energy and to promote renewable energy utilization in South Africa, Eskom established the first wind farm (Klipheuwel) on the west coast of South Africa in 2002 to study wind energy for electricity generation. It proved fruitful and paved the way for wind farm development in parts of the country with wind energy being the fastest growing renewable energy in the country (Akinbami, et al., 2021). As of 2019, there are 33 wind farms in the country of which 22 are fully operational and 11 are still under construction (Figure 16) (SAWEA, 2019). The smallest wind farm consists of 7 wind turbines, whilst the largest consists of 96 wind turbines generating 144 MW. October 2020 saw the commencement of operations of two additional wind farms with bid window 5 awarding preferred bidder status to 12 more onshore wind farms that have a combined capacity of over 1.6GW in late-2021 (Richard, 2021), thereby showing the country's existing and potential capacity to harvest wind energy thus relying less on coal for electricity generation in the future. The different colours of the wind farms correlate with the bid window under which it became operational: red – bid window 1, yellow – bid window 2, blue- bid window 3, and green – bid window 4.

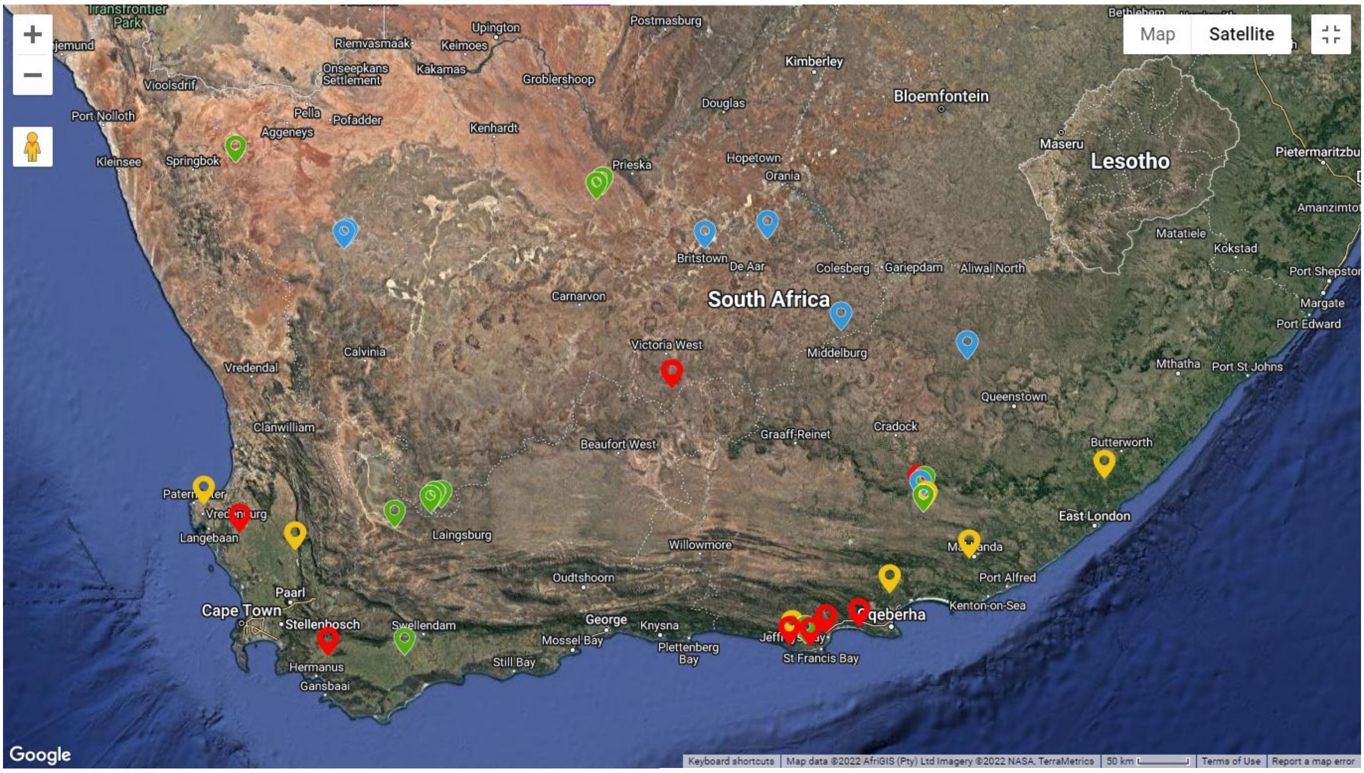

Figure 16: South African Wind Farm distribution (SAWEA, 2019)

3.6. Biodiversity in the Western Cape

The Western Cape was chosen as the case study area due to the majority of threatened terrestrial ecosystems being found in the lowlands of the fynbos biome, where extensive habitat loss occurs due to field and horticulture crop farming (SANBI, 2018) with the majority of South Africa's critically endangered and endangered terrestrial ecosystem types occurring in the Western Cape. The Western Cape province accounts for 23 Important Bird and Biodiversity Areas (IBAs) in the country, with the estuaries of the Western Cape province being the most productive (but still vulnerable) habitats, providing nursery areas for fish and staging areas for a large percentage of migratory birds (BirdLife South Africa, 2018) who are threatened by unsustainable land-use and unsound land-management practices.

BirdLife South Africa's Western Cape Estuaries Conservation Project aims to improve conservation action within the three-high priority estuary areas which are the most important estuaries for conserving birds and biodiversity and are considered havens for populations of international and nationally important bird species (BirdLife South Africa, 2018). These areas offer employment for local communities, thereby educating them on the importance of conservation and protection of the surrounding natural environment.

According to Avibase – Birds Checklist of the World (2022), the Western Cape has 687 species of birds of which 86 are endemic, 38 are globally threatened and nine were introduced into the area. The Western Cape has nine fully operational wind farms in the area (Figure 17) (WindFarms, n.d.), together with the knowledge that turbines do pose a threat to endemic birds in the country, it becomes crucial to have prevention and conservations strategies and techniques in place to ensure that these endemic and vulnerable birds are not further threatened within their habitats especially if more wind farms should be developed in this province in the future.

Figure 17: Wind farms in the Western Cape (Google Maps, 2022)

3.7. Environmental legislation in South Africa

In Southern Africa, it is estimated that between 11800MW and 12500MW of wind energy will be deployed by 2030 (Mukonza & Nhamo, 2018). As the country is set to benefit from the transition to a green economy, challenges surrounding policies, institutions and programmes aimed at upscaling wind energy and its resource exploitation need to be addressed. The implementation of robust policies and legislation internationally has resulted in the acceptance of wind energy, as it has not only promoted the development of alternative and sustainable green energy, but facilitates the growth of economies, industries and investor confidence (Mukonza & Nhamo, 2018). Cheng (2011) and Liao (2016), state that the three main taxonomies of wind energy policy surround environmental, supply and demand, with Table 3 showcasing their explanation. Countries must develop policies that are country-specific and that speak to local markets, economies and industries.

Table 3: The classification of wind energy policies (Cheng, 2011; Liao, 2016)

Policy type	*Instrument name*	*Definition*
Environmental	Goal-planning	Demand for clean energy determines development of wind energy. The national government will then enact policies to achieve it.
	Financial support	Government avails financial incentives for the development of wind energy and relaxes some of the restrictions that would have been imposed.
	Tax preference	Tax reductions are given to enterprises, researchers and production companies in the industry and these are extended to consumers.
	Regulation control	For a fair and orderly competitive environment, the government establishes laws and regulations.
Supply	Technology information support	Development of wind energy requires setting up information databases and government providing scientific and technological support.
	Infrastructure construction	Environment favouring establishment of research and development laboratories.
	Capital investment	Financial resources provided at various stages of wind development value chain by government.
Demand	Government procurement	Purchasing wind power equipment and the energy produced by wind.
	Outsourcing	The government entrusts research and development plans to corporate or private research institutions to promote wind energy R&D.
	Trade control	Government creates enabling environment for investment and trade opportunities.

In South Africa, the Department of Energy (DoE) along with the Energy Development Corporation, South African National Energy Development Institute, South African Wind Energy Association (SAWEA), South African Renewable Energy Council, South African Renewables Initiative and Sustainable Energy Society Southern Africa are the institutions responsible for promoting renewable energy. Also, several policies provide entry points for the development of wind energy in the country (Mukonza & Nhamo, 2018), together with environmental policy and assessments that safeguard the protection of the environment as per Table 4. Not all policies are stated below and not all stated will be discussed in this report.

Table 4: South African renewable energy policies and environmental policies and assessments (BirdLife South Africa, 2018; Mukonza & Nhamo, 2018)

Renewable energy development Policy	**Environmental Policy**	**Environmental Assessments**
The White Paper on Renewable Energy of 2003	The Environment Conservation Act (Act no.73 of 1989)	Birds and Wind Energy Best-Practice Guidelines (BAWESG)
The 2008 Energy Act	National Environmental Management Act (NEMA) (Act no.107 of 1998)	National Biodiversity Assessment (NBA)
Integrated Resource Plan 2010-2030 (updated 2013)	National Environmental Management Biodiversity Act (NEMBA) (Act no.10 of 2004)	Environmental Impact Assessments (EIA)

Green Economy Accord (2011)	National Environmental Management: Protected Areas Act (Act no.57 of 2003)	Strategic Environmental Assessments (SEA)
National Development Vision Plan of 2030 (2012)	National Biodiversity Strategy and Action Plan (NBSAP)	Avifauna Impact Assessments
Wind Energy Industrial Strategy for South Africa (2014)	National Biodiversity Framework	Flora and Fauna Impact Assessments
International Energy Agency Guideline for Renewable Energy Projects (2015)	National Protected Areas Expansion Strategy (NPAES)	Biodiversity and wetland baseline and impact assessment
		Integrated Biodiversity Assessment Tool (IBAT).

3.7.1. National Environmental Legislation

National environmental legislation forms the foundation of environmental improvements and outlines key strategies and methods that need to be adopted in practice to secure sustainable development whilst addressing socio-economic and political issues (Department of Environmental Affairs and Tourism, 1996). Stated below are several environmental policies and environmental assessments that are used to guide where and how wind farms can be located. These offer the premise of what needs to be considered when wind farms are proposed in a specific area and are used to govern decision making on wind farm proposals. Only a select few will be discussed and were chosen on a personal premise of what I deem as important policy that should not be overlooked.

3.7.1.1. The Constitution of South Africa

According to Section 24 of the Constitution of South Africa, environmental law and practice are important because it *"sets out the right to an environment that is not harmful to health or wellbeing"* (Constitution of the Republic of South Africa, 1996, pp. 10-11). It further leads to the goals of achieving and preventing pollution and ecological degradation, securing ecologically sustainable development and promoting conservation and using natural resources in a justifiable manner that promotes economic and social sustainability. Environmental policy and impact assessments are important in achieving these goals and ensuring the sustainable use of land, protection and improvement of the environment and evaluating the intensity of human activities on the natural and social environment.

The Department of Forestry, Fisheries and the Environment (DFFE) with the *Department of Energy* (DOE) is mandated to provide citizens with the right to an environment that is not harmful to their health and to provide secure, sustainable and affordable energy. This leads to the effective development of various acts, environmental policies and environmental impact assessments.

3.7.1.2. The National Environmental Management Act (NEMA)

The National Environmental Management Act of 1998 is intended to promote cooperative and environmental governance and ensure the rights of people are upheld whilst recognizing the importance of economic development and environmental protection. The Act accounts that sustainable development can only be met through the integration of social, economic, and environmental factors in the planning, implementation, and evaluation of decisions to ensure development aids present and future generations. Legislation should uphold the protection and conservation of the environment by preventing pollution and ecological degradation, promoting conservation and secure ecologically sustainable development and the use of natural resources whilst promoting sustainable economic and social development (NEMA, 1998).

Furthermore, all spheres of government and organs of state must cooperate, consult and support each other in addressing and enacting social and economic development in an environmentally sustainable and integrated way. Avoidance of ecosystem disturbance and loss of biodiversity is a high priority and should be minimized and remedied. Overall, NEMA should govern sustainable development that responds to local community needs whilst ensuring the protection of ecological ecosystems and habitats with limited damage being done to the surrounding landscape.

3.7.1.3. The National Environmental Management Biodiversity Act (NEMBA)

The National Environmental Biodiversity Act (NEMBA) of 2004 provides, within the framework of NEMA and the Constitution, the management and conservation of South African biological diversity with the use of natural biodiverse resources in a sustainable manner and the protection, usage and distribution of biological resources and knowledge (NEMBA, 2004). It seeks to regulate the use of indigenous genetic and biological resources sustainably whilst promoting social and economic development through the provision of a regulatory framework that monitors bio-trade activities (NEMBA, 2004).

3.7.1.4. The White Paper on Renewable Energy of 2003

The White Paper on Renewable Energy of 2003 recognizes the significant potential of renewable energy for medium and long-term energy generation in the country. It is based on the integrated planning criteria of "e*nsuring that an equitable level of national resources is invested in renewable technologies, given their potential and compared to investments in other energy supply options"* (White Paper on Renewable Energy, 2003:8). The South African government recognizes that the country is well endowed with renewable energy sources that can be sustainably harvested and used as an alternative to fossil fuels.

3.7.1.5. The National Environmental Management: Protected Areas Act (Act no.57 of 2003)

The Protected Areas Act of 2003 provides for the protection and conservation of ecologically viable areas illustrative of the country's biological diversity, natural landscapes and seascapes. It seeks to manage national, provincial, and locally protected areas per national norms and standards (Protected Areas Act, 2003). The Act allows for the declaration of an area on state, communal or private land and for the owner to be recognized as the management/ co-management authority of the protected area. Furthermore, the Act promotes the use of the protected areas for the benefit of the public in a manner that will preserve the ecological character and not degrade it and encourage community management protection.

3.7.2. National Environmental Assessments

National Environmental Assessments are tools developed to assist in protecting and conserving biodiversities and ecosystems across the country. The main assessment tool used in South Africa is the EIA, whilst others (e.g.: SEA, Avifauna, VIA) are used based on the proposed development and the area in which the development is to occur to understand the data of surrounding biodiversity and habitats.

3.7.2.1. Environmental Impact Assessments (EIA)

The Environmental Impact Assessment process was introduced under NEMA and is a tool that requires the integration of social, economic, and environmental factors in planning, implementation, and evaluation of decisions. This is to ensure that development serves present and future generations. EIAs are the key regulatory instrument in South Africa that actively promotes and ensures sustainable development and is used to mitigate/ manage the impacts of new developments and activities which are considered to potentially impact the environment (Department of Environmental Affairs, 2018).

But EIAs are cited as key barriers to development due to their stringent requirements for arduous participatory processes and investigations, which is time-consuming and expensive. However, EIA assessments value and consider all comments and inputs from 'interested and affected parties' regarding development applications. Government invests in the EIA process with the understanding that they will lead to sustainable development in the country.

The Department of Environmental Affairs – EIA Guideline for Renewable Energy Projects (2015), aims at ensuring that all environmental issues affecting renewable projects are swiftly addressed to ensure the effective roll-out of said technologies through the creation of a better understanding of the environmental assessment and approval process. The Guidelines state that the construction and operation of wind turbines will lead to unfavourable environmental impacts on biodiversity, land-use and communities through the noise and visual pollution; species disturbance and mortality; and habitat loss and fragmentation of plants, birds and bats and as such potential impacts of wind turbines need to be assessed and mitigated where necessary (DEA, 2015). Furthermore, mitigatory measures and procedures are laid out and make specific mention of site selection being made that will not affect birds, bats and other animals (e.g.: nesting areas, movement and hunting corridors and migratory routes) and that development should not occur in sensitive species habitat areas.

3.7.2.2. Strategic Environmental Assessment (SEA)

The Strategic Environmental Assessment (SEA) forms part of the Integrated Environmental Management (IEM) tools. It is complementary to the EIA and is used to determine the environmental implications of policies, plans and programmes on the environment, with the role to allow decision-makers to proactively determine if the proposed development is most suited to the area before proposals are devised. SEA, thereby, assesses a proposed policy, plan or programme that is existing or when it is being formulated and will advocate solely for the environment or play an integrative role in combining environmental, social and economic considerations. However, there is no single approach in conducting an SEA.

As such, SEAs strengthen EIAs by addressing a broader range of alternatives and providing context. It, therefore, is a broader regulatory framework that guides and assists the EIA process by addressing causes of environmental impacts rather than treating symptoms of environmental degradation and assisting in the integration of concepts to achieve sustainability (DEAT, 2004). Due to it being a broader assessment tool, there is no mention of renewable energy, wind energy, biodiversity or avians.

3.7.2.3. Avifauna Impact Assessment

The Avifaunal Impact Assessment was developed by BirdLife South Africa and EWT as a rigorous impact assessment that determines the impact that a proposed wind farm will have on birds in the area. It was specifically designed to protect birdlife in the country with the emergence and growth of the wind industry. The Avifaunal Impact Assessment aligns with international practices and standards as it sets a minimum standard for impact assessments in the industry and must accompany the wind farm proposal. According to the Bird and Energy Best-Practice Guidelines (BAWESG) (2015), the avifauna impact assessment forms part of Stage 2: preconstruction monitoring and impact assessment when impact assessments are being done for wind farm proposals. It sets out sensitivity ratings and further procedures to be followed as stated in the BAWESG.

This assessment tool is, therefore, an important tool used to determine the impact that wind farms would have on avian species in the area. It is the only tool that specifically looks at protecting and conserving birdlife. It must, therefore, be taken seriously and must accompany all wind farm proposals as it considers the impact that wind farms will have on migratory routes, nesting and feeding areas.

3.7.2.4. National Biodiversity Assessment (NBA)

The National Biodiversity Assessment (NBA) is the primary tool for monitoring and reporting on the state of biodiversity in the country and is used to inform policies, strategies, decision-making and actions for managing and conserving biodiversity more effectively (SANBI, 2022). The NBA uses two main indicators – ecosystem threat status and protection level - for tracking the status of ecosystems to understand trends over time. It covers aspects of all biomes and terrestrial, freshwater, estuarine and marine components.

However, according to the NBA Provincial Summaries Report (2018), the report does not consider the effects of renewable energy on the environment or see renewable energy as a pressure worth noting. Whilst it accounts for mining and climate change, no mention is made of renewables or wind energy, which is important in the different provinces as it does pose some level of threat to the biodiversity in the area.

3.7.2.5. Other environmental assessments

Other important assessment tools used to measure the impact of developments, including wind farms, on the environment as part of the EIA process include: (1) *The Flora and Fauna Impact*

Assessment with the role of providing sufficient data to identify, predict and evaluate the potential impacts of proposed developments upon surrounding flora and fauna (Quiatchon-Moreno, n.d.); (2) *The biodiversity and wetland baseline and impact assessment* which includes identifying the vegetation units and habitat types within the project area, assessing whether any identification relates to any Red Data species within the project area and seeing how it can be mitigated if any Red Data species are identified; and (3) *The Integrated Biodiversity Assessment Tool (IBAT)*, which is an international database that helps the World Bank, individuals and organizations to screen conservation and biodiversity values of areas where projects are financed. It relays data and information surrounding threatened species and critical habitats to minimize the impact of project development on biodiversity (IBAT, 2008-2022).

3.7.3. Environmental Legislation and Assessments Discussion

From the five identified national environmental policies, the timeline of these policies are as follows: (1) The Constitution of South Africa (1996), (2) NEMA (1998), (3) The National Environmental Management: Protected Areas Act (2003), (4) The White Paper on Renewable Energy (2003), and (5) NEMBA (2004).

As such, The Constitution of South Africa acts as the foundational text in ensuring the protection and upkeep of the natural environment. NEMA is a statutory framework that enforces Section 24 of The Constitution and as a broader framework, provides the generic bases of how sustainable development should be done and what the governing parameters should include in protecting the environment. The Protected Areas Act is a subset of NEMA and identifies specific land parcels that has endangered or threatened species of flora and/ or fauna. Development of these parcels of land is not allowed as a way to preserve the ecological character of such parcels of land. Furthermore, NEMBA (2004) works within the framework of both the Constitution and NEMA to provide management and conservation techniques to protect the upkeep and distribution of the country's natural biodiversity.

However, whilst all of these policies are based on environmental laws and standards, identify the importance of the natural environment and provide a broader bases on understanding why specific parcels of land should be protected that has endangered or threatened species and/or what 'activities' are limited to these parcels of land, no specific mention of ensuring the protection of specific species and ecosystems is stated within these policies/ Acts. This is shown in NEMBA, the White Paper on Renewable Energy and the Protected Areas Act, as detailed below.

NEMBA has a draft list of threatened and protected species in the country, but it is extremely outdated as it was issued in 2005, and has not been updated since. This lends to an incomprehensible understanding of the vastness and depth of threatened species within the country and what species have already been lost to extinction. Concurrently, whilst NEMBA seeks to control and protect biodiverse areas which would include the protection of vulnerable and endangered avians and the habitats in which they are found, the Act does not account for the harm and detrimental effects that wind energy will have on surrounding ecosystems. This is a result of the Act only providing a broader framework for the protection of biodiverse areas.

Similarly, within the White Paper on Renewable Energy (2003), whilst wind energy potential is identified as being a source of energy supply and improving local economies and industries and local employment in the country, the Act only states that the placement of wind farms should be placed carefully to minimize potential noise and visual pollution. No mention is given towards wind farm placement considering local environmental areas, habits, ecosystems and biodiversity.

Within the Protected Areas Act, whilst the Act refers to the protection of biodiverse areas and management that should occur to preserve and ensure its conservation, no consideration is given towards renewable energy and applicable activities, hence only mining activities are stated and considered.

I assume that the Act and policies above, do not make mention of specific subjects such as renewable energy or wind turbines in particular because they provide an over-arching framework in which regulations and assessments are guided by and thus applied in a broader sense. Hence, environmental assessments are more thorough, precise and detailed because it is individually tailored to a specific project and site.

While South Africa's legislation may be on par with international standards in ensuring the protection of the natural environment, I believe that these policies and Acts need to be more detailed and more tailored to the context within South Africa, especially as the renewable energy sphere becomes more prominent with the technological and infrastructural components directly and indirectly altering and affecting the landscape in which it is placed.

3.8. Conclusion

This chapter showed that renewable energy in South Africa, particularly wind energy, is the fastest growing alternate energy source in the country, with bid window 5 paving the way forward for wind energy in the country. However, it is evident that fossil fuel usage is still extremely high in the country and continues to contribute to South Africa's environmental and carbon footprint. Wind energy, although important in paving the way for less reliance being placed on fossil fuel, does nevertheless pose environmental risks.

South Africa is a biodiverse and ecologically rich country with many biomes that are home to a diverse array of ecosystems, habitats and living organisms. The protection of these areas is not only important for the country's tourism industry, but also for the protection of the endemic wildlife. Birdlife is an important environmental indicator and due to the vast number of endemic species and migratory species in the country, it is important to protect their habitats and ecosystems as the wind energy industry establishes itself to limit and mitigate the number of bird fatalities. An average of four bird deaths per turbine per year shows the negative impact that the turbines can have on bird species that are endemic or vulnerable.

The Western Cape is chosen as the case study area as it is considered a viable province for wind farms, but at the same time is considered to be the province with the most endangered or vulnerable ecosystems and habitats in the country. This increases the reasoning to identify mitigatory measures that limit development and protect wildlife. As such, various national policies and environmental assessments were reviewed with the outcome identifying that only a few policies considered renewable energy, wind energy and wildlife protection. It is evident that national environmental policies provide a broader framework for assessments to be done and provides the overarching aim and principles of what needs to be identified and mitigated. The assessments provide clear objectives and specify their stance in protecting the environment and birdlife.

Chapter 4 Findings and Analysis)

"A bird doesn't sing because it has an answer. It sings because it has a song" - Maya Angelou

4.1. Introduction

This chapter will discuss the findings of three identified vulnerable and endangered diurnal raptor species in the Western Cape with two wind farms in the province. This is done to understand the overlap between the placement of wind turbines and how said turbines negatively impact the habitats in which the avians are known to occupy. Through a review of both wind farm's EIA reports, it is hoped that an understanding can manifest as to the degree of influence that national policy and assessments have on the development of wind farms, whether they do protect avian life or if they should be amended. Furthermore, this chapter will identify what other mitigatory measures exist that could potentially reduce the rate of collision and fatalities that birds have with wind turbines.

4.2. Endangered bird life in South Africa

The collision rate of avians in South Africa with wind turbines is estimated to be around 4.6 birds per turbine per year (Perold, et al., 2020). Since the inception of wind turbines, monitoring of the impacts on birds has been limited to weekly inspections, but with search intervals ranging between 4-14 days (Perold, et al., 2020) for at least one-year post-construction (BirdLifeSA, 2017). This has resulted in fatalities being underestimated, due to the probability of finding collision victims being dependent on search extent, searcher efficiency (detection rate), carcass persistence, site-specific characteristics and types of scavengers present at the site (Perold, et al., 2020).

A study done around wind energy facilities (WEFs) in South Africa revealed that from 130 species of birds that belonged to 46 families and of whom 16 species were migrants, most carcasses found were diurnal raptors (birds of prey) (36%), passerines (30%), waterbirds (11%), swifts (medium-sized aerial birds) (9%), large terrestrial species (5%), pigeons and doves (4%) and other near-passerines (1%) (Perold, et al., 2020). This accounts for the aforementioned 36% of bird fatalities identified by wind turbines being birds of prey that are endemic to the country (Murgatroyd & Amar, 2021).

Furthermore, large, slow-flying species are prone to collisions with turbines as these structures are placed in open airspaces and are obstructive to the bird's flight path which can lead to habitat displacement (BirdLife South Africa, 2018). It is recorded that larger-bodied bird carcasses (i.e., raptors and large terrestrial species) are more likely to be detected than small carcasses as it is harder for scavengers to remove the bodies and thus small bird species fatalities are likely to be higher than recorded.

The IUCN Red List identifies 55 avian species in South Africa that are critically endangered (CR), endangered (EN) or vulnerable (VU) and this is the highest number in Sub-Saharan Africa.

Table 5 details avian species that are identified on the IUCN red list and which inhabit the Western Cape area. However, this list does not account for species that are listed as least concerned (LC) and near threatened (NT). Table 6 specifies other avian species identified by BirdLife South Africa which inhabit the Western Cape province.

Table 5: IUCN Red List Data for CR, EN and VU avians in South Africa ((IUCN, 2021)

Common name	**Scientific name**	**Red List Assessment**	**Population Trend**	**Number of Individuals**
Blue Crane	*Anthropoides paradiseus*	VU	Decreasing	17,000-30,000
Lappet-faced vulture	Torgos tracheliotos	EN	Decreasing	6500
Secretary bird	*Sagittarius serpentarius*	EN	Decreasing	6,700-67,000
Egyptian Vulture	*Neophron percnopterus*	EN	Decreasing	12,400-36,000
Cape Vulture	*Gyps coprotheres*	VU	Decreasing	9,600-12,800
Black Harrier	*Circus Maurus*	EN	Decreasing	251-999
Cape Gannet	*Morus CZapensis*	EN	Decreasing	246,000
Bank Cormorant	*Phalacrocorax neglectus*	EN	Decreasing	5000
Wandering Albatross	*Diomedea exulans*	VU	Decreasing	20,100
Ludwig's Bustard	*Neotis ludwigii*	EN	Decreasing	Unknown
Southern Black Bustard	*Afrotis afra*	VU	Decreasing	Unknown
Fynbos Buttonquail	*Turnix hottentottus*	EN	Decreasing	250-999

Knysna Warbler	*Bradypterus sylvaticus*	VU	Decreasing	2,500-9,999
Martial Eagle	*Polemaetus bellicosus*	EN	Decreasing	Unknown
Cape Cormorant	*Phalacrocorax capensis*	EN	Decreasing	234,000

Table 6: Other identified avian species in South Africa (BirdLife South Africa, 2018; IUCN, 2021)

Common name	**Scientific name**	**Red List Assessment**	**Population Trend**	**Number of Individuals**
Verreaux's Eagle	*Aquila verreauxii*	LC	Stable	Unknown
Black Stork	*Ciconia nigra*	LC	Unknown	Unknown

The above tables show the vast number of avians that are high status on the Red Data list with most having decreasing population trends. These trends are attributed to various threats that are presented in the different habitats that the species inhabit in different environments and, occasionally, in different countries, depending on the season. This includes residential and commercial development, transportation, service corridors, biological resource use, agriculture, aquaculture, pollution, energy production and mining (IUCN, 2021). With the population trend decreasing, of the above species, this demonstrates the importance that protection and conservation play in securing habitats in which these avians inhabit and reducing activities that result in fatalities.

4.3. Endangered birdlife in the Western Cape

Whilst the above list identifies 17 species that are in the Western Cape, only six fatalities can be attributed to renewable energy and in particular, wind energy. They include the Blue Crane, Cape Vulture, Black Harriet, Ludwig Bustard, Black Stork and Verreaux's Eagle, all of which are either large terrestrial birds or diurnal raptors. BirdLife South Africa has released three reports in the past on the Verreaux's Eagle (2017), Cape Vulture (2018) and the Black Harrier (2020), detailing the risk that wind turbines pose to these species. These reports will be looked at in further detail.

4.3.1. Verreaux's Eagle

Figure 18: Verreaux Eagle (BirdLife South Africa, 2015)

The Verreaux's Eagle (Figure 18) is an apex predator and is distributed widely in the country across the biomes inhabiting mountainous terrain in the fynbos, grassland, savannah, Nama-karoo and succulent karoo (Figure 19) (BirdLife South Africa, 2015). It is a long-lived species but a slow breeder. The population trend, in 2015, suggested that the species population was stable, but recently it has been identified that the regional population in certain areas is undergoing a decline, at an unknown rate.

In 2015, the main threat to the Eagle was from localized stock farmers, urbanization and electrocution with powerlines (BirdLife South Africa, 2015). However, the '*Verreaux Eagle and Wind Farms*' (2017) report identifies that during wind turbine post-construction at six wind farms, two wind farms identified Verreaux's Eagle mortalities soon after the turbines became operational. Preliminary findings indicate that the Verreaux's Eagle is vulnerable to collision and suggests that poorly planned wind farms could negatively affect the species. No indication is given identifying the location of the wind farms. Due to no in-depth studies being evident and available, information is extracted based on the Golden Eagle and White-Tailed Sea Eagle in the Northern hemisphere. This identifies factors including abundance, flight activity, topography, wind, and behaviour that may influence vulnerability to collision potential but remains poorly understood (BirdLife South Africa, 2017).

Mitigation measures that could help in reducing Verreaux's Eagle mortalities involve studying the surrounding landscape and biological features that may be associated as a risk (i.e., breeding sites). This includes wind farms avoiding sensitive areas by creating buffer zones around core inhabited regions and areas that represent high flight zones around rocky terrain where nesting might occur. However, mitigation measures are relied upon from international experts as this is a relatively new study arena in South Africa. 'Shut-down on demand' based on periods of increased hunting behaviour is an option, but could mean long periods of no energy generation. However, the hunting behaviour of the Verreaux's Eagle is not truly known and relocation of Verreaux's Eagle nests are not deemed as an option (BirdLife South Africa, 2017).

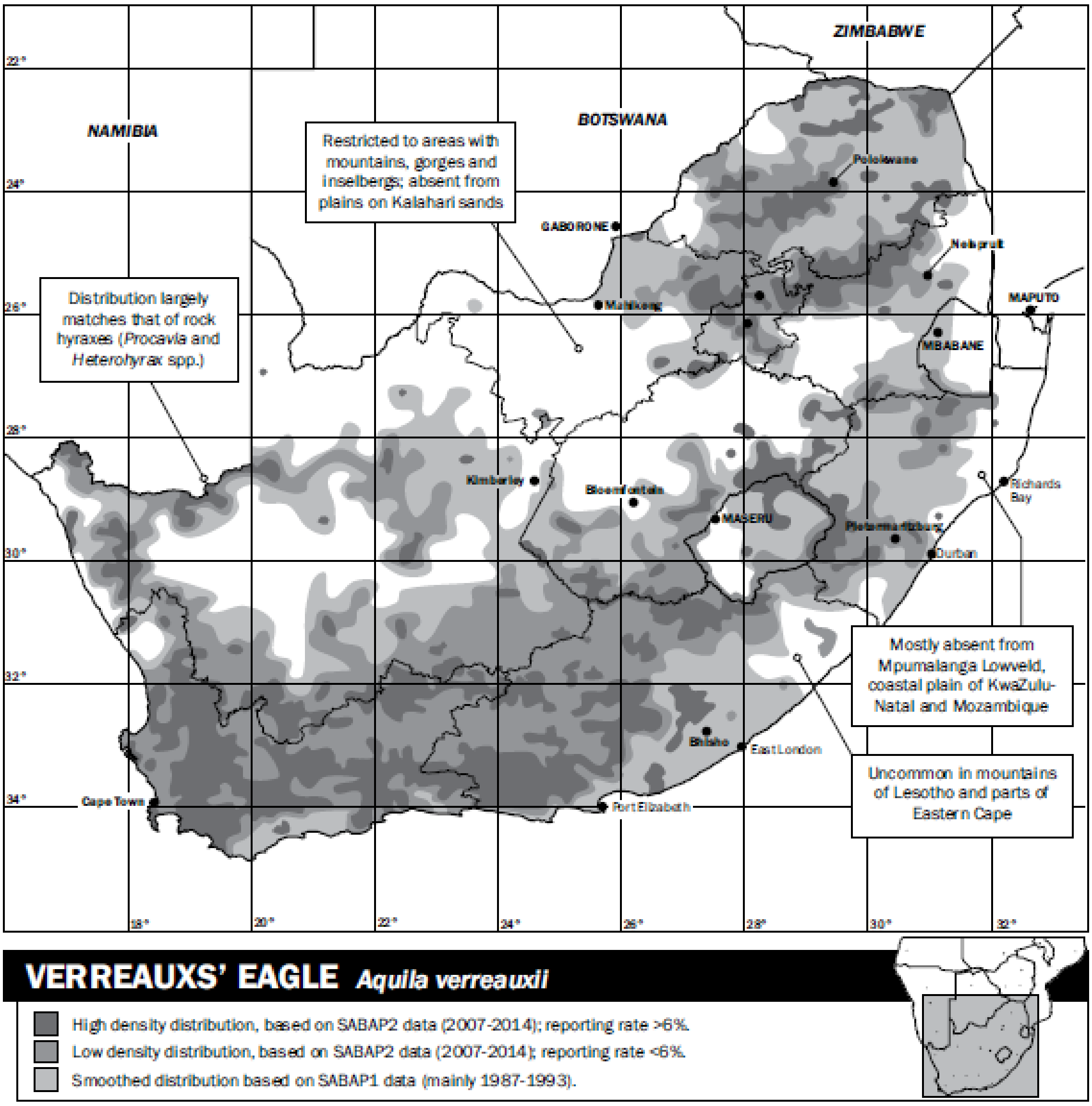

Figure 19: Verreaux's Eagle distribution map (BirdLife South Africa, 2015)

Adaptive management through continuously improved management policies and practices are needed through constant pre- and post-construction monitoring and learning. The Birds and Wind Energy Best-Practice Guidelines (BAWESG) recommends that avifaunal impact assessments should cover a minimum period of 12 months, but should preferably span over several years to collect sufficient data and understand the different dynamics of the species. BirdLife South Africa suggests a two-year monitoring duration where wind farms may pose a threat to the Verreaux's Eagle as they identify that turbines placed within an area that is used regularly by the Verreaux's Eagle pose a significant risk of collision. Existing turbines that are too closely located to Verreaux's Eagle habitats should be relocated (BirdLife South Africa, 2017).

4.3.2. Cape Vulture

The Cape Vulture (Figure 20) is an endemic and Endangered (EN) species and has one of the most limited distributions of any Old World Vulture species with it being restricted to South Africa and Lesotho (BirdLife South Africa, 2015). It is a long-lived species with low reproductive rates, and poorly planned wind farms are likely to accelerate population decline. Whilst the Cape Vulture is primarily located in the Eastern part of the country, it can also be found in the Western Cape (Figure 21) (BirdLife South Africa, 2015).

Figure 20: Cape Vulture (BirdLife South Africa, 2018)

In 2012, the Cape Vulture colony in the Western Cape encompassed only a single, small and highly isolated breeding colony, with 69 pairs. The Cape Vulture is extinct as a breeding species in Namibia and Zimbabwe. Determining the population trend presents challenges, as not all breeding colonies are continuously monitored. It has been noted that a few breeding sites across the country are no longer active. There has been a >50% decrease in regional population in 50 years (BirdLife South Africa, 2015), indicating the importance of protection and conservation of this species in the country.

The *'Cape Vulture and Wind Farms'* (2018) report indicates that the Cape Vulture is threatened by collision and electrocution with electrical infrastructure, poisoning and poaching. It is stated that the effects of wind turbines on Cape Vultures have not been well studied and information regarding wind turbine effects on vultures needs to be extrapolated by understanding the European and Asian vulture counterparts. Recorded Cape Vulture fatalities at wind farms have shown that the vulture does not learn to avoid turbine collisions, suggesting that they are susceptible to collisions with turbines from the time of construction (BirdLife South Africa, 2018). Studies have shown the fragility of vulture nesting and breeding with any disturbance in the area affecting fledgling and mating rates.

Mitigation measures, therefore, include site screening and placing wind turbines in areas where the risks to the vultures are the lowest. Further considerations need to take proximity to vulture colonies and roosts, topography and wind scape (flight activities and risky behaviour) and food availability into account (BirdLife South Africa, 2018). Buffers should be used and areas of roosting and feeding should be established and considered highly sensitive. Furthermore, adaptive management should go beyond the requirements outlined in the BAWESG. If an energy facility is proposed in a highly sensitive Cape Vulture area, monitoring should go beyond the required two-year requirement. SEAs play a vital role in determining sensitive areas and should

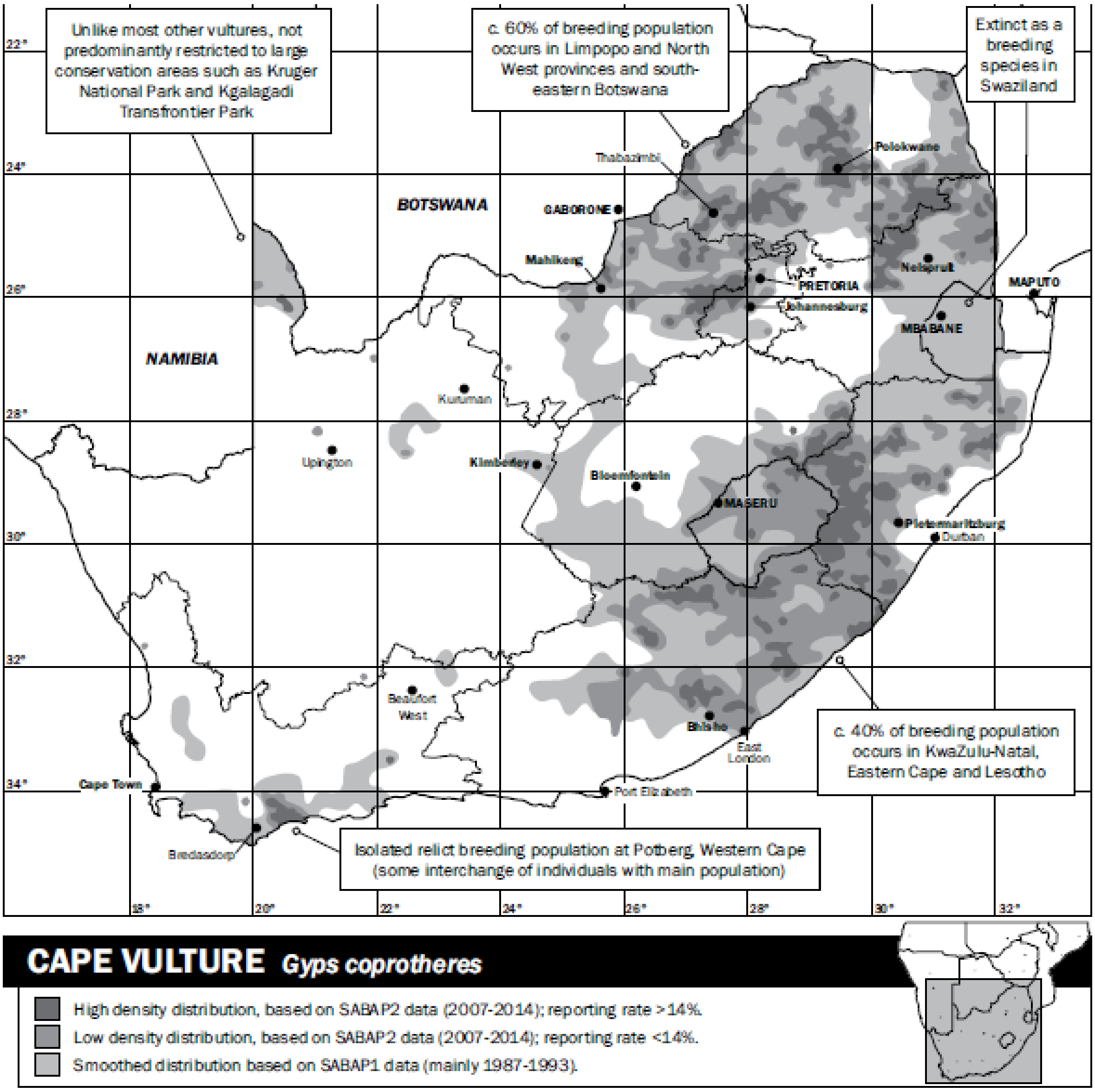

Figure 21: Cape Vulture distribution map (BirdLife South Africa, 2018)

be used as per requirements in the BAWESG but BirdLife South Africa states, “they do not endorse the outcome of the first phase of the SEA due to failure of this process to address the cumulative risk to Cape Vulture and other species” (BirdLife South Africa, 2018:6). Adaptive management of the Cape Vulture includes monitoring in highly sensitive areas and accurate recording and reporting of injuries and fatalities to ensure that specialists and rehabilitation centers are aware of deaths and injuries (BirdLife South Africa, 2018).

4.3.3. Black Harriers

Black Harriers (Figure 22) are listed as globally endangered (EN) with the species being one of the most range-restricted harrier species in the world and primarily inhabiting the fynbos biome in South Africa (BirdLife South Africa, 2015). The species has lost 50% of its breeding habitat in the last century, due to increased agricultural land transformation, invasive alien vegetation and urbanization. The Black Harrier mainly inhabits in the Western Cape (Figure 23) with its distribution being restricted to coastal strips and mountainous inland areas due to its preference for cool south-facing slopes and mountainous conditions. The species further undergoes seasonal migration during the summer to the eastern parts of the country (BirdLife South Africa, 2015).

Figure 22: Black Harrier (BirdLife South Africa, 2020)

Black Harriers are the scarcest endemic raptor in southern Africa with fatalities occurring at three WEFs, confirming predictions that the species is potentially at risk. Black Harriers populations have declined and can be attributed to the large loss of habitats to agriculture and degradation. The species has very low genetic diversity, suggesting that it would not adapt to the rapidly changing world caused by climate change (BirdLife South Africa, 2020) and presents dynamics to further species loss. However, preferred nesting sites are often within or near Protected Sites with protected sites in the Western Cape including the West Coast National Park, Table Mountain National Park, Bontebok National Park, Agulhas National Park and Koeberg Nature Reserve (BirdLife South Africa, 2020). Black Harriers provide a vital conservation role as they rely on unspoiled patches of vegetation within the rich Cape Floral Kingdom and are good indicators for mammal species richness and small bird abundance in the areas.

The "*Black Harriers and Wind Farms*" report (2020) indicates that harrier species do not have a high collision percentage with wind turbines and this can be attributed to their low flight heights, but they are not immune to collisions. Fatalities have been recorded at three out of 23 operational WEFs. However, if there is only a small number of breeding pairs in the area, then any collision and fatality will dent the local population. With approximately only 1000 harriers in the world, small disturbance events can have shattering consequences, especially in breeding birds as fatalities can negatively affect the fledgling stage and rate (BirdLife South Africa, 2020).

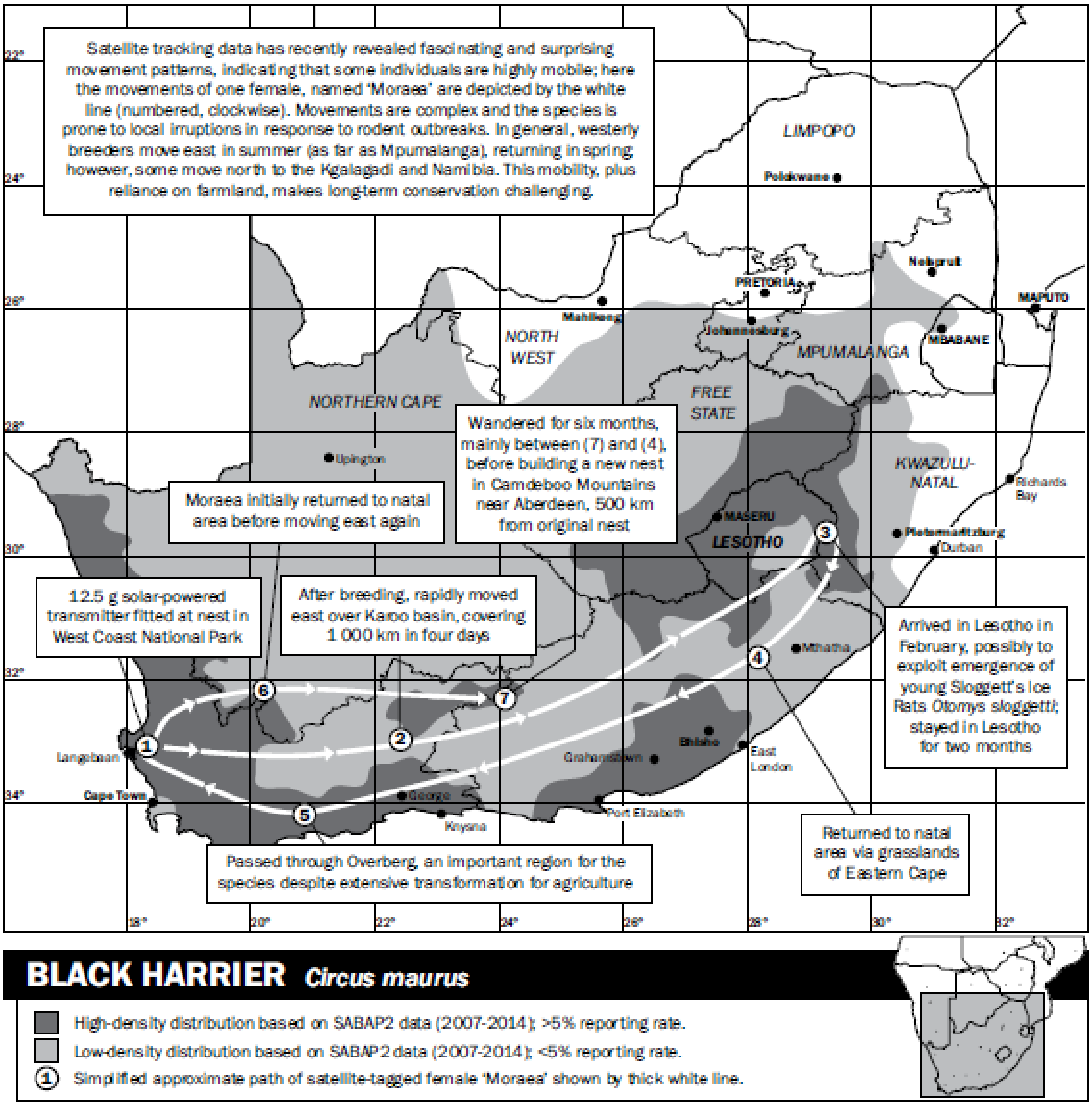

Figure 23: Black Harrier distribution map (BirdLife South Africa, 2020)

Wind turbines present risk collision risks to Black Harriers in times when their breeding behaviour changes and they increase their flight heights, when aerial sky-dancing displays occur, females soaring higher when protecting nests from predators and during night-time movements when hunting. Turbines further present challenges during times of migratory flights and movements and changes in topography, landscape and wind speed (BirdLife South Africa, 2020). Habitat loss contributes significantly to Black Harrier population loss, whilst turbines contribute a small percentage to this number, construction and operation of turbines within foraging, breeding and roosting habitats add to the pressure and could potentially displace the species, limiting habitat spaces. Whilst external studies on similar species extrapolate that the birds identify the risk that the turbine presents and move their nesting away from the turbines, it affects the breeding and fledgling rates which will have a detrimental long-term effect on the environment, but no data is yet available on this (BirdLife South Africa, 2020).

It is suggested that through proper site screening and adaptive management, collision rates can be reduced. However, if suitable breeding habitats, prime foraging and breeding areas, flight paths and high-use areas are identified then proper mitigatory and buffer zones should be applied. BirdLife South Africa (2020) prescribes conducting focal point surveys and vantage point surveys, monitoring over two full breeding and non-breeding seasons, and through data analysis estimating collision risk and population size effects to ensure that turbines are not placed in areas known for breeding, roosting, foraging and migrating. Buffer zones of 3-5km should also be placed around these sensitive areas. Black Harriers are the scarcest raptors in the world and have an increased risk of collision and fatalities with turbines during the breeding season. It is important to not overlook site screening used to identify places that Harriers inhabit to ensure that appropriate protection and conservation methods are employed to protect the species.

4.4. Wind farms in the Western Cape

South Africa has 35 operational wind farms, with two major farms having become operational in late-2021. The Western Cape province is currently home to 10 wind farms, but is also the province in which The Oya Energy Hybrid Facility is set to be developed in the upcoming months which will encompass a combination of solar photovoltaic (PV), wind and lithium-ion battery storage (Caboz, 2021). This shows the abundance of natural wind and solar resources that the province has and the potential in harvesting and using energy generated and distributing it into the national grid. Table 7 details the wind farms that are in the Western Cape.

Table 7: Wind Farms in the Western Cape.

Wind Farm name	Owner	Online	Type of wind turbine used	Wind turbines operational	Power per turbine (MW)	Total nameplate capacity (MW)	References
Darling Wind Farm	Eskom	2007	Horizontal axis – 3 blade	4	1.3 MW	5.2 MW	(SA-Venues, 1998-2022)
Dassiesklip Wind Energy Facility	BioTherm Energy	2014	Horizontal axis – 3 x 55m blades	9	3 MW	27 MW	(Barradas, 2013)
Excelsior Wind Energy Facility	BTE Renewable Projects	2020	Horizontal axis – 3 Gold wind blades	13	2.5 MW	32.5 MW	(BTE Renewables, 2021)

Gouda Wind Farm	ACCIONA Energia	2015	Horizontal axis – 3 blade	46	3 MW	138 MW	(Energia, n.d.)
Hopefield Wind Farm/ Umoyo Energy Wind Farm	Umoyo Energy	2014	Horizontal axis – 3 blade	37	1.8 MW	66.6 MW	(Umoyo Energy, 2021; WindBase, 2019-2022)
Ishwati Imoyeni Wind Farm Project	Windlab	2023	-	65	-	140 MW	(Carmen, 2022)
Perdekraal East Wind Farm	Lekela Power	2020	Horizontal axis – 3 blade	48	2.3 MW	110 MW	(Pedekraal East Wind Farm, 2020)
Roggeveld Wind Farm	G7 Renewable Energies	March 2022	Horizontal axis – 3 blade	47	3.15 MW	147 MW	(G7Energies, 2016-2019)
Sere Wind Farm	Eskom	2015	Horizontal axis – 3 blade	46	2.2 MW	100 MW	(Carmen, 2021)
West Coast One Wind Farm	ENGIE	2015	Horizontal axis – 3 blade	47	2 MW	94 MW	(Windlab, 2022)
Rietkloof Wind Energy Facility	-	Proposed	-	51	-	140 MW	(Carmen, 2022)
Brandvalley Wind Energy Facility	-	Proposed	-	58	-	140 MW	(Carmen, 2022)
Klipheuwel	Eskom	2003-2016 (decommissioned)	-	9	3.2 MW	27 MW	(GlobelEQ, n.d.)

It is evident that after the initial pilot programme of wind energy in South Africa, in 2002 by Eskom, since the introduction of the REIPPPs, nine wind farms have become operational. In total, 11 wind farms exist and supply 887.3 MW (including the decommissioned plant) of energy generated through wind energy. As technology has advanced, individual turbine power generating capacity has increased, increasing the total MW produced at the wind farm. All wind farms use 3-blade horizontal axis turbines which are widely used throughout the world and are considered the best option for generating electricity. There are currently two proposed wind farms in the Western Cape – Rietkloof and Brandvalley Wind Energy Facility – that are set to be commissioned in 2024 that will add a further 280 MW of energy to the grid.

However, in conjunction with section 4.3, specifying the species of Red Listed avians in the province, it is important to note the location of the wind farms to the three species identified to understand the potential and the existing impact that the wind farms could have on these species. The Verreaux's Eagle and Black Harrier are distributed throughout the Western Cape province (Figure 19 & Figure 23), whilst the Cape Vulture is only found in a small portion of the southern part of the province as per Figure 21. This indicates that all wind farms in the province need to comply with all environmental assessments to supply necessary scoping, screening and monitoring assessments that indicate the extent to which the wind farms will extend into the bird's habitats and what risk the turbines pose to the birds, especially the Verreaux's Eagle and Black Harrier. Reviewing EIA assessments and additional environmental assessments produced by two selected wind farms below will potentially indicate the extent to which scoping and screening are done and portray if environmental policy and assessment propels avian protection.

4.4.1. Roggeveld Wind Farm

Roggeveld Wind Farm is located on the border of the Western Cape and Northern Cape. The nearest towns include Matjiesfontein, Laingsburg and Sutherland, in the Karoo. The wind farm manages 47 x 3.15 MW generating wind turbines, has an installed capacity of 147 MW and a contracted capacity of 140 MW (PEI, 2022). Roggeveld, to date, is the lowest electricity tariff wind farm and was the first wind farm project to sign the PPA, in 2021, in bid window 4 as part of the REIPPP. Roggeveld Wind Farm achieved commercial operation on 11 March 2022 (G7Energies, 2016-2019).

The "*Final Environmental Impact Assessment Report: Proposed Construction of the Roggeveld Wind Farm Phase 1 and Associated Infrastructure*" report (2014) details that the wind farm has a total energy generating capacity of 750 MW, but to comply with the Department of Energy's (DoE) bidding requirements, the proposal was broken up into three phases, of which phase one is considered the most crucial. The Final EIA report only assesses the impacts associated with Phase 1 with wind turbine energy generation capacity being 140 MW and the site of phase one expanding over 13 farm portions. The wind farm originally proposed the placement of 60 wind turbines to be placed on the site with a generating capacity of 140 MW with placement to be informed by the outcomes of the EIA report. The proposed site was chosen based on predictions of high wind speeds, suitable proximity to the existing electrical grid and minimal technical constraints. Furthermore, the surrounding landscape encompasses agriculture, but assures that current land use will be retained with livestock continuing to graze on portions where turbine infrastructure is not present, representing a 'win-win' situation for the owners and developers of the wind farm.

The Roggeveld Wind Farm site is within a SEA identified zone and is identified as being best suited for the rollout of wind or solar PV energy projects, complying with the Renewable Energy Development Zones (REDZ) mandate. The Final EIA Report had to be amended to include the result of bird and bat monitoring studies as requested by the DoE. The site selection phase included the use of environmental and pre-feasibility assessments of several sites with the results indicating that several sites were flagged as having potentially significant environmental issues, two sites were considered 'fatally flawed' and a further two were identified as having the most potential to hold cumulative impacts. These sites were excluded from the priority and potential sites. The layout of wind turbines on-site was according to optimization potential based on technical and environmental assessments. Access to roads and site access, uses existing farm roads, with minor upgrading required and a few new constructed roads to accommodate construction vehicles with minor adjustments needing to be done to accommodate environmental, technical and economic aspects.

The report identifies various National, Provincial and International legislation, standards and guidelines which include at a national level *The National Environment Management Act, National Environment Management: Biodiversity Act, National Heritage Resource Act* to name a few. At a provincial level it includes the *Western Cape Planning and Development Act (Act no.7 of 1999), Department of Environmental Affairs and Development Planning NEMA EIA Regulations and Information Document Series 2009* and the *Strategic Initiative to Introduce Commercial Land Based Wind Energy Development to the Western Cape, 2006.* At an International level the *Equator principles, IFC Performance Standards* and the *Clean Development Mechanisms (CDM)* were identified. These attribute to understanding the compliance requirements presented at various levels which inform the final placement of the wind turbines. These not only include standards and guidelines issued by Government but also those issued by BirdLife South Africa and EWT (i.e.: BAWESG).

Regarding avifaunal and impact assessments done on bird movements, the report identifies that flora in the area is least threatened, but with these conditions being suitable sites for foraging, nesting and hunting sites for birds of prey and bats. It is identified that the proposed wind farm site falls within the critical biodiverse areas (CBAs) of the Western Cape and Northern Cape and, thereby, identifies as a priority area that is resilient to climate change providing refuge to animals and plants to persist in the changing environments.

The avifauna assessments identified 121 bird species in the proposed site with the Verreaux's Eagle flying within the turbine blade swept area[2], whilst the Black Harrier flew below the turbine blade swept area. The Verreaux's Eagle is seen as a species for collision risk mortality, especially as two nests were recorded in the proposed wind farm area (Figure 24). Furthermore, a nesting area for the Black Harrier was noted, but the bird was not seen during the site visit and observation which coincided with the breeding season. Overall, it was determined that the Verreaux's Eagle, Black Harrier and Martial Eagle, as threatened or scarce species, are susceptible to collision and displacement from the area caused by the turbines. As such, the placement of the turbines should not occur close to the edge of steep slopes or nesting areas to minimize the potential negative impact. The distance between turbines has also increased providing more manoeuvre space between the turbines. The potential impacts of the turbines include habitat destruction, population displacement and mortality. This is not limited to the operation of the turbine but includes the collision with power lines. However, it is noted that the impact intensity associated with habitat loss, disturbance to birds, operational impacts disturbance and displacement of birds are low with collision mortality during operational phases and the impact of the powerline on birds during the operational phases is considered to be medium intensity and residential impact significance considered to be low for all of the above. It is concluded that the only concern lies with avians colliding with the rotor blades and that there is a minimum impact in terms of habitat loss, disturbance and collision if mitigatory plans and guidelines are followed.

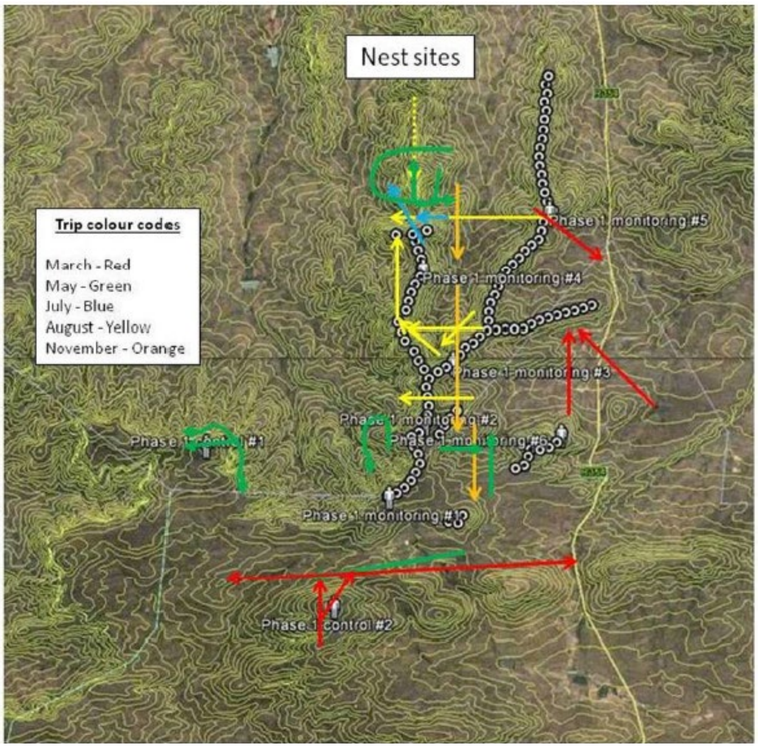

Figure 24: Recorded flight paths of Verreaux's Eagles (Savannah Environmental, 2014)

The Roggeveld EIA report further accounted for heritage resources (i.e.: stone age artefactual material, precolonial indicators, graves and colonial heritage) and social (i.e., the demographic profile, education, health, economic profile, employment, unemployment and household income,

[2] Blade swept area: when directly facing the center of the rotor blades on a wind turbine, the swept area is the area through which the blades of a turbine spin (Darling, 2016).

tourism and heritage and general infrastructure) aspects that would be directly and indirectly affected and impacted by the development. As part of the EIA process, a visual impact assessment (VIA) was also done. The impact assessment notes that human presence and uncontrolled access to the site (during pre-construction and construction) would negatively impact fauna and flora through fauna poaching, site and vegetation clearing and exploration activities. This would impact listed plant species and high-biodiversity plant communities further leading to the loss of sensitive faunal species, habitats and ecosystems. The operational phase is said to generate noise and disturbance which could lead to fauna determent from the area. However, it is conclusively stated that if proper mitigation is followed through and policies are adhered to then no environmental fatal flaws should prevent the development of the wind energy facility. Figure 25 shows the revised layout of Phase 1 of the wind farm indicating the placements of wind turbines in the area with indications to where the Verreaux Eagle nesting site is.

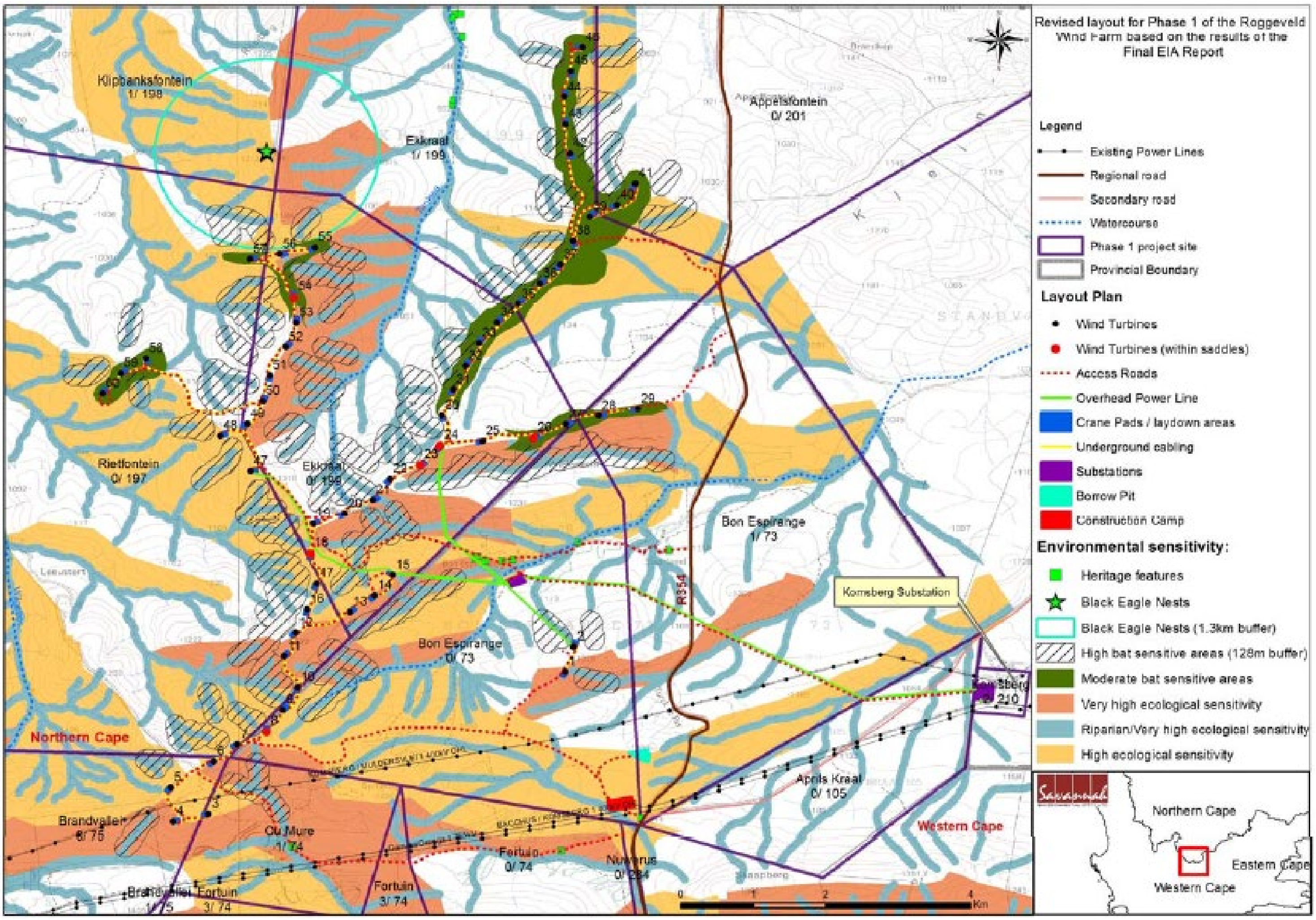

Figure 25: Revised layout for Phase 1 of the Roggeveld Wind Farm (Savannah Environmental, 2014)

Through the above, I duly realized that environmental legislation paved the way forward for certain areas to be considered as being in SEA zones and CBAs which would not have been 'zoned' off were it not for the policies and Acts. However, environmental assessments played the major part in ensuring the protection of note only the natural environment but ensured the continuation of existing socio-economic activities in the area and the amalgamation of such activities. The potential of a site for wind farm development was realized and whilst legislation saw the broader importance of the site and its resources, it was through the assessments that reinterpreted what needed to be done as it identified the various scopes of the surrounding environment that would be affected with such a development.

4.4.2. Perdekraal East Wind Farm

Perdekraal East Wind Farm is located close to Touwsriver in the Western Cape. The wind farm operates 48 x 2.3 MW energy-generating wind turbines and became the first operational wind farm (October 2020) as part of round 4 of the REIPPPP (Lekela, 2022). The wind farm contributes to the empowerment of the local community (in terms of job creation) and continues to support the community through the investment in education, entrepreneurship and the environment, with the local community benefiting from the shareholding of the wind farm via the community trust (Lekela, 2022).

The "*Final Environmental Impact Report: Proposed Renewable Energy Facility at the Perdekraal Site 2, Western Cape*" (2012) report details that the facility proposed to have a generation capacity of 310MW - 468MW, but due to EIA findings of wind turbines encroaching on highly sensitive areas, the capacity had to be altered and the output is thus between 140MW – 150MW. To comply with the DoE IPP requirements, the proposed site had to be divided into two sites – Perdekraal 1 and Perdekraal 2 – with the Final EIA report covering Perdekraal 2. The site covers two land portions over two farms and was initially planned to support 169-230 wind turbines with an individual capacity of 1.5MW - 3.5MW, but has since been reduced based on environmental and social constraints. The lifespan of the turbines is 20-25 years. Perdekraal 2 site is a mixed-use renewable site that incorporates wind energy and solar PV. Access to the site will use existing roads where possible but will include the updating of gravel roads to facilitate the transportation of turbine infrastructure. This will result in the removal of indigenous vegetation and will have a medium negative impact without mitigation.

The proposed site was chosen based on desirable wind and solar resources, which makes the energy facility financially viable; sufficient space for the placement of wind turbines and solar PVs and access to the existing grid. Existing agricultural land use would not be disrupted and farming could continue once the facility was operational. Local economic stimulation and landowner support were also considered. 60 potential sites were chosen by mapping out significant environmental areas together with wind resources specifying metrological data and the above-mentioned desirability. After mainstreaming, eight sites were chosen based on favourable parameters. Turbine placement localities were determined, based on technical and environmental criteria with areas that were unsuitable based on potential impacts to flora, fauna, avians and heritage, being disregarded. The EIA report states that having alternate design considerations presents the first step in minimizing negative environmental impacts as avoidance can be achieved through revision.

The proposed site for the energy facility is located close to several nature reserves and game farms, with the site and surrounding areas consisting of low hills and flat/ gentle sloping open plains. The area is covered in indigenous vegetation that is being grazed and lost due to livestock feeding. The proximity of the Grootrivier and associated floodplain and drainage lines are important features of the landscape as they increase structural diversity and habitat variety resulting in the area being inhabited by at least 44 mammal species. Endemic rabbits and shrubs cover the plain negating that negative impacts on the species' populations would be a global consequence. The areas in which the shrubs inhabit are considered highly sensitive with turbine placement needing to be rethought and reconfigured. Moist areas around drainage lines further home regional endemic frog species with a further 25 regional endemic animals being identified.

As such, the Grootrivier landscape is considered an ecologically sensitive area with outlying areas considered to be of medium sensitivity (Figure 26). Furthermore, as the site falls within the boundaries of the Succulent Karoo biome, soils and climate determine the array of plant species,

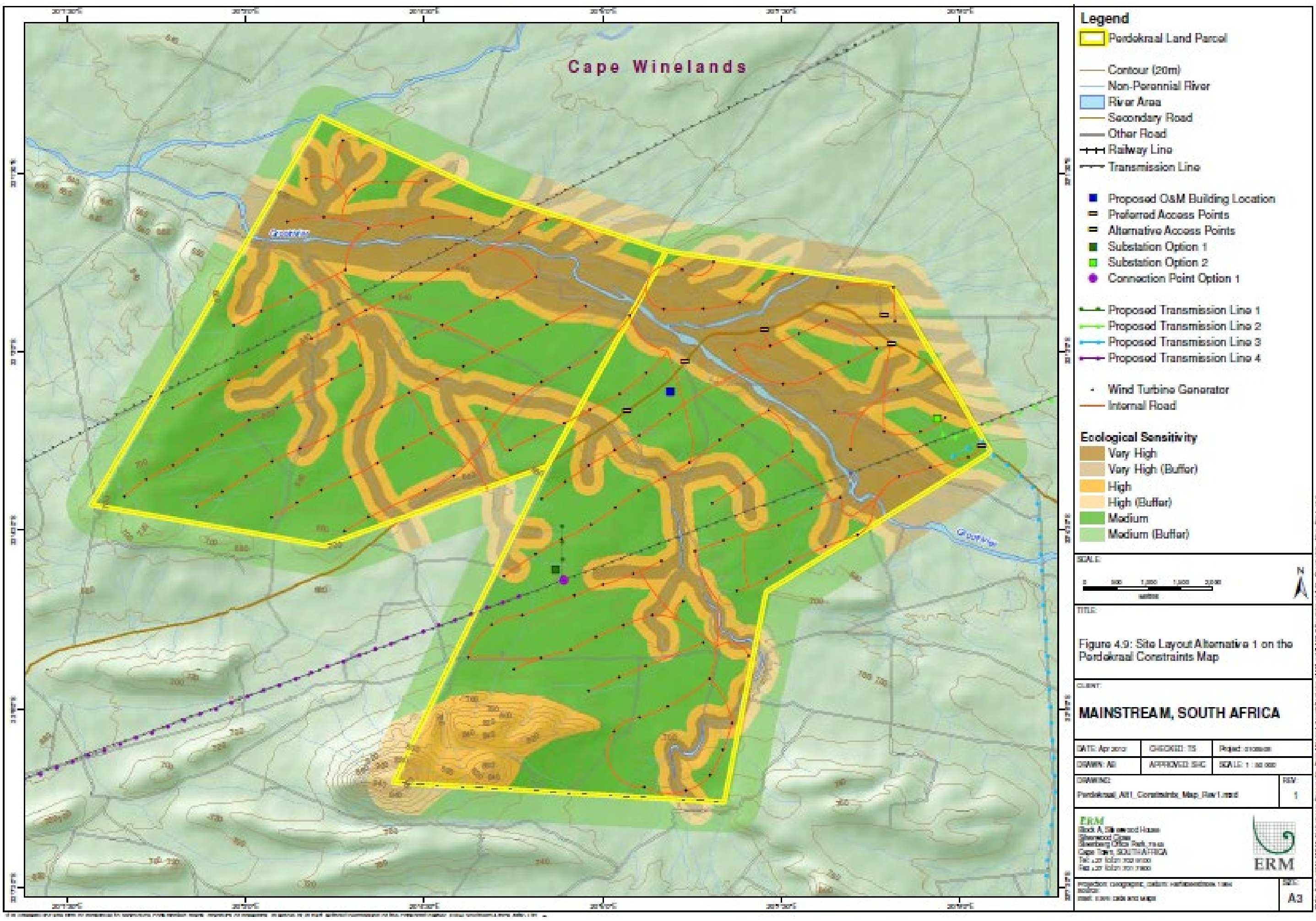

Figure 26: Site Map showing Ecological sensitivity (ERM, 2012)

but which have been overgrazed indicating overuse spanning over several decades. Due to the occasional flooding of the river, which recharges the nutrients in the surrounding soil, the vegetation surrounding the river offers valuable livestock feed. This is the reason that land use cannot change and has to incorporate existing agricultural practices. Four communities of vegetation were identified and varied in sensitivity rating according to the National Spatial Biodiversity Assessment (NBSA) with most of the area identified as a critical biodiversity area (CBA) and as ecologically support areas (ESA) needing to be protected and conserved. The highly sensitive ecological area surrounding the river is considered a 'no-go' area and has to be excluded from the placement of wind turbines and solar PV as it will have highly detrimental effects on the ecosystems (Figure 27).

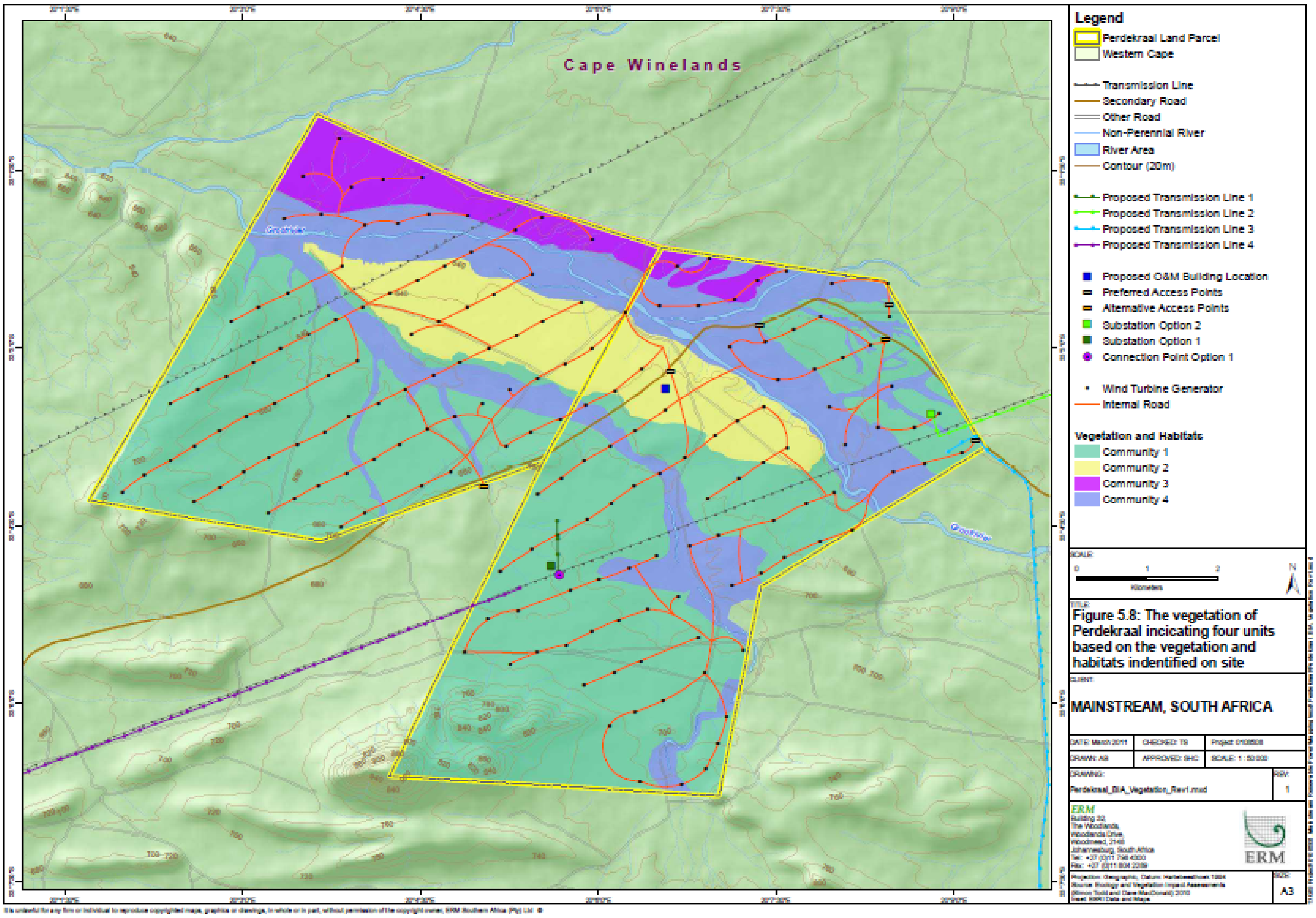

Figure 27: Site Map showing identified four vulnerable vegetation and habitats (ERM, 2012)

The Grootrivier and river-basin homes various waterbirds with existing Eskom power pylons being used as nesting, roosting and hunting habitats for raptors and other birds with the cliff-line, close to the river, homing cliff-nesting raptors. 30km to the north-west is a National Important Bird Area and 30km south-west is an important habitat for wetland birds. More than 200 bird species were identified, including 12 red-list birds, 66 endemics (or near endemics) and three red-listed endemics which include the Black Harrier. The Black Harrier would use the open expansive Karoo as its habitat seasonally and for breeding after rain. The Verreaux's Eagle would use the limited areas of exposed rock for nesting and surrounding areas for hunting.

In conducting avifauna impact assessments, 13 priority species were recognized and are either nationally and/or globally threatened species. At the time of publication of the Final EIA report in 2012, the Verreaux's Eagle was not red-listed, but has since been red-listed showing the important ecological role that it plays as an apex predator in the area and thus why it should be protected. The avifauna impact assessment identified that resident and breeding raptors (i.e.: Black Harrier and Martial Eagle) are susceptible to collision risks with wind turbines and displacement from the area; populations of endemic species that lose habitat will be displaced and disturbed and wetland species in and around the dam are at risk of colliding with the turbines.

The Final EIA report notes that the key economic sector of the area is centred around agriculture (fruits, viticulture and vegetables) and the production of wine. This is important because as the industry expands and new products are grown, agricultural land intrudes on habitats that home endemic avian species, resulting in disruption of their natural habitats and displacement. The use of pesticides and bird killings by farmers to protect their crops could have further negative impacts on species populations in the area.

The EIA report details the various National, Provincial and Local legislature, standards and guidelines used that not only look at conserving nature, but at the preservation of historical sites and graves, paleontology and meteorite fossils and noise and visual pollution. The EIA report details that flora studies were done in a three-phase period (scoping, site visit and impact assessment) in December 2010 and were done using vehicles and Garmin GPS; fauna studies were done in the above-mentioned three-phase study over two days through photography inventory and walk-throughs surveys. Avifauna studies were also conducted using the three-phase study that includes a literature review of bird and renewable energy facility interactions, site visits and sampling of avifauna in their habitats. Similar studies were conducted for bats, noise pollution, visual pollution, heritage sites, socio-economic factors and potential gaps and uncertainties that might arise due to lack of information, data and understanding.

The report notes that to mitigate potential disruption to various ecosystems and habitats during the design, construction and post-construction phases, wind turbine placement should not occur in sensitive areas and turbines should be relocated if they were initially placed in highly sensitive areas. Further consulting with specialists during construction would ensure that demarcations of indigenous flora are marked to ensure that they are protected, educating construction workers about conservation and not disturbing areas marked as sensitive and rehabilitating/ ecological restoration of areas with indigenous plants during and after the construction phase is complete.

The report notes that the proposed development is medium-sized and does present some level of threat to birds and species even though there are no recordings of regionally or nationally threatened species and habitats in or close to the development area. The major impact noted is the collision of birds with the wind turbine and associated powerlines with collision prone birds, including larger bodies species. Birds are more susceptible to collide with the turbine if there are birds in abundance; changes in their flight behaviour; size, number and spacing of turbines in close proximity and poor weather conditions. As such, the direct way identified to reduce collisions include avoiding key sensitive areas identified; the use of modern blade designs that discourage perching; reducing the length of new powerlines and including bird flight divider markers; monitoring and investigating collision incidents and applying proper mitigatory measures and implementing pre- and post-construction monitoring. These measures align with the requirements stated within the BAWESG.

Due to the site chosen being ecologically sensitive, the proposed number of wind turbines is suggested to be reduced from 169-230 to 48-60 as shown in Figure 28. The EIA report reveals that the development of several wind farm facilities in close proximity would be detrimental as it

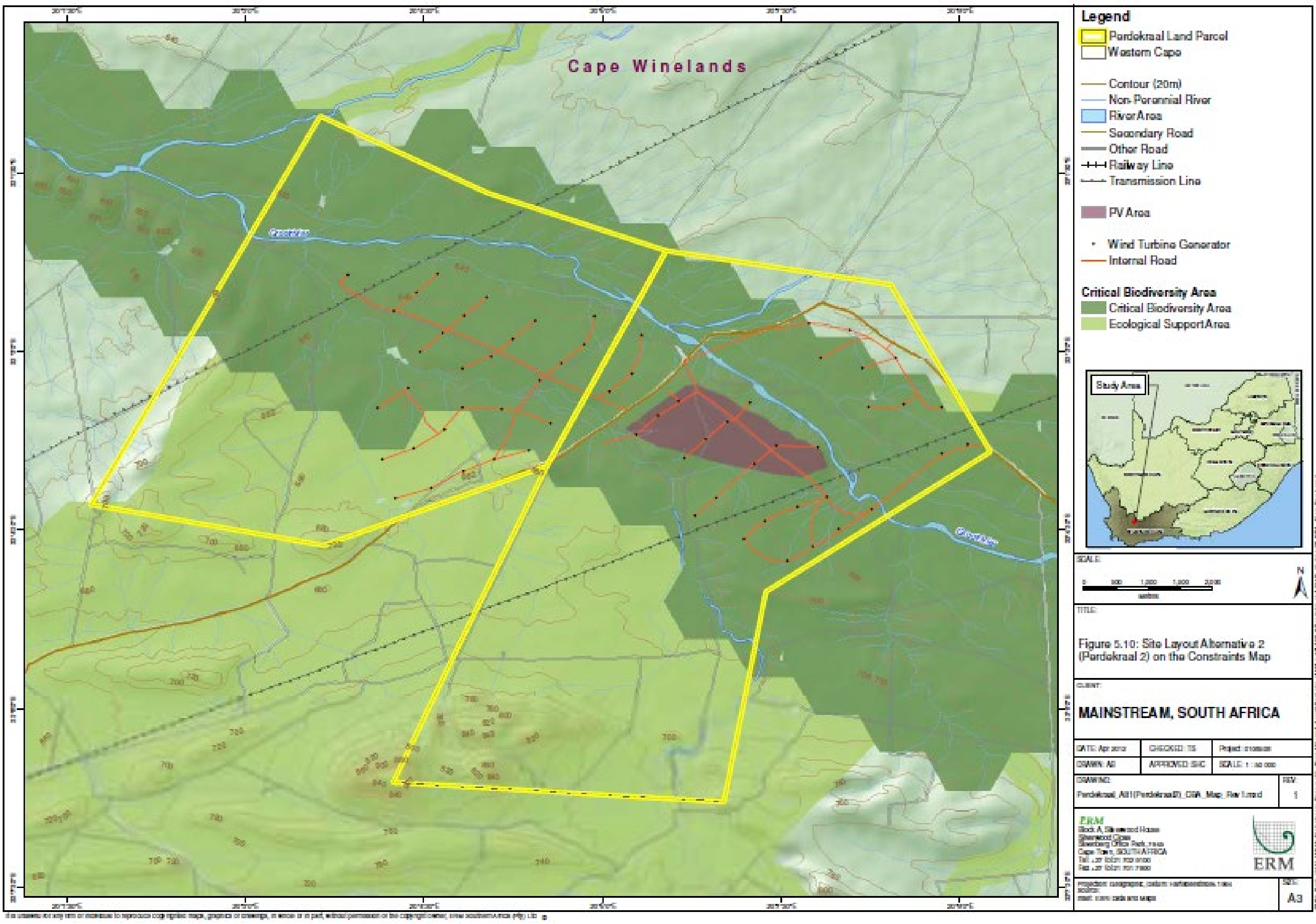

Figure 28: Site Map showing reduction in wind turbines numbers (ERM, 2012)

would have cumulative impacts of habitat destruction; disturbance; displacement by construction; maintenance and operation of the facility; mortality caused by collision and electrocution from powerline collision. However, due to limited data existing in the country on the interactions of birds with wind turbines, more research is required thus imparting that long term monitoring is required before construction and during the operation of the energy facility is recommended.

4.4.3. Understanding the EIAs

Due to limited time, only two EIA reports could be looked at for this research. The Roggeveld EIA report had more substantial information in providing a deeper understanding of the current climate and situations on the ground of the facility and how the wind turbines impact the surrounding bird species. The Perdekraal EIA report did not specifically state what would be done to ensure bird protection in this energy facility.

It is evident that both EIA reports acknowledged and were cognizant of various National, Provincial and Local legislation, standards and guidelines. Not only was scoping, screening, surveying and monitoring done, relating to all various aspects of the site, but monitoring of bird habitats were done accordingly as prescribed in the BAWESG. It is important to note that at the time of publications for both reports, the latest version of the BAWESG (2015) was not released which detailed that monitoring of sites should be done for a minimum of two years, with more specifications detailing further requirements of what kind of monitoring should be done for specific threatened and endemic species. Such information was only published by BirdLife South Africa at a later date through the Verreaux Eagle, Black Harrier and Cape Vulture reports.

EIAs are conducted as part of fulfilling and adhering to section 24 (5) of NEMA. As such, various environmental assessments need to be done and specialists involved to concurrently capture data for specific sites where wind farms are proposed. This is not only done to adhere to NEMA but is done to ensure the protection of environmental resources, flora, fauna and species that are endemic and vulnerable to extinction. Both reports state that renewable energy provides a much-needed alternative for energy generation, but the cost of reducing CO_2 emissions should not be done at the cost of degrading and harming the environment.

The identification of the Black Harrier and Verreaux's Eagle at both wind farms show the wide range of areas in which these species inhabit. Whilst it is evident that the Verreaux's Eagle flies at higher altitudes than the Black Harrier, both species are at risk of colliding with wind turbines. It is simple mitigatory aspects, such as placement and distance between wind turbines, that can be the difference between the bird being able to manoeuvre away from the turbine instead of colliding and resulting in its fatality. Whilst policy does ensure environmental protection, the EIA reports relay that environmental assessments and accompanying guidelines are the main components in ensuring avian and wildlife protection in the development of wind farms.

4.5. What does this mean for the protection of birdlife in South Africa?

When reviewing the above wind farms and their respective environmental reports, it is evident that environmental assessments (i.e.: EIAs, SEAs), together with the BAWESG, are the most vital mitigatory assessments and tools that are needed to be done for a wind farm to be developed as compared to environmental legislation that only provides an over-arching theme and framework for environmental protection and conservation. Whilst South Africa has environmental policies in place that govern protection and conservation measures in the country for the betterment of the environment and its people, it is evident that national environmental policies (i.e.: NEMA, NEMBA) provide a broader framework of what development needs to be cognizant about, but not specifically of what should occur in situations where the environment is strained due to expansive threats (i.e.: urbanization, habitat loss, environmental degradation).

Due to national renewable energy policies being enacted when renewable energy was not yet a large industry in the country, significant negative impacts that wind turbines present to the environment, such as avian fatalities, have not been considered and accounted for in the policies. Policies, such as the National Environmental Management: Protected Areas Act and Biodiversity Act, continuously mention mining and its negative environmental implications, but the negative effects of wind turbines are limited with only noise and visual pollution being mentioned. Acts and policies that were drafted and enacted before renewable energy was developed in the country should be amended to incorporate the industry that is said to help reduce reliance on fossil fuels for energy generation.

However, it is important to note that whilst national legislation (i.e.: NEMBA, Biodiversity Act, Protected Areas Act) does pave the way for environmental protection and conservation, it is environmental assessments and other guidelines (i.e.: BAWESG) that reduce the likelihood of birds colliding with wind turbines and correlatory cumulative effects (e.g.: habitat loss, destruction, displacement) associated with the installation and operation of the turbines. The assessments conducted not only identify protected areas but identify areas that are populated with red-listed species and provide guidelines as to how development should occur if specific aspects are encountered on sites, (e.g.: creating buffer zones around nesting and roosting areas). Guidelines are, therefore, crucial in ensuring that development is cognizant of birds but even of their characteristics and behaviour to ensure that wind turbines can be placed in the most optimal locations without impacting birds and their habitats.

As a way to further reduce collisions, the idea of utilizing the 'black-blade' has taken ahold of developers. This entails one rotor blade being painted black whilst the others remain white

(Figure 29). This adaptive mechanism ensures that the bird does not experience 'motion smear'[3] and can, therefore, distinguish the blades of the turbine whilst in motion as the white blades are made more visible against a bright background (Engineering News, 2020). However, on days plagued with poor visibility and shadows, the black blade is not distinguishable to the eyes of the birds. This technology is yet to be tested in South Africa.

Figure 29: Black-blade wind turbines (ERM, 2012)

A study done in Germany, in 2020, on a new wind farm sees wind farm developers fitting cameras and motion detectors on the top of the turbine as a way to reduce avian mortalities. The sensor detects the movement of the bird and subsequently reduces the speed at which the blade is spinning. As the blade moves slower, this allows the bird to acknowledge the obstacle in its way and manoeuvre to avoid it. Once the camera no longer detects movement, the blades of the turbine start to rotate again. This technology is still being tested and analyzed, but provides a promising way for turbines to still be operational, whilst reducing avian mortalities (Wind power getting headwind in Germany, 2020).

Furthermore, advanced design technology of wind turbines that do not use blades are seen as a promising way for turbines to still be effective without causing bird mortalities. This design encompasses the 'skybrator', as previously mentioned, and the Inner Compression Cone Turbine that does not have any exposed turbine blades, but consists of a cone that encompasses the blades while still producing air compression (Green Building News, 2012). Not a lot of design interventions are on the market as they are still being tested and analyzed, as this is a fairly new issue. The use of vertical-axis turbines in urban environments is an alternate option as they are smaller in stature but do require a power source that starts the motor.

[3] 'Motion smear' is when the brain can no longer process the retinal image of the fast-moving object (i.e., the bird not being able to distinguish the difference between the different turbine blades due to its speed)

4.6. Conclusion

The Western Cape province in South Africa has a vast array of flora, fauna and avian species. 55 bird species were identified in South Africa as being on the red list, with 17 of them being found in the Western Cape. Studies show that larger-bodies birds are more susceptible to colliding with turbines than smaller birds, but mortality statistics are not accurate due to predators removing carcasses and/ or carcasses not being found. The Western Cape has nine operational wind farms in the province with one decommissioned wind farm and three farms in the development stages.

The Black Harrier and Verreaux Eagle are predominant in the entire area, whilst the Cape Vulture occupies only a small area in the southern part of the province where wind farms are not generally located. The EIA reports of Roggeveld Wind Farm and Perdekraal Wind Energy Facility identified that national, provincial and local legislation is used in conducting environmental assessments. However, the BAWESG guideline plays a larger role when environmental assessments are conducted, as it has more stringent guidelines which need to be followed and adhered to. Mitigation measures to reduce the rate of bird collisions with turbines do exist, but due to the problem identified being fairly new, mitigation measures and designs are still being tested and analyzed in different parts of the world. However, these measures are promising and pave the way for ensuring reduced mortality rates, in terms of bird collisions with wind turbines.

Chapter 5 (Conclusion and Recommendations)

"What wild creature is more accessible to our eyes and ears, as close to us and everyone in the world, as universal as a bird" – Sir David Attenborough

5.1. Introduction

This chapter concludes the entire research report by presenting a summary and conclusions of the report, answering the research question and providing recommendations based on the findings of this research. The summary of the research report allows for an understanding on how the aspects surrounding sustainability, renewable energy, wind energy and wildlife protection have come together and created the foundation of this research. It will further provide detail of said aspects, relate it to the South African context and will stipulate the main findings of this research. Furthermore, recommendations making further research for this topic easier will be stated.

5.2. Summary of the Research Report

Since the onslaught of the industrial revolution, the environment has undergone substantial destruction. Resource exploitation, together with various developments that have encroached on the environment, has resulted in the loss of ecosystems, habitats and flora and fauna. The further increase of GHGs being released into the atmosphere has contributed to the erratic weather events that the world has felt in recent years. As a result, sustainability concepts and theories emerged as a response to try and achieve a balance between the three sustainability pillars - environment, social and economy – and for societal behaviours to be more cognizant of the negative effects that development has on the natural environment

Renewable, alternate and 'green' energy emerged as a response to reduce the reliance and usage of fossil fuels for energy generation. Green energy further provides a solution to achieve a sustainable future and for cities to meet developmental needs and climate change objectives. Developing countries account for 70% of global renewable energy growth by 2030 (IRENA, 2016). Wind energy is the most widely used as it is the most efficient and feasible renewable technology available. The wind energy industry is said to grow at a CAGR of 4% by 2025, with annual installations exceeding 110GW. Wind energy is cost-effective, a clean energy fuel source, a domestic source of energy, offers employment opportunities and provides socio-economic development and growth. The harvesting of wind energy offshore is relatively new, but generates two times more electricity than onshore wind farms and is said to grow at a CAGR of 31.5% over the next five years. However, onshore wind farms are cheaper and more cost effective, but have environmental impacts, including negatively impacting wildlife, by causing habitat loss, fragmentation and endemic and migratory bird fatalities.

Avifauna is an important resource as birds positively contribute to the protection of societies' economic and social systems and ensures the survival of habitats and ecosystems that they inhabit. The IUCN red-list data states that one in every eight bird species is threatened with extinction. Wind turbines are not the main cause of bird fatalities, but as an emerging industry, corrective measures need to be taken to reduce the number of fatalities of birds as the industry expands and grows. This can be achieved through the enactment and enforcement of environmental legislation and assessments.

Relating the above to the context of South Africa, South Africa is the world's 7th largest coal producer and is among the world's top 10 GHG emitters. As a response to reducing dependency and reliance on coal for energy generation, South Africa introduced the Renewable Energy Independent Power Producer Programme to increase foreign investment in the country's renewable energy industry. This has resulted in 3.4GW capacity of wind power being built, R80.5 billion investment into the country and over 100 wind turbine technicians being trained, empowering local communities. A further 1600MW of wind energy will be introduced via onshore wind energy, with the industry set to grow at a CAGR of 3% in the next five years. South Africa has 22 fully operational wind farms, with 11 still under construction. The Western Cape was identified as one of the provinces that are ideally located to harvest energy from the strong winds with the province having nine fully operational onshore wind farms.

South Africa is rich in biodiversity, but 16% of South Africa's plants are threatened with extinction stemming from crop cultivation, urban development, overgrazing from livestock and drought. Furthermore, 132 bird species in South Africa are listed as regionally threatened with 13 being critically endangered species. The country has between 69-160 endemic or near-endemic bird species. Due to wind energy being relatively new in the country, understanding of the impact that wind turbines have on birdlife is limited with information and data being extrapolated from other countries. However, it is estimated that 4.6 birds are killed per wind turbine per year in South Africa, with the majority of carcasses found being larger-bodied birds (e.g.: diurnal raptors and apex predators). The Western Cape province has 86 bird species that are endemic and 38 that are globally threatened with the province having the most endangered and vulnerable habitats and ecosystems in the country.

Environmental protection is needed so environmental legislation and assessments identified as being the most important in the protection of birdlife in the country include the Constitution of South Africa, NEMA and NEMBA, the White Paper on Renewable Energy of 2003 and the Protected Areas Act of 2003. Important environmental assessments include EIA, SEA, Avifaunal Impact Assessments and the National Biodiversity Assessment. Current environmental legislation does not specifically mention wind energy, or renewable energy, as the policies were enacted at the inception of the wind energy industry. If wind energy *is* mentioned in the aforementioned policy, it does not specify the impact that the turbines have on wildlife, but rather mentions only noise and visual pollution impacts. Rather, the environmental assessments are more structured to address and ensure the protection of endangered and vulnerable species of flora, fauna and avians.

The findings of the research include the identification of the Verreaux's Eagle, Cape Vulture and Black Harrier as the three bird species that are most impacted by wind turbines in the Western Cape. The three reports published by BirdLife South Africa, of the relationship between the three species and wind turbines identify that site screening, surveys and monitoring of the proposed area for the wind farm is an important aspect of the development process, as it identifies where relevant nesting areas, roosting and hunting areas are. Buffer zones need to be placed around these zones with the turbines being placed at a specified distance as stipulated in the Bird and Wind Energy Best Practice Guidelines. Fatalities of birds are attributed to the collision of birds with turbine blades and associated powerline infrastructure. The Verreaux's Eagle and Black Harrier are found within the wind farms areas of the Roggeveld Wind Farm and the Perdekraal East Wind Farm in the Western Cape.

The respective EIAs of the aforementioned wind farms, identify that the construction of the wind farms can result in avian and flora habitat loss and destruction if proper mitigatory procedures are not followed. To ensure that bird mortalities of the above two bird species are reduced, the placement of wind turbines should not occur in sensitive areas which are used for nesting, roosting and hunting. Furthermore, the distance between turbine structures should increase to allow a broader window of maneuvering for the birds.

Overall, through the EIA reports, it is evident that whilst environmental legislation underpins the protection and conservation of the natural environment in the country, environmental assessments have the most important role in ensuring the protection of avians and wildlife against the negative impacts that wind turbines present because it is thorough in identifying all potential aspects that can be affected by the development and thereby inserts mitigatory practices to deter from encroachment.

5.3. Answering the Research Question

The main research question for the research report is as follows:

> Have South Africa's environmental policies and assessments reduced the negative effects of destruction and mortality of birdlife caused by wind turbines?

The research report provides an understanding surrounding the renewable energy industry in South Africa and confirms that the onshore wind energy industry is set to grow in the coming years due to bid window 5 under the REIPPP programme. Whilst South Africa is rich in biodiversity, the Western Cape province has the most endangered and vulnerable ecosystems and habitats in the country. By identifying the three species of diurnal raptors, Verreaux's Eagle, Cape Vulture and Black Harrier, and correlating the presence of these birds with the two wind farms and their EIA reports, it is evident that whilst environmental legislation provides an important basis for how the environment should be looked after in the country, that environmental assessments, such as EIAs, are the most important tool to reduce the negative impacts of wind turbines on birdlife.

It appears that South Africa's environmental policies and assessments have helped to reduce bird fatalities, but this conclusion is based on only a few published studies to date. National legislation enacted before 2010, barely mentions renewable energy/ wind energy and if mentioned, identifies noise and visual pollution as the only impacts associated with wind turbines. This is due to the industry only really developing after this period.

But national environmental legislation does provide the *framework and basis* of what development should be cognizant about in the environment, with resources and endangered species being protected under these Acts. Because of this, to some extent, policies (The White Paper on Renewable Energy) do specify how the development of wind farms should occur to ensure the protection of affected wildlife, including birdlife. However, *environmental assessments* are more specific and involve the process of scoping, monitoring and conducting surveys in proposed wind farm sites which enable specific data to be collected and analyzed.

Through these assessment processes, endangered, vulnerable and endemic flora, fauna and avifauns can be identified. The Bird and Wind Energy Best Practice Guidelines developed by BirdLife South Africa and the Endangered Wildlife Trust specify guidelines that need to be followed based on those organizations' mandates to protect birdlife and wildlife in the country. Guidelines are, therefore, crucial in ensuring that development is cognizant of birds and their characteristics and behaviour so as to ensure that wind turbines can be placed in the most optimal locations without impacting birds and their habitats.

Furthermore, the introduction of different turbine designs that do not have blades (e.g.: skybrator) can be seen as the future for onshore turbine design as it is less likely that birds will experience collisions and/or fatalities with the structure. Alternatively, painting one blade black ensures that a soaring bird can distinguish between the moving blades, enabling them to manoeuvre around the blades. Having motion detectors on the turbine enables the turbine blades to reduce their speed once a bird is detected. However, not a lot of design alternatives exist in the market, but the above shows the willingness of people to want to reduce bird collisions and fatalities as a result of wind turbines through simple mitigatory measures.

5.4. Recommendations

Based on the challenges that I faced in conducting this research, it is recommended that more studies on all operational wind farms be done to provide accurate data on the various bird species in the area. Monitoring of bird fatalities should be done at regular intervals by wind farm personnel during the lifetime of the wind turbines, and not only for one-year post-construction as stipulated in the BAWESG. This will help provide the public and interested and affected parties with accurate information and data on bird mortalities experienced in that area.

National legislation enacted before the development of the wind energy industry in South Africa should be amended to incorporate all types of renewable energy as the principles of these policies will be used as a basis for environmental protection. Policies relating to the renewable energy industry that was enacted after the wind industry was developed, should also be amended as no proper correlations are made detailing the positive and negative impacts of each specific renewable energy.

Government websites and corresponding sites that navigate the wind industry in the country (i.e., South African Wind Energy Association), should be updated regularly, especially if more wind farms are under construction and becoming operational. Due to these sources being outdated, correlating various sources to provide an accurate description of what is happening in the wind industry, is time consuming, confusing and frustrating. Updated information from accredited sites will ensure that accurate information, relating to the wind industry, is available to the public and for research reference.

5.5. Conclusion

The research report has attempted to determine if South Africa's national environmental legislation and assessments have contributed to the reduction of bird fatalities caused by wind turbines in the country. Based on the literature presented, the wind energy industry is growing globally, as it is considered the most efficient and feasible energy technology. Whilst wind energy presents an opportunity for energy generation that ensures South Africa will have less reliance and dependence on coal usage to generate electricity, it is evident that wind turbines are the cause of many endemic, endangered and vulnerable bird fatalities. Environmental legislation provides the foundation for ensuring the protection of the country's wildlife, but it is environmental assessments (e.g.: EIAs) and guidelines published by environmental and bird protection NGOs that have contributed to the protection of birdlife to date. Based on the recommendations provided, more studies need to be done as the wind energy industry continues to grow in the country, together with the development of turbine technology and designs that can ensure the longevity of the wind industry, whilst also protecting wildlife and birdlife that inhabit the areas around the wind turbines.

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Appendix

Appendix 1: Ethics Clearance

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG | SCHOOL of ARCHITECTURE + PLANNING

29 March 2022

Faculty of Engineering and the Built Environment:

Ethics clearance letter:

Dear Nadeemah Docrat

Student number (1655640), this letter confirms that your ethics application has been cleared. Your clearance/protocol number SOAP112/06/2021

Yours sincerely

Lerato Nkosi

Appendix 2: Plagiarism Declaration

Faculty of Engineering and the Built Environment

Private Bag 3, Wits 2050, South Africa * Telephone (011) 717 – 7007 * Fax: (011) 717 7009 * Email: febe.pg@wits.ac.za

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I Nadeemah Docrat (Student number: 1655640) am a student registered for the degree of Master of Urban Studies in the academic year 2021/2022

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this in not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Signature: N Docrat Date: 29 December 2022