The Impact of Quarrying activities and Communal perceptions towards the Environmental and Animal Welfare in the Ashburton community located in KZN Province, South Africa.

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Declaration

I, Ntuthuko Cyprian Mathe, declare that this paper is my original work and has not been submitted to any university. I also certify that this is my independent design and manufacturing work and that all materials contained herein are properly acknowledged. The research reported in this thesis has been conducted under the supervision of Dr Z.T Rani and Dr N.R Mkhize.

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List of abbreviations

Al	Aluminium
As	Arsenic
Cd	Cadmium
Cr	Chromium
Hg	Mercury
Ni	Nickel
Pb	Lead
Se	Selenium
NO_3	Nitrate
WQI	Water Quality Index
AIC	Akaike Information criterion
No.par	number of parameters
(ψ)	Estimated occupancy
(p)	Estimated probability of detection
DH	Distance to the household
DR	Distance to the road
LL	Leaf letter
No.T	Number of trees
GH	Grass cover

BG	Bare ground
DQ	Distance to the quarry
HC	Herbaceous cover
DW	Distance to the water source

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Abstract

The aim of this research was to evaluate the animal distribution, water quality, and how the communal residents perceive the quarry existence in the surrounding community. A qualitative survey in a form of semi-structured interviews was conducted among nine key informants out of 18 landowners at Lower Mpushini community, Msunduzi Municipality in the KwaZulu Natal, Province of South Africa. A larger sample number on the qualitative research approach diminishes the return, which is much more time consuming and costly. The results indicated mixed perceptions from the residents towards the impact of the quarrying activities and the existence of the quarry in the area. According to the results, the community appeared to be divided, with one side demonstrating negative perceptions and the others indicating positive perceptions towards the quarrying activities performed in the area. The impact of quarrying activities on river water quality neighbouring the quarrying mine which act as the source of water for animals in the surrounding area was also studied. A total of five water samples were collected (upstream, open pit, downstream 1, downstream 2, and downstream 3).

The Water Quality Index (WQI) of both upstream and downstream sampling were found to have the same status of excellent water quality as the distance from the quarrying point increases. The levels that were acquired from the river water quality were in line with the South African National Standard (SANS) despite the fact that the quarry is suited to the banks of the river. The animal habitat use was studied over the period of 56 days of camera trapping at 20 sites that resulted in 1120 trap-nights with 2071 independent photos. According to the data that was collected from these photos, five species of antelopes Impala (*Aepyceros melampus)*, Nyala (*Tragelaphus angasii)*, Kudu (*Tragelaphus strepsiceros*), Wildebeest (*Connochaetes*), and Bushbuck (*Tragelaphus sylvaticus*) were identified to dominate the area with livestock kept inside the resident's homesteads. However, only two species Nyala and Impala were considered as study animals, as they had naïve occupancy of ≥ 0.2 and the other species had naïve occupancy of <0.2. The naive occupancy for Nyala was 0.90 and for Impala it was 0.30. Nyala's average estimated site occupancy and detection were 0.90 ± 0.05 ($\psi\pm$SE) and 0.69 ± 0.07 ($p\pm$SE) respectively. Impala average estimated site occupancy and detection 0.40 ± 0.11 ($\psi\pm$SE) and 0.77 ± 0.04 ($p\pm$SE) respectively. The top model (deltaAIC=0) for Nyala species was psi (DH+No.T),p(DH+DW+DR) with the highest AIC weight of 0.098. The top model (deltaAIC=0) for Impala was psi (DH+BG+NoT), p(DR+BG+DH+NoT) with the highest AIC weight of 0.164. The results indicated that distance to the quarry (DQ) did not have a significant influence ($p>0.05$) on the presence or absence of the two-study species.

Based on the findings of this research, it was concluded that there was no conclusive evidence that the quarrying activities have any negative impact on the well-being of the community, animals, and environment. However, more specific, and specialised research is advised to draw more solid scientific conclusions.

Key words: Quarrying, occupancy modelling, water quality index, animal welfare, occupancy probability, detection probability.

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CHAPTER 1

GENERAL INTRODUCTION

1.1 Background

Imagine a modern world without building materials that are fundamentally key in infrastructure development. Building materials are in high demand in developing countries as they are directly proportional to economic growth (Windapo & Cattell, 2013). Many developing countries are striving for rapid infrastructure development related to the tremendous growth in building material production (Devi & Rongmei, 2017; Unanaonwi & Amonum, 2017; Belay *et al.*, 2020). Quarries are open-pit surface mining from which mineral rocks are extracted and construction materials such as ornamental stones, dimension stones, and industrial raw materials are made (Endalew, 2019). This industry plays a crucial role in the country's development and economic growth. The department of South African mineral resources employ and provide multiple cascading economic benefits that improve local communities' living standards and well-being. Quarrying mines through the production of building materials contribute significantly to the country's economy (Bewiadzi *et al.*, 2018).

Quarrying plays a significant role in South Africa as it supports local economic development and in addition, the use of extracted materials enhances trades and creates job opportunities. The government has identified the construction industry as fundamentally key in its efforts to close the gap of inequality and poverty by the year 2030. This signifies the importance of the quarrying industry and the vast contribution it has in the country's economy. In its 2017 report, the Department of Mineral Resources stated that the market analysis of the construction industry has shown an exponential growth over the past ten years to the actual value added to Gross Domestic Product (Department of Mineral Resource.,2017)

Despite of all the beneficial effects towards the country's economy profitability and popularity, mines and quarries which produce the building materials are faced with many challenges due to environmental concerns and sustainability issues (Nartey *et al.*, 2012; Sayara, 2016). Poor management and operation performed by the quarrying mines have led to significant negative impacts on environmental degradation (Agyemang *et al.,* 2007). There are indications that activities performed may result to an ecological destruction, destroying natural habitats, which results in soil erosion, and air pollution (MA *et al.*, 2018).

The mining industry uses water, as a significant component of open-cast mining operations (Howard, 2016). This is challenging, especially in light of the fact that South Africa is a water-scarce country and given that water is life and plays a pivotal role in maintaining a balance in the ecosystem. Water demand has increased due to exponential population growth linked to increased industrialization and urbanization (Ochieng *et al.*, 2010). Water availability continues to decline due to resource depletion and water pollution (Ashton *et al.*, 2001; Konikow & Kendy, 2005). Poor water management by the mining industry has led to more scrutiny by environmentalists worldwide to correct and provide guidelines regarding the use and disposal of wastewater. The stone quarrying industry is at the upper end of water-polluting industries with proven significant impact on the ground and surface water quality (Kumar, 2017; Bewiadzi *et al.*, 2018).

Heavy metals are well-known industrial pollutants associated with open-cast mining with devastating negative impacts on the environment (Munnik *et al.*, 2010). The pollutants are categorised under environmental contaminants due to their toxic effect on animals and plants

(Masindi & Muedi, 2018). Heavy metals are metals with high density and are toxic in low quantities, such as, lead (Pb), arsenic (As), mercury (Hg), cadmium (Cd), and chromium (Cr) are among the most toxic heavy metals (Chibuike & Obiora, 2014). These metals accumulate in the food chain through primary producers and consumption at the consumer level, and at higher levels, are deadly harmful to both animals and plants (Chibuike & Obiora, 2014). Quarrying activities expose organisms to heavy metals and negatively impact the surrounding environment situated nearer where the quarry is situated. According to Suleiman *et al.* (2019) standard protocols were put in place to enforce noise protection policies and assess environmental noise for humans. However, environmental noise policies for animals are limited due to the wide range of hearing and sensitivities compared to human hearing (Radford *et al.*, 2012). Therefore, more relevant research is required to establish policies that protect wildlife from anthropogenic noise. This is important in order to cater for their well - being and welfare. According to the Animal welfare, animals must have freedom from discomfort, which may be caused by noise pollution. Most quarrying mines use the 500m radius around the mine to determine the effect of noise pollution and ground vibrations to the neighbouring community. Based on the noise and vibrations phenomena, the waves diminish as they travel away from the source (Casati *et al.*, 2020). The 500m radius policy indicates that all structural buildings including homes should be outside this radius from the open cast mining site (Mwale, 2015). The adversity of the environmental impacts caused by quarrying mines largely depends on the distance from the source. Nobuntou *et al.* (2010) state that environmental impacts are inversely proportional to the distance from the mine. Health issues and structural fractures caused by vibrations, noise, air, water, and soil pollution tend to decrease with increased distance from the quarrying site. Research by Yeboah (2008) show an increase in health issues and environmental impacts closer to the mine than in communities further away from the mining site. This study adopts this approach to study the community perceptions, with an assumption based on previous research that community members residing closer to the quarrying mine will have negative perceptions towards the quarrying activities when compared to community members further away from the quarrying mine.

Moreover, it should be noted that the mining industry is responsible for the displacements of rural communities in Africa for one-sided benefit to businesses, which has led to conflicts between quarrying companies and the local communities (Wilson, 2019). A drastic increase in company-community conflicts have been observed in recent years. Kemp *et al.* (2011) define it as a disagreement between the mines and local communities where the majority of mines operate on a common share of land use, water resources, environmental impacts, livelihood, and economic security. Under such circumstances, community participation is usually at the centre of solutions to resolve company-community conflicts. However, the participation is influenced by the demographics of the local community, where age, sex and education turn to play a crucial role (Que *et al.*, 2018). For a successful relationship between mining companies and the local community, the economic, social and environmental aspects are significant and must be balanced. Hence the community engagement in mining plans and management must be encouraged (Esteves, 2008). Lower Mpushini community where the research was conducted, is part of the Ashburton community suited about 12 km via N3 road from Pietermaritzburg city centre, KwaZulu Natal. The community is part of the protected area called Lower Mpushini Valley Conservancy. Landowners pride themselves of the area and are actively involved in conserving their precious natural environment. The landowners share the land with the quarry, which is the open cast mine producing building and construction materials within the conservancy. The quarry is a leading black empowered Group with its main business and core competence in open pit mining.

A local newspaper referred to as 'The Witness' released an article titled "Residents quarry rage" covering the dispute between the Quarry operators and several members of the Lower Mpushini Valley community in 2019. The dispute focussed mainly on the illegal blasting, where members of the community argued that the quarry conducted an alleged unscheduled blast. The concerns raised were that the blasting resulted in their houses to accumulate cracks, adverse effects to the environment, animals in the surrounding area and how the area would be rehabilitated at a later stage. Concerns that were raised led to some recommendations for further investigations and prompted to this research to find ways in which the quarry and the community can coexist without or with minimal interference. Hence the aim of this research was to determine if the quarrying activities have any environmental impact focusing on water pollution, impacts on antelopes which are common and abundant wildlife species in the area, and their habitat use. Furthermore, the perceptions/views from the communal residents in relation to the impact of the quarry activities were also determined.

1.2 Aim and objectives

The main objective was to determine the impact of quarrying activities on the surrounding community, animals, and the environment.

- **Specific objectives were to:**

(i) To evaluate the community perceptions of quarrying activities on the environment, community wellbeing, and habitat use by antelopes in the area surrounding the quarrying mine

(ii) To determine the effect of quarrying activities on quality of water found in a nearby river.

(iii) To determine the impact of quarrying activities on habitat use by animals in relation to distance from the quarrying activities.

1.3 The hypothesis tested was that:

The null hypothesis of this study was that the quarrying activities do not affect the neighbouring community, the environment and dominating animals including their welfare. The specific hypotheses were the following:

(i) Community perceptions on quarrying activities are similar.

(ii) There is no difference on the perceptions of residents residing closer to the quarry and those that are further away from the quarry.

(iii) There is no difference in water quality of the river closer and further away from the quarry.

(iv) The quarrying activities do not have an impact on habitat use by animals found closer to the quarrying mine.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Infrastructure development associated with quarrying mines in South Africa employed about 471 000 people on aggregate during the fourth quarter of 2015 (South African Mineral Resources Government's Annual Report, 2017). This indicates the significance of the quarrying industry to the South African economy, followed by the agricultural sector (van Aswegen & Retief, 2021). Both quarrying and agriculture play a vital role in rural livelihood establishment and the well-being of local communities (Asante *et al.*, 2014). However, environmental destruction such as water pollution, air pollution, soil dislocation, soil infertility, change of landscape, and loss of plants/vegetation caused by quarrying activities has been noted to have considerable impacts on the environment and agricultural sector. For example, quarrying activities have been associated with a significant impact on the environment and animal habitat use (Bewiadzi *et al.*, 2018). Lameed & Ayodele (2010) indicated that most companies use explosives to blast rocks during the extraction of material for processing, resulting in air pollution, noise pollution, water pollution, and habitat destruction. Quarrying activities impact surface water where some places are flooded or dry out, which directly affects wildlife surrounding the quarry (Endalew, 2019). Averbeck (2002) defined habitat as an area that enables life, where the animal can reproduce and survive. Amongst antelopes, different species prefer different habitats categorised by type of vegetation structure and forages. Habitat preference is determined by the factors such as slope, elevation, soil, and surface water Averbeck (2002). Antelope habitat use might be influenced by the presence of predators and other grazing competitors (Hensman *et al.*, 2014).

The environmental impact caused by quarrying activities includes reducing farmland by disturbance of fertile soil, blocking free movement of grazing animals, alteration of water sources including water pollution, and reduction of plant vegetation that is usually the main source of food for grazing animals (Endalew, 2019). Quarrying activities may expose some areas to soil erosion that leads to storm water runoffs. This has been a challenge for most communities neighbouring quarrying mines in Africa, water runoff causes farmlands to be flooded, and in some cases, these quarrying mines pump out water from open pits into the nearby stream/river which communities depend on for water daily uses and agricultural practices (Nartey *et al.*, 2012). Animals cannot access grazing lands when the lands are flooded, which affects animal growth and reproduction, hence changes in neighbouring animal populations are likely to occur.

Quarrying sites produce dust during blasting operations and transportation of the products that cause air pollution. The impact of dust on the surrounding habitat depends on the area's climate conditions, the concentration of dust in the air, the type of rocks being mined, and dust chemical content (Lameed & Ayodele, 2010; Kalu & Ogbonna, 2019). Dust directly impacts both plants and animals which causes poor growth in plants and lung diseases in animals. However, among pollution caused by quarrying activities, noise pollution has been the most devastating to neighbouring communities (Melodi, 2017a). Noise pollution results from blasting operations and heavy machinery used during the extraction and transportation of mineral rocks. Noise pollution has a significant impact on animals. Noise commonly affects animal behaviour and changes in metabolic rate, communication, and grazing behaviour (Radford *et al.*, 2012).

Quarries worldwide have been associated with environmental and heavy metals pollution (Tiimub & Maxwell, 2015). Heavy metals are metals with high density and are toxic in low quantities, e.g., lead (Pb), arsenic (As), mercury (Hg), cadmium (Cd), and chromium (Cr) (Sonone *et al.,* 2020). These metals have been identified to have a significant effect when consumed by grazing animals and absorbed by plants. These are found in nature in small quantities. However, human activities such as quarrying mines turn to expose them to the surface in high doses that are more toxic to plants and animals. Company-community conflicts have arisen, necessitating this research. The community has questioned the impacts of quarrying activities on the animals within the nature conservancy and the quality of water from the sources surrounding the mine.

2.2 Social impact of stone quarrying activity

Quarrying is economically important in South Africa and has been around ever since historical times (Maggs, 1976; Koruyan *et al.*, 2012). However, despite its popularity, profitability and contribution to economic development, some negative impacts have been noticed (Lameed & Ayodele, 2010). All over the world, quarrying mines have improved into an industry that can provide services to local communities and better management in their efforts to reduce the effects of quarrying risks on their surroundings (Koruyan *et al.*, 2012; Al-Otaibi *et al.,* 2018). Community involvement in economic development programs has resolved conflicts between quarrying mines and the local community, and these programs involved additional educational facilities, infrastructure, and environmental management (Lameed & Ayodele, 2010). Company-community conflicts have arisen because, in most cases, quarrying projects are planned without incorporation of local community aspirations and involvement, which has led to disputes over environmental management, water resources, land use and benefits (Vanclay *et al.,* 2015). Quarrying mines are involved in the destruction of the habitat, including the environmental impacts such as changes to ground and surface water, the surrounding community, and the environment.

Communities neighbouring the quarry mines are more exposed to factors and destruction caused by quarrying activities than those located far away. The local communities face different major challenges with quarrying mines, despite the positive local and national economic impacts (Afeni & Adeogun, 2015). In cases where mining companies turn to neglect or do not involve the community in the development programs that are in place to enhance the locals' living standards where they operate, the neighbouring communities usually face real rather than the perceived impacts caused by mines. However, a study by (Bewiadzi *et al.*, 2018) showed that even though quarrying activities negatively impact the environment, it is the main source of livelihood in many local communities who work in these quarrying mines directly or indirectly. This indicates a need for the best ways in which communities and mining companies can co-exist under a safe ecosystem with minimum negative environmental impacts, need to be explored.

The first step towards achieving that ecosystem would be to establish the levels of awareness of the benefits and impacts of mining activities among local communities and especially those employed by quarrying mines (Melodi, 2017b). Results from previous studies indicated that when both residents and staff are aware of the impact caused by the quarrying mine on the environment, efforts are made to reduce them by both government and quarrying companies (see Table 2.1 below).

Table 2. 1 Environmental effect of mining operations

	Respondents		Chi-square	p-value
	Resident	Staff		
Land degradation				
Yes	36	35	3.038	0.081
No	6	13		
Water pollution				
Yes	22	33	2.526	0.112
No	20	15		
Air pollution				
Yes	22	35	4.068	0.044
No	20	13		
Noise pollution				
Yes	28	43	7.064	0.008
No	14	5		
Other effects				
Yes	0	1	0.885	0.347
No	42	47		
Any governmental or company attempts to reduce the impact?				
Yes	17	37	11.758	0.001
No	14	11		

Adapted from:(Melodi, 2017b)

Commonly quarrying mines are in remote areas, where most locals lack the skills required to operate the modern complex mining equipment (Melodi, 2017b). This has resulted in high-paying jobs being given to the export labour force. This means local communities neighbouring mines remain at the lower end of the development spectrum. Studies have shown that formal education background influences the ability of the local communities to benefit from mine's community development programs (Afeni & Adeogun, 2015; Bewiadzi *et al.*, 2018). People from far away from the operation site (as opposed to the local communities), often get the benefits such as bursaries and funding; this is based on the lack of infrastructure development such as additional schools to boost formal education in the rural community.

2.3 Potential environmental impacts of stone quarrying activities.

During the extraction of mineral rocks, the quarrying activities produce dust and waste materials, which contain chemical agents that settle on the land, plants, vegetation, and surface water (Lameed & Ayodele, 2010). This causes various negative impacts such as changes in water pH and poor growth in plants and vegetation. Furthermore, quarrying activities dislocate fertile soil disrupting the vegetation cover, which is vital for the well-being of the habitat and the survival of the animals (Sayara, 2016; Sayara *et al.*, 2016). The chemical content of dust depends on the type of rocks mined, and certain chemicals may cause stunted growth in plants and affect water quality (Nagajyoti *et al.*, 2010). Given that quarrying involves the use of heavy machinery and explosives to extract minerals, these processes are inevitably associated with air pollution, noise pollution, and significant damage to biodiversity (Sayara *et al.*, 2016). The destruction of habitat linked to water and soil has been associated with a significant impact on the growth and reproductive performance of domestic and wild animals in areas surrounding the quarrying mines (Lameed & Ayodele, 2010). Studies point out that animals are affected by quarrying activities through the directly disrupting of water, soil, and vegetation that support these animals (Bewiadzi *et al.*, 2018). Common environmental impacts are caused by different mining activities. Table 2.2 indicates the different environmental impacts of open cast mining, dust and noise are the most common in several activities involved (Muntingh, 2011).

Table 2. 2 Potential environmental impacts from mining activities

Activity	**Environmental impacts**
Mineral extraction	Soil erosion
	Habitat and vegetation destruction
	Change in land use
	Impacts on water table
	Dust
	Aesthetics
Transportation	Dust
	Noise pollution
	Soil contamination
	Oil and fuel spills
	Gas emissions

Adapted from: (Muntingh, 2011)

2.3.1 Water quality

The fundamental key to a mining project is water resources, as it is needed for almost every mining process, and this has led to a significant impact on water resources surrounding the mining site. Water quality and availability are in question, whether it will be enough to support life surrounding quarrying sites. Several factors affect water quality around the quarrying sites, such as pH, minerals, microbial, temperature, and total dissolved solids [TDS] (Umar *et al.*, 2014a). Organic and inorganic matter are the major pollutants of natural water sources; these organic and inorganic matters affect the availability and quality of water in different ways, where most of the inorganic matter influences water quality. Kumar (2017) indicates that the quarrying industry destroys the local environment and affects the quality of ground and surface water. Removal of vegetation and soil during the extraction of rocks has been viewed as a significant factor contributing to water pollution in areas surrounding quarrying mines. This may lead to soil erosions causing storm water runoff (Kalu & Ogbonna, 2019). Kumar (2017) indicates that minerals from rocks exposed during the blasting operations have chemical elements that can alter water quality around the quarrying site.

The removal of vegetation increases the rate of contaminated storm water runoff down to nearby streams, thus decreasing water quality down-stream. The physicochemical properties of water closer to the quarrying mine are more compromised compared to much further away from the quarrying mine (MA *et al.*, 2018; Kalu & Ogbonna, 2019). This study shows that quarrying activities affect water quality close to the quarry, and the effect diminishes when moving away from the quarrying site. Water quality plays a pivotal role in animal performance. There is evidence that poor water quality does not only alter animal health, resulting in poor growth and performance but also reduces water intake (Umar *et al.*, 2014a). Given that water intake is directly proportional to food intake, contaminated water will result in low water intake by livestock, thus low food intake will decrease animal performance (Umar *et al.*, 2014b; Mdletshe *et al.*, 2017)

2.3.2 Heavy metals

Quarries around the world have been associated with environmental and heavy metals pollution. Heavy metals are elements with high density, and some are toxic even in low quantities (Sonone *et al.*, 2020). Heavy metals are present in the environment but have low nontoxic quantities. However, certain activities by humans in search of economic benefit in the environment increase the presence of these metals in high quantities (Shozi, 2015; Tiimub

& Maxwell, 2015). Some metals are essential for body metabolism but toxic at high concentrations, such as iron (Fe) and manganese (Mn). Heavy metals can enter the body via food, drinking water, and air (Koréneková *et al.*, 2002; Raikwar *et al.*, 2008; Kalu & Ogbonna, 2019). The toxicity in animals depends on the length of exposure, dose, and animal species. Environmental contamination by heavy metals is becoming a threat to animals dwelling in areas surrounding the quarrying mines. Research has indicated that animals in the close vicinity to the quarrying mines tend to be exposed to acute doses of chronic heavy metal toxicity that results in dysfunction of the reproductive system and the overall health of the animals (Guvvala *et al.*, 2020).

2.3.3 Noise pollution

Noise pollution due to quarrying activities in areas surrounding quarry mines depends on several factors that determine the degree of the impact and how far the sounds travel, factors such as climate, source of the sound, land use, distance, and topography (Lameed & Ayodele, 2010). Noise pollution mainly affects animal behaviour, which results in the extinction of certain animal species due to increased anthropogenic noise. There is evidence that noise could affect grazing behaviour, sleeping behaviour, and habitat use and causes vigilance that affects the metabolic rate which is crucial to animal health (Radford *et al.* (2012). Quarrying activities during the day may affect day-active more than night-active animals and noise pollution can also interfere with animal communications, where predators follow sounds to hunt for prey (MA *et al.*, 2018; Berger-Tal *et al.*, 2019). Animal populations depend on successful reproduction for their fitness. Noise pollution affects mating processes and has been shown to result in abortions, thus affecting animal survival (Yeboah, 2008). Blasting operations, crushing, and heavy machinery movement generates noise that significantly impacts the surrounding area. Noise stress has been identified to negatively influence weight gain and food intake in animals (Brouček, 2014). Noise pollution has been noted to affect the reproduction and development of the foetus directly through sound waves or indirectly where the sound affects the pregnant female (Kight & Swaddle, 2011). Moreover, some animal tends to be more vigilance which decreases time spend foraging, thus a decrease in body weight is seen in the animals under noise stress. Noise affects a wide range of animal groups but the effects may differ from species to species among the same taxonomic group (Kunc & Schmidt, 2019). In a long-term noisy environment, permanent animals in the area tend to adapt and change their communication to overcome the noise, animals do this by increasing or decreasing the amplitude of vocal output (Berger-Tal *et al.*, 2019). However, this does not justify the effect of noise pollution on animals that cannot adapt or relocate, whose population is diminishing, and some go to extinction.

The noise pollution largely depends on the distance from the source, more concentrated closer to the source. Research on the effect of noise levels in relation to distance indicates that noise intensity decrease with distance (Menkiti & Ekott, 2014). Meaning that the wildlife and communities closer to the mine will be more affected than those further away from the mine. However, the long-term effect is felt more by permanent residents. In the case of wildlife and the local community, wildlife can migrate to less noisy places but that is not possible for community members which are permanent in the area (Afeni & Osasan, 2009). Hence more measures are needed to protect local communities from noise pollution.

2.3.4 Air pollution

Air pollution caused by quarrying can disrupt plants (vegetation cover), which are the main component of the ecosystem, maintaining the balance of oxygen and carbon dioxide through photosynthesis. Studies have indicated the extinction of plants in the areas surrounding the quarrying mine (Lameed & Ayodele, 2010; Sayara, 2016). During quarrying, dust is produced, causing air pollution during windy seasons; lots of dust is blown away from the site, during transportation affecting a wide range of areas neighbouring the quarry (Kumar, 2017; Endalew, 2019). Quarries produce dust that is carried out to the atmosphere over long distances by wind settling on surfaces, and the chemical content causes negative impacts where the dust settles. Surface water is most likely contaminated by dust pollution, and chemicals containing dust can change water quality, making it unsuitable for plants and animals (Lameed & Ayodele, 2010; Kumar, 2017). Quarrying dust results from blasting, excavation, drilling, transportation, and crushing. However, the amount of dust produced depends on environmental conditions, and the negative impact decreases as you move away from the quarrying site (Langer, 2001; Sayara *et al.*, 2016). Moisture, ambient air, wind speed, and the actual type of rock being mined determine the factors of dust's impact on the environment. A study by Sayara *et al.* (2016) indicated that high dust concentration and dust chemical content could eliminate vegetation cover and plants in a habitat leading to soil erosions. Proper dust management by quarrying mines must protect the environment and habitat surrounding the quarrying site and rehabilitate areas after project completion. Quarrying activities most likely produce dust with a diameter of 1 – 75 μm (micron) and which is most lately inhaled by animals and people dwelling in the surrounding areas (Nartey *et al.*, 2012; Sayara, 2016). Inhalable dust particles are less than 10 μm and can cause lung diseases in animal life surrounding the quarry and are lighter in weight, enabling them to stay in the atmosphere for a longer time and travel far from the source.

2.4 The use of camera traps to study wildlife and habitat use.

Human-wildlife conflicts continue to rise, and human activities in search of prosperities causing habitat loss and isolating wildlife areas have been noted in many parts of Africa (Spies, 2015). Keeping the balance between the ever-growing human population and wildlife is critical, which requires a better understating of the ecological needs and dwellers. Studies aimed at evaluating methods such as the transect method, unmanned aerial vehicles, and camera traps for monitoring wildlife, have shown that camera traps produced more accurate and precise results and could be used to study the most elusive wild animals without disturbing the habitat (Rahman & Rahman, 2021). Camera trapping methods has been regarded as the most cost effective and non-invasive in ecological studies. This method is used in quantifying animal activities and behaviour, and In recent years remote-sensing camera traps have become increasingly popular (Amin *et al.*, 2016). Camera trapping was used in this study to evaluate the impact of quarrying activities on habitat use by antelopes in the study area.

2.5 Ashburton quarry

Ashburton quarry is one of the leading black empowered groups with their main business and core competence being in open pit mining construction aggregates. It has been listed within the ‘Construction and Materials’ sector of the JSE Main Board since 2006. The group supplies a broad range of products ranging from construction materials (aggregates, bricks, blocks, pavers and ready-mix concrete), industrial minerals (lime and lime products) to bulk commodities (iron ore, anthracite and manganese).

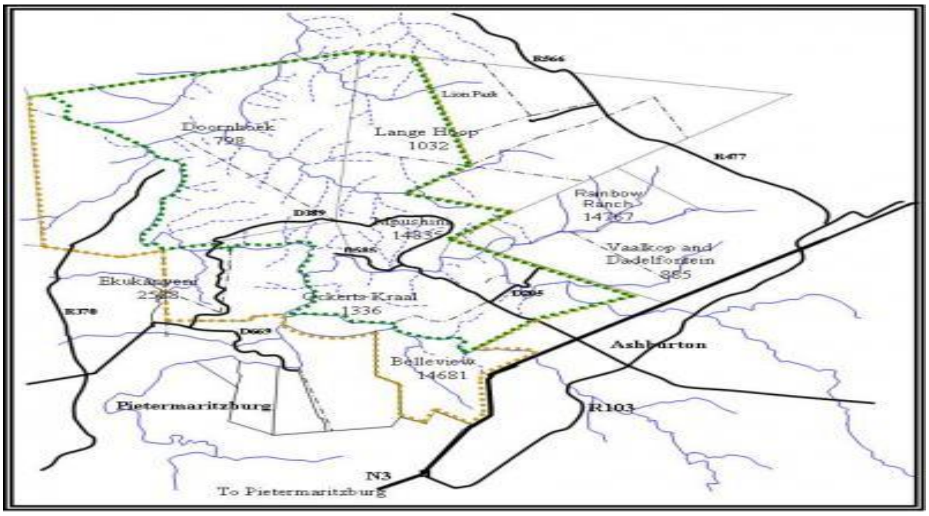
Figure 2. 1 Diagram representing the quarrying mine with its surrounding, perennial river, nonperennial river and roads**.**

Ashburton Quarry is located about 17 minutes' drive (14km) from Pietermaritzburg city centre via N3, KwaZulu Natal (29° 39′ 57.6″ S, 30° 27′ 14.4″ E). The quarry obtained its mining rights in 2007 to operate in the area, the group owns about 84 hectares of the Lower Mpushini land. The land is shared with landowners of the Lower Mpushini Valley community, which is registered under a protected area. The quarry`s property is not fenced this is due to the decision made to allow free movement of wildlife that is found in the conservancy. Figure 2.1 shows the quarrying site, with its surrounding habitat, Perennial and nonperennial rivers, and the roads crossing through the quarry property.

2.6 Lower Mpushini Valley Conservancy and its community

Ashburton community is under the Msunduzi local municipality of uMgungundlovu district in the KwaZulu-Natal (KZN) province of South Africa. The uMgungundlovu district is situated in the KwaZulu-Natal midlands. The community is comprised of mixed races black

African, White, Coloured, and Indian/Asian. Lower Mpushini community is under the protected natural area known as Lower Mpushini Valley Conservancy. The current study focuses on the Lower Mpushini Valley community and it located about 12km via N3 road from Pietermaritzburg city centre, KwaZulu Natal. The Conservancy is a nature-protected area, with community members as custodians of the land and it is registered with KZN Ezemvelo Wildlife under protected nature conservancy. Landowners pride themselves on the area and are actively involved in conserving their precious natural environment.



Source: Lower Mpushini Valley Conservancy website (https://ecofocus.page.tl/).

The Valley consists of steep hillsides with drainage ravines that flow into the Mpushini River that passes through the Conservancy giving life to the wildlife species such as Antelopes, birds, reptiles, amphibian etc in the area. Mpushini River joins the Msunduzi River which is the main river at the end of the conservancy. The terrain is rugged and the vegetation ranges from dense valley bushveld, with *Acacia* trees dominating the valley. The Conservancy is rich in plant, bird and animal biodiversity. This biodiversity is supported by the sufficient rainfall in the Pietermaritzburg region of 966 mm per year with the lowest rainfall in the middle of the year at about 23 mm and peaks at the beginning of the year to an average of 140 mm.

2.7 Conclusion

Human activities searching for economic benefit have caused drastic environmental impacts, dislocated many rural communities in Africa, and caused an extinction of many indigenous animals and plants. Mining is one activity that contributes significantly to economic development and has a significant social influence on the local community, creating jobs and generating revenue for the country and communities. However, the negative impacts caused by these mining activities sometimes outweigh the economic benefits, resulting in contradicting opinions regarding their activities in rural communities. There is a need for precise planning and management by the quarrying mines to minimise negative environmental impact and enhance the local community's livelihood.

CHAPTER 3

PERCEPTIONS OF COMMUNAL RESIDENTS TOWARDS THE QUARRYING ACTIVITIES AND WELFARE OF ANIMALS

3.1 Introduction

Although quarrying mines have a considerable contribution to the South African economy based on the production and exports of building materials. However, it should be considered that they also have an adverse impact on the environment and the living standards of the people, especially those who reside in the neighbouring areas where these mines are situated (Muntingh, 2011). The existence of these mines has a potential to transform land use, where farming lands or natural landscapes can be degraded. This has been seen as a challenge whereby there are rising conflicts between communities and quarrying mines around Africa, as many of the rural communities in Africa still depend on farming for a living (Muntingh, 2011; Bewiadzi *et al.*, 2018). At times the economic benefits of these mines outweigh the costs to the environment and livelihoods of the local community (Melodi, 2017a). The majority of the individuals who reside in neighbouring communities to the quarrying mines still live below the poverty datum line with no infrastructure for community development(Sisimayi, 2015) (ref).

Animals and their habitat in the quarry's vicinity suffer the negative impacts imposed by quarrying mines (Bewiadzi *et al.*, 2018). Quarrying activities involve using heavy machinery to move raw materials, explosives during the extraction of mineral rocks, drilling and crushing. All these activities impact animals and habitat use directly and negatively, where noise can interfere with animal vocal communication, and sleeping patterns resulting in elevated stress levels among animals (Berger-Tal *et al.*, 2019). Dust pollution has a potential to cause lung diseases in animals and people that are residing in the surrounding areas

(Dontala *et al.*, 2015) . In this manner, animal welfare and human well-being are violated. In addition, this can impair growth in animals, leading to the extinction of indigenous plants and animals.

The socio-demographic background is important when studying the impacts of the quarrying mines on community livelihoods and the environment (Bewiadzi *et al.*, 2018). Age, sex, and education play a vital role in individual awareness of the quarrying impacts and their involvement in quarrying activities. Kativu & Oskarsson (2021) highlighted that educated people turn to have more awareness and better understand the negative impacts caused by quarrying mines in their community.

This study was aimed at evaluating community perceptions of quarrying activities on the environment, community wellbeing, and habitat use by animals in the area surrounding the quarrying mine. Muntingh (2011) emphasized that mining companies tend to make decisions on behalf of the surrounding communities without any proper research and involvement of the community. However, this chapter adopts the approach of hearing the voices of the community with regards to the issues that concern them based on face-to-face interviews.

The hypothesis for this chapter states that the community closer to the quarrying mine has negative perceptions towards quarrying activities, compared to those further away from the mining activities.

3.2 Methods and materials

3.2.1 Study site

The community perceptions of quarrying activities were conducted in the Ashburton Lower Mpushini valley community (S 29° 39′ 57.6″, E 30° 27′ 14.4″). Ashburton is under the Msunduzi municipality of the uMgungundlovu district in the KwaZulu-Natal Province of South Africa. The lower Mpushini Valley area under this study investigation consists of 18 landowners and is situated in the protected nature conservancy with free-roaming wildlife. The community is part of the nature conservancy and practices crop and livestock farming. The Conservancy is rich in plant, bird, and animal diversity. This biodiversity is supported by the sufficient rainfall in the Pietermaritzburg region of 966 mm per year with the lowest rainfall in the middle of the year at about 23 mm and peaks at the beginning of the year to an average of 140 mm (Le Maitre *et al.*, 2018).

3.2.1 Measurements

The study was based on a qualitative research design. Community members were interviewed to gather their perceptions of quarrying activities on the environment, animals' welfare, and wellbeing of the community. To gather information on the impact of the quarrying activities, interviews were conducted with the communal residents who reside in the surrounding area.

Qualitative data collection of community members' perceptions was conducted using a semi-structured interview guide and recorded using audio recording devices. Prior to data collection, the primary investigator tested the interview guide to determine the feasibility of the questions being asked to participants by conducting pre-test interview with honours student. The communication with respondents was done in the vernacular (Zulu) and English languages. Interviews were carried out with "key informants" and with ordinary community members based on the distance of the local community from the quarry Reponses were not restricted to the interview question only to elicit as many other details as possible.

The researcher was responsible for collecting data, recording device was used to record responses from the respondent. Community members were interviewed at their homesteads on a door-to-door approach. The interview consisted of both open and closed questions. The semi-structured interview guide (Appendix 1) captured demographic profiles, and perceptions of quarrying activities on environmental impacts, animals and blasting operations. Each interview took an average 30 minutes and participants were given the freedom to express additional views and comments. The anonymity was ensured by not mentioning names of the participants on the voice recording and no names were recorded on the consent forms.

The community perception of quarrying activities and the impacts of these activities on the surrounding environment were divided into two sections (A and B) for qualitative data collection. Section A collected the demography of the participants and factors that can influence the participant's response to the key questions and section B investigated the perception of quarrying impacts on the environment, community and animals surrounding the quarrying mine and thematic analysis was done. Local people are the key informants in terms of their surrounding community and have a better understanding of the quarrying effect on their lives.

Selection of respondents

The study used a combination of random and stratified sampling methods. The respondents were divided into two categories, those who reside closer to the quarrying site and further away (>1km) from the quarrying site. Respondents included community leaders (custodians of nature conservancy), ordinary community members and quarry staff members. The lower Mpushini Valley community consist of about 18 landowners. A total of nine respondents representing a total of 18 landowners of the sampled area were randomly selected and interviewed based on their availability, and appointments with participants were made before the interviews.

Ethical considerations.

Ethical permission to conduct the interviews was obtained from the Humanities and Social Sciences Ethics Committee of the University of KwaZulu-Natal (certificate no: HSSREC/00003330/2021). The purpose of the survey was first explained to the respondents who demonstrated interest to participate in the study. Consent form that assures confidentiality were issued for the participant to sign before the interviews.

3.2.2 Experimental design and Statistical analysis

Qualitative data processing and data quality control were performed, and thematic analysis was used to label the questions and statements. A total of the nine respondents who agreed to participate in the survey, four respondents who represented the community from the nature conservancy, four from ordinary community members, and one from the quarrying mine (Quarry Manager). This was done to determine variations in responses regarding mining effects on the local community by distance from the mine.

3.3 Results

3.3.1 Demography characteristics results of the neighbouring community.

The characteristics of the respondents who participated in the survey are presented in Table 3.1. The demography results indicate the imbalance distribution of the participant's characteristics. Most of the participants were of age >55 (Table 3.1) which is an indicator of the life experience linked with the understanding of the community. The majority (89%) of the participants have been residents of the community for >15 years. Demographic results indicate that even though both males and females of the community may be affected by the quarrying activities, however, females are more involved in community activities. However, the majority of the residents from Lower Mpushini community shown to be more educated with 66.7% of the participants representing tertiary and 33.3% having obtained high school level of education (Table 3.1).

Table 3. 1 Demographic characteristic of the study participants

Characteristics	Frequency	Percentage (%)
Age		
25 – 35	1	11.1
35 - 45	1	11.1
45 – 55	2	22.2
>55	5	55.6
Gender		
Male	3	33.3
Female	6	66.7
Level of education		
High school	3	33.3
Tertiary	6	66.7
Years of residence (years)		
5 – 10	1	11.1
> 15	8	88.9
Population group		
Black	1	11.1
White	8	88.8

3.3.2 Quarrying impacts on environment, community, and animals

Theme 1: The question on the history of the nature conservancy and the relationship with the quarrying mine was directed only at the key informants of the nature conservancy as it was assumed that these individuals will have more knowledge:

> *Key informant (group 1)* – According to the information that was gather, the nature conservancy started in 1979 at Lion Park in the Umlaas Road area. The development pressure of the area and the opening of the quarrying mine was the main reason that kick-started the nature conservancy at the Lower Mpushini Valley area.
>
> The quarry was opened in 1984 and closed by the initial owners in 2001 and the quarry was closed for 3 to 4 years. The key informant (group 1) indicated that there was no form of the land rehabilitation process and no end-of-use project done to benefit the community by the initial owners.
>
> The current owners took over in 2005 and obtained the mining right in 2007. The nature conservancy is part of the South Africa biodiversity stewardship program, and that status was awarded in 2011. The lower Mpushini nature conservancy is located on 3000 hectares and was established in 2003. The protected area consists of about 25 landowners.

What is the relationship between the quarrying mine and the neighbouring community?

> *Key informants (group 1 and 2)* – The community is on fairly good terms with the quarrying mine, as the quarry has committed to meeting the community's demands. However, part of the community does not want the quarry operating in their nature conservancy.

Theme 2: Perceptions towards the quarrying impacts on community and environment, the questions focus on factors that can influence the response of the participants.

Any family member working for the quarrying mine and nature conservancy?

Key informant (group 1 and 2) – In this group, there were no family member working in the quarrying mine

Key informant (group 3) – This group indicated that no community members from Lower Mpushini Valley are working for the quarry. However, most of the staff members are from the local municipality.

Key informant (group 1 and 2) – Yes, there is a family member working for the nature conservancy. However, work at the nature conservancy is based on volunteering work, only one security guard work for the nature conservancy on a pay roll under the quarry.

Any positive contribution by the quarrying mine to the community?

Key informants (group 1, 2 and 3) - Participants from all three groups indicated that there were some issues resolved by the current owners as compared to previous owners, and the quarry has contributed to community projects such as contribution to Ashburton primary school, employment of one security guard for nature conservancy, and elimination of invasive plants along the river.

Key informant (group 1 and 2) – According to this set of respondents, there is no positive contribution done by the quarry to the community.

Key informant (group 2) – According to this set of respondents, the community of Lower Mpushini is divided into two sections, the upper section on the eastside of the nature conservancy up the hill and the lower side downhill. From the interview, it was reported that the eastside does not receive any benefits or infrastructure development from the quarry.

The question on water availability and quality was directed to all three groups to mostly identify the source of water for each organisation and wastewater management by the quarrying mine.

Key informant (group 1 and 2) – From the interviews, it was reported that the community receives water from four different sources namely from the municipality, the quarry mine, the borehole and the Rainbow company which is located within the community. It was further reported that the quarry does provide water to some community members but not all.

Community members that are close proximately with the quarry previously received water from the quarrying mine. However, the quarry stopped supplying water to some of the members after the community protested. The main reason for the protest revolved around an unscheduled blasting by the quarrying mine and the blasting levels.

Key informant (group 3) – The report from this group revealed that the quarry mine has two water sources, portable water from the Municipality used for drinking and ablution facilities. The rainwater which accumulates from the bottom of the pit – normally used for dust suppression and road wetting.

Wastewater and storm water management, the question directed to the key informant group 3.

Key informant (group 3) - From the interview, it was reported that the quarry has septic tanks for wastewater treatment. Most of the wastewater identified by the quarry is due to flash floods. The group indicated that, the storm water runoff proves to be a challenge to control due to the geographic location of the quarry, and the gradient causing runoff to the river. The measure taken; is that the quarry created tunnels to direct storm water to the bottom of the pit and has a silt trap on site that filters water runoff before flows into the river. However, when there is excessive rain the silt trap is not sufficient to filter the water before leaving the site.

Figure 3. 1 The silt trap built on site to filter storm water runoff from the quarry to the nearby perennial river.

Key informant (group 3) – The report from this group revealed that the open pit has not been overflown in recent years, and the quarry is addressing the possibility of pit overflow due to flash floods to prevent runoff to the river.

Theme 3: The impacts of quarrying activities on domesticated and wild animals. The question on the abundance of wild animals aimed at identifying whether the quarrying activities affect the wellbeing of animals.

Key informant (group 1 and 2) – Its was reported that previously, there were a lot of animals which dominated around the area, especially antelopes which were observed to be the main dominating species. However, in the recent years, low numbers have been observed. However, there is no conclusive evidence that the disappearance is due to quarrying activities alone and the development pressure of the area has contributed.

Key informant (group 2) – From the interview, it was reported that there was a decline in the antelope population in the area compared to past years. The assumption is that the decline may be due to several factors such as poaching, traffic, and area development not solely on quarrying activities.

Key informant (group 2) – This group indicated that there have been no changes in antelope visibility and population compared to the past. Based on our knowledge and observations the quarry has no impact on animal.

Question on based on animals' movements in the nature conservancy, any obstacles blocking animal movement/migration in the area due to quarrying?

Key informants (group 1, 2 and 3) – From the interview, this group indicated that the quarrying activities have an impact on antelope migration due to truck traffic in and out of the quarry, and the increase in area development comes with more people which affect the antelope's movement.

Key informant (group 1) - An increase in human presence and traffic in the area has resulted in less ability to keep the area in control as a nature conservancy.

Death of antelopes due to the quarrying activities

Key informant (group 1, 2 and 3) – All three groups indicated that there is no death of animals due to quarrying activities.

The question focused on group 1 and 2 to identify the impacts of quarrying activities on domesticated animals such as cats, dogs, and livestock.

Key informants (group 1 and 2) – From the interview, the participants from this group indicated that the quarrying activities have some negative impacts on domesticated animals, with the behavioural changes being the most noticeable. As there are behavioural changes such as sudden running and jumping of horses during the blasting which causes vibrations to have been observed.

Key informant (group 2) – According to their observations, the quarry has no effects on welfare of domesticated animals in the homestead. Adaptation plays a crucial role in animals' reactions to quarrying activities during the blasting. Horses will suddenly stop feeding and lift their head when the blast goes off and continue feeding shortly after.

Key informants (group 1) – This group indicated that dogs show signs of distress when the siren goes off and after the blasting operation.

Key informants (group 1 and group 3) – They believe that the quarry mine does not have risk management in place for animals in the area during blasting.

Theme 4: The question is set to evaluate the operation methods used by the quarrying mine to extract raw material. Does the operation method impact the environment, regarding dust, noise, and water pollution?

Key informants (group 1, 2 and 3) – From the participants, the quarrying does impact the environment, there are determining factors to the scale of impacts such as seasons, rain, wind speed and direction.

Key informant (group 3) – indicated that there is the environmental impact caused by the operation methods, as there will not be earth movement without the destruction of the environment.

The impacts of quarrying activities on noise pollution.

Key informants (group 1, 2, and 3) – All three groups indicated that noise pollution depend on the wind directions and speed. Noise pollution is more intense in dry seasons.

Key informants (group 1) – They indicated that noise pollution caused by the quarry is unbearable.

Key informants (group 2) – From the response, this group indicated that geographical positioning of the homestead plays a crucial role, as the noise level from the quarrying activities is bearable.

The impacts of quarrying activities on water pollution.

Key informant (group 1 and 2) –In the interview, this group indicated that water pollution is more visible during flash floods when compared to upstream from the quarrying mine, which may be due to storm water runoff from the quarry. The visibility of silt builds downstream which is caused by quarry unmanaged storm water runoff, as water runoff is not well managed by the quarry.

Key informant (group 2) – The participants indicated that there is no river pollution caused by the quarrying activities, as the quarry has put measures in place for storm water management.

The impacts of quarrying activities on air pollution.

Key informant (group 1) – Indicated that the quarry produce dust during working hours and blasting days. The wind speed and direction determine the severity of the impacts, in high wind speed dust travel distances. Dust is fairly well managed as the quarry has measures in place such as dust suppressors and do wet the roads with water to reduce the dust.

Key informant (group 1, 2 and 3) – They indicated that the dust is more intense in dry seasons and less intense in wet seasons. More dust has been observed during normal working hours compared to weekends or after operating hours.

Key informant (group 2) – From the interview, this group indicated that the quarry has no impact on the air pollution, the dust during blasting lasts for a few minutes after blasting and does not pollute far areas, and most of the dust affecting the household is from the community gravel road and it more intense in the dry season.

Key informant (group 3) – Indicated that more dust in dry seasons compare to wet seasons. However, on monitoring their measures are still below the limit. To combat the dust, in wet seasons more water is used to wet the roads in the quarry.

The quarry environmental management programs (EMPs). The question is to identify if the community is satisfied with the ways the quarry manages the environment they operate and whether the quarry has programs in place to manage the impacts on the environment.

Key informant (group 1) – Indicated that the quarry does not have a signed EMP in place, there were issues of mining footprint and blasting radius raised in the past. Their reports revealed that the blasting radius was shifted without public participation. Complaints have been presented to the quarry to improve their environmental management. However, there is an improvement in environmental management compared to the past years.

Key informants (group 1 and 2) – Reported that the EMP is not satisfying, as the quarry is operating right at the riverbank, which is questionable in terms of the programs that govern their operation.

Key informant (group 2) – Some participants from group 2 stated that the quarry's EMPs are up to date and the quarry has done more in ensuring less impact of their activities on the environment.

Key informants (group 3) – Indicated that the quarry has a system in place that monitor and manage environmental impacts in the quarry. The quarry has completed seven specialist studies which are part Environmental Impact Assessment (EIA) application, and the quarry is in the process of updating EMP.

The quarry does not hold a signed EMP on site and in the process of addressing the issue, the quarry anticipates completing public participation which is part of the EIA application process by end of October 2022 and submits to the Department of Mineral Resources and Energy (DMRE) by end of 2022.

Theme 5: Community engagement with the quarrying mine. Does the community participate in the decision making concerning environmental management and the community member's livelihoods?

Key informants (group 1 and 2) –Indicated that there is no public participation in decision making on issues concerning the community.

Key informants (group 2) – Some participants from the group 2 indicated that the community is involved in decision making concerning the environmental management and the wellbeing of the community.

Key informant (group 3) – Indicated that there is public participation concerning issues concerning community and environment management. The community and the quarry used to hold meetings twice a year to discuss any matter, which since has failed due to ongoing disputes. The quarry has initiated the establishment of an independent forum to look at matters concerning the community which was not successful. To address specific issues, meetings are arranged as the matter arises.

Blasting operations during extraction of raw material. Is the community notified about the scheduled blasting operation before the day of operation?

Key informants (group 1, 2 and 3) – Participants indicated that the community is notified by email about the blasting a week prior to the blasting day. There is a blasting notification WhatsApp group, and a message is sent to the community members close to the quarry a day before the blasting operation.

Key informant (group 2) – Some participants in group 2 indicated that the upper side households from the quarry do not receive a form of notification regarding the blasting operation.

Key informants (group 3) – Stated that the quarry mine is accessible from three roads, and all the roads passing through the quarry are closed during the blasting operation as means of limiting access and preventing any incident that may cause by the blast. The siren is put on for 3 minutes right before blasting time.

Dispute between the quarrying mine and the community members.

Key informants (group 1, 2 and 3) – From the interview, the participants indicated the there is a dispute between the quarrying and community members which has resulted in community division among those with the dispute and the other side without dispute with the quarry.

Key informant (group 1 and 2) – They indicated that the dispute is regarding the quarrying activities, blasting levels and vibration which results to property damage and issues concerning environmental management.

Any property damage caused by the quarrying activities, and any form of compensation to the affected community?

Key informants (group 1) – Indicated that there was property damage caused by the quarrying activities. However, a compensation settlement by the quarry to affected members was released. There were five affected members, one accepted the funds and four rejected the funds because the quarry issued the funds without accessing the individual damage to all affected members which was not fair as the damage was not the same to all members.

Key informant (group 2) – Stated that there was no property damage caused by the quarrying activities in the household, this may be due to the geographical location of the household.

Key informant (group 3) – Indicated that complaints were received concerning blasting operations damaging some of the community members' properties. The quarry investigated the claims involving all affected parties. The investigation indicated no scientific proof of the claims.

Based on the investigation, the quarry takes no responsibility for the property damage. The quarry decided to ease the tension between the community and the quarry with

the purpose to start an effective relationship, the quarry made funds available without taking any responsibility for the damage.

What has been done by both parties to resolve the dispute?

Key informant (group 1) – This group mentioned that both parties have attempted in resolving the dispute. However, core issues regarding the community and quarry have not been resolved. *Key informant (group 2)* –Stated that there is no effort by the quarry to resolve underlying issues raised by the community. *Key informant (group 2)* – Some participants from group 2 indicated that the quarry has attempted to resolve the issues raised by the community. However, some of the community members did not welcome the attempts resulting in the matter being left open for discussions. *Key informant (group 3)* – Indicated that quarry made funds available to resolve the dispute without taking responsibility. The funds were divided among five affected members, one member accepted the funds and the other four did not accept the offer, one member indicated the reason for not accepting the funds was that the offer was insufficient for the damage caused. However, the matter is still open for discussion.

3.4 Discussion

This chapter focuses on the community's perceptions of various aspects of quarrying activities and their impacts on the environment, community, and wellbeing of animals in the surrounding area. The results indicated mixed perceptions towards the impacts of quarrying activities in the area which was in contrast with the study hypothesis of negative perceptions of quarrying activities by the neighbouring community closer to the quarrying site. The community was divided into a side indicating negative perceptions and the other side indicating positive perceptions towards the quarrying activities in the area. These mixed perceptions can be attributed to the past dispute between the quarry and the community, which divided the community into two. The dispute was regarding the quarrying activities, blasting levels and vibration causing property damage and issues concerning environmental management.

Community and mining companies' conflicts are the result of unsatisfied community members about company management and activities (Wang *et al.*, 2016). Some factors that influence the positive or negative perceptions of the community members towards mining companies include but are not limited to public participation in decision making concerning the community, community employment, land use, resource distribution, and positive quarry contribution to community development (Kemp *et al.*, 2011). The conflicts are the results of disagreements between the two parties regarding issues which were discussed, but not mitigated to the point of explicit (Muntingh, 2011). The results of this study indicate that the dispute between the quarry and the community is due to land use and quarrying activities. The landowners indicated that the initial dispute was based on the blasting level and uncontrolled blasting from the quarry which was causing property damage and manifested into the issues of animal risk management by the quarry as is it located in the protected nature conservancy. Both parties have been in discussion regarding the disputes, and some issues have been resolved, with other issues still open for discussion to both parties.

3.4.1 Positive contribution to the community development

Community members indicated that the quarry has had two owners since starting in 1984, in which initial owners operated for five years before the present owners. On positive contributions to the community, the participants indicated that there has been improvement in terms of management and some issues resolved compared to previous owners. The quarry has provided a security guard to the nature conservancy to combat wildlife poaching, contributed to the local Primary school, and assisted in alien invasion plant elimination in the area. Half of the participants were not satisfied with what the quarry has done in the effort of positive contribution to the community, comparing what the quarry is taking out in their area in terms of revenue.

3.4.2 The impacts of quarrying activities on domestic and wild animals.

The major factor that affects antelopes may be the road that crosses through the nature conservancy, which results in traffic. Roads that were built through the nature reserve have been the focus of many researchers worldwide (Mkhohlwa, 2017). Roads contribute to factors affecting the wellbeing of animals, noise pollution affects the vocal communication of animals, interferes with their sleeping patterns and cuts migration patterns to a more suitable area for grazing (Dean *et al.*, 2019). The community indicated that the trucks in and out of the quarry cause more traffic which has affected the movement of animals. Road traffic is one of the common factors that threaten the survival of the fauna in most nature protected areas (Garriga *et al.*, 2012). The quarry introduced more people to the nature conservancy making it difficult to keep the area under control, as indicated by the community members. Also, the results indicated that most of the community members are concerned about the litter caused by truck drivers coming in and out of the quarry. On the domesticated animals such as dogs, cats, horses and livestock, the results show that most of the households are not involved in livestock farming. However, some members were involved in livestock farming in the past. Most of the community members have dogs and horses in the household. The results in regard to the impacts of the quarrying activities on domesticated animals indicate mixed perceptions where some members indicated that there are behavioural changes in dogs as they run and bark which are signs of stress after blasting. Some indicated that adaptation has played a role as there is no quarrying effect on domesticated animals.

3.4.3 The impacts of quarrying activities on the surrounding environment

The results indicated that most of the community members are aware of the quarrying impacts on the environment as there will be no earth moving without disturbance. The result indicated that noise and air pollution depend largely on seasons which determine wind speed and direction, and also on the geographical location of the household, as close households are affected more compared to those much further away. Continuous noise level decrease with the increase of distance from the source as well as the air pollution (Menkiti & Ekott, 2014). Households much further away from the quarry indicated that air pollution is mainly due to the gravel road which produces dust with the community traffic, not by the quarrying activities. Quarrying operations involve the use of heavy machinery and equipment which produced noise and vibrations (Sayara, 2016). However, blasting is the major cause of noise and vibrations, and households close to the quarry are more affected.

The difference in river water pollution was reported to be much more visible when comparing upstream and downstream from the quarrying site. Heavy rains and flash floods are the main causes of river water pollution due to water runoff into the river. The community indicated that the quarry is suited to the riverbank, thus less control of storm water runoff to the river causing pollution and silt build-up. The quarry is located on the riverbank about <50 metres from the river. A study done by the quarrying company to update their EMP in February 2021 revealed that the rivers and streams are generally well buffered from the quarry area except for a small section near the entrance where the silt trap is located. Storm water flows into the riverbanks as well as many areas where stockpiles and other material eroded into the valley below and subsequently into the river. The quarry manager indicated that due to the geographical positioning of the quarry it has been difficult to control storm water runoff. However, the quarry has invested in building silt traps to prevent silt build up in the river and dug tunnels that collect storm water to the bottom of the pit. The community in close proximity to the quarry is notified a week before the scheduled blasting day via email, and WhatsApp message a day before. However, the community indicated that this disrupts their daily route as they are not allowed to pass during the blasting. Other community members indicated that they do not receive communication about blasting, as the quarry considers them as much further away from the quarry. Some members' show that is not a good approach as they are part of the community.

3.5 Conclusion

The ever-changing environmental policies and demands have been the fuel to the company-community conflicts in most parts of the world. Mining companies need to adopt and adapt by becoming responsible and responsive corporates to minimise conflicts with communities and the public in general. In this study, the effect of quarrying activities was evaluated from the perspective of the neighbouring community. In comparison, views and perceptions from quarrying mine staff were not in line with those of the community members, and the community is divided in terms of perceptions. In conclusion, it is recommended that to save the company`s funds and the future of the business in the operation area, the quarrying mine needs to address issues in an open and sincere manner with the neighbouring community members.

CHAPTER 4

THE IMPACT OF QUARRYING ACTIVITIES ON THE QUALITY OF RIVER WATER USED AS A RESOURCE FOR ANIMALS AND RECREATIONAL ACTIVITIES BY THE COMMUNITY

4.1 Introduction

Quarrying mines use different methods in extracting rocks and minerals depending on the type of rocks targeted and the location of the minerals deposited in the earth's core, which determines the severity of the environmental impacts. Negative environmental impacts are expected as rock and minerals cannot be extracted without affecting the surrounding (Jones *et al.*, 2018; MA *et al.*, 2018). However, proper planning and management can assist to minimise the negative impacts caused by quarrying activities. Water is considered a significant component in balancing the ecosystem for all life on earth (Lameed & Ayodele, 2010).

Water is essential in sustaining life on earth (Umar *et al.*, 2014a) and is the key to social and economic development in the modern world. Water is an indispensable resource of all-natural resources, and is needed in all life forms (Ashton *et al.*, 2001). According to Melodi (2017a) quarrying mines contribute significantly to water pollution around the world. Quarrying is categorised into physical and ecological impacts on the environment (Devi & Rongmei, 2017). The physical impact alters the slope and morphology of the water channels and ecology when habitats and animal disturbances are lost (Elosegi *et al.*, 2010). Distance from the quarrying site determines the degree of environmental impacts caused by the quarrying mine. Studies have shown that water resources and soil close to the quarrying site were more affected by contamination than those situated further away from the quarrying site (MA *et al.*, 2018; Kalu & Ogbonna, 2019). Quarrying activities expose soil to erosions and contamination. Also expose plants and animals to heavy metals toxicity (Rabiu, 2022).

Water quality is defined by it biological, physical, and chemical parameters (Boyacioglu, 2007). The purpose of water quality analysis is performed to determine whether water meets pre-established standards for its intended use in comparison with existing guidelines. The Water Quality Index (WQI) was developed to make water quality measurements easier to understand. Indicators summarize water quality data, making it easier to report and draw conclusions about water quality (Boah *et al.*, 2015). This index classifies water into an ascending hierarchical schema of five classes and was adopted in this study to assess differences in water quality between open pit and river water. Hence the objective of the current study was to study the water quality of the river neighbouring the quarrying mine with the hypothesis that the quarrying activities do affect the quality of river water.

4.2 Methods and materials

4.2.1 Study site

The study was conducted in Ashburton Low Mpushini Valley stream located 15km from Pietermaritzburg city centre (29˚38ˈ15ˈˈS, 30˚28ˈ25ˈˈE). Ashburton community is under the uMsunduzi municipality of uMgungundlovu district in the KwaZulu-Natal Province of South Africa. The Mpushini river passes through the quarrying mine and nature conversancy which flows into the Msunduzi River.

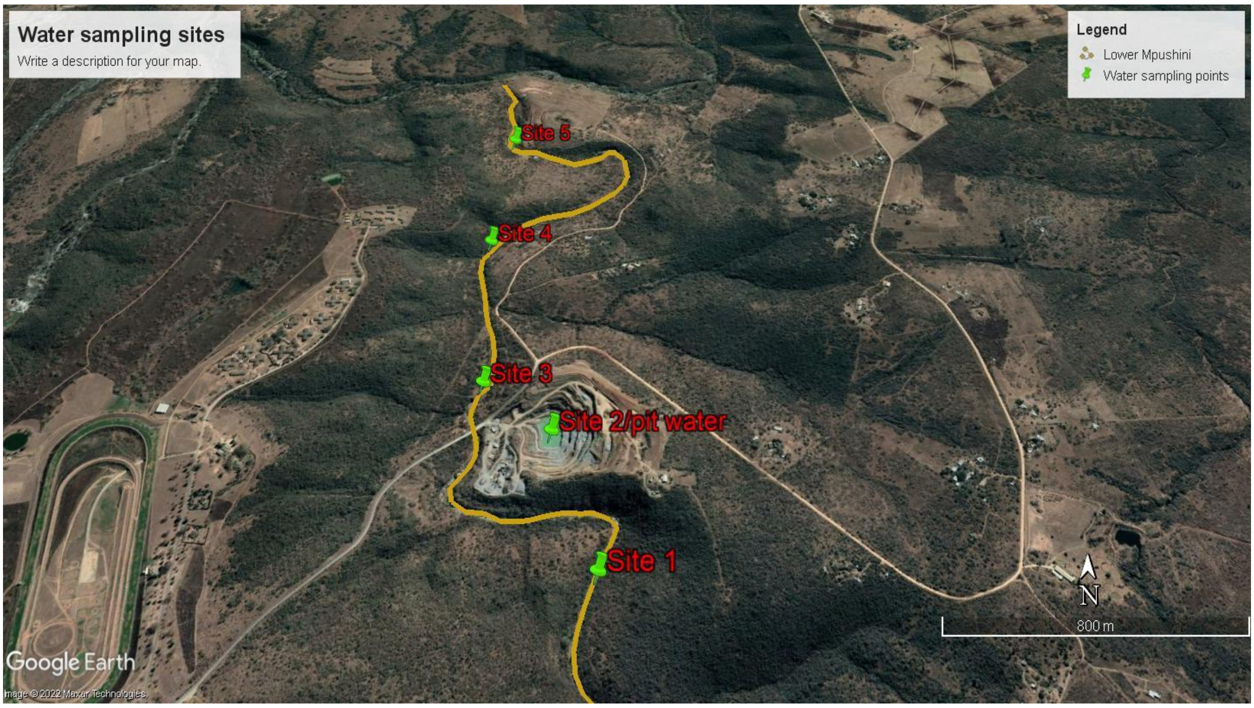


Figure 4. 1 The diagram represents the Lower Mpushini Valley Perennial River that passes through the quarrying site and the Pin marks indicate the water sampling site along the river.

4.2.2 Measurements

Water sampling were conducted along the river that passes by the Ashburton quarrying plant. The quarrying site was used as a referral point to differentiate between upstream and downstream. The sampling site was divided into, upstream and downstream as the distance from the quarry point increased, 1 kilometer upstream and 3 kilometers downstream from the quarrying point. Water samples for analysis were collected in a 250ml glass bottle which was thoroughly washed twice with the water to be sampled from September 2021 to May 2022. Four water samples were taken from different locations in the river, and one was taken from an open pit, for a total of five water samples. Initially, water (250ml) from the quarry pit was sampled and transported to the laboratory for analysing pH - hydrogen potential, Nitrate (as NO_3) and 32 Metals (Liquids) by ICP-MS. The results obtained were compared to South African national standards for drinking water (SANS241:, 2015). Elements exceeding the SANS241 limit were selected, and their presence traced from nearby rivers to determine whether the quarry discharges wastewater into nearby rivers or whether there is a correlation between quarry activity and river water quality. Ice cooler box was used to deliver samples to the laboratory for analysis. External laboratory was used for water analysis.

Buffer solution was used to calibrate electrode and radiometer of pH instrument to determine water pH. The samples were then homogenised and tested. An electrode was dipped in the water sample and pH was displayed on the meter, adopting method by (Seymour *et al.*, 2020). Dissolved metals were determined using an Agilent 7900 ICP-MS and tested against (SANS241:2015). Samples were filtered through 0.45 µm syringe filters into 15 mL vials and acidified with 1 drop of concentrated nitric acid (55%) using standard procedures (Yazbek *et al.*, 2020). NO3/NO2 combinations, NO2 and NO3, were measured using a Gallery Plus Discrete Analyser. Standard working solutions was used to fine-tune the used instrument. The samples were then homogenised, and an aliquot removed for testing. Addition of reagents and necessary dilutions were automated using standard procedures (Young *et al.,* 2005).

4.2.3 Experimental design and Statistical Analysis

A five-class Water Quality Index (WQI) categorization schema was adopted for this study. The schema is an increasing scale that is identical to the percentage hierarchy. The index values between 0 to 25 represent excellent quality; with 26 to 50 indicating good quality; 51 to 75 indicating poor quality, 76 to 100 indicating very poor quality, and above 100 unsuitable for consumption (Brown *et al.*, 1972).

4.3 Results and Discussion

The importance of water cannot be emphasized enough for animal health, and it is considered the most important nutrient vital to sustaining life on earth. Water Quality Index (WQI) of both upstream and downstream sampling had the same status of excellent water quality 4.81

and 6.54 respectively (Table 4.2). Thus, there was no indication that the quarrying activities have an impact on the river water quality. According to the current result river water quality meets (SANS241:2015) standards despite the quarry being suited to the banks of the river. The results from this study diverted from the initial hypothesis; that the quarrying activities do affect the quality of river water and the severity of negative impact depends on the distance from the quarrying point as the results from upstream show no significant difference from the furthest sampling point downstream 3.

Table 4. 1 Represents the calculation of Water Quality Index (WQI) of different sampling points against WQI status.

Sites	Index values	WQI status
Upstream	4.81	Excellent
Open pit	25.0	Excellent
Downstream 1	2.72	Excellent
Downstream 2	5.02	Excellent
Downstream 3	6.54	Excellent

Table 4.1 represents the WQI calculation with the water quality status of the different sampling points. The WQI was determined from different sampling points and compared with WQI standard method developed by (Brown & Forsythe, 1974). Water quality may be affected not only by quarrying activities but other human activities in the area upstream and downstream (Muma *et al.*, 2020). In this study, both upstream and downstream water quality

meets the national drinking standards, thus indicating no activities affecting water quality. In a previous research study that was launched by the quarry in February 2021 focussing on Lower Mpushini River, the results revealed that both from upstream and downstream from the quarrying site the river have low sediments. Which indicate the low impacts caused by quarrying activities to the river water.

Table 4.2 represents Mean, Standard deviation, and P-values of analysed elements on five sampling point against SANS241:2015 of dissolved Chromium (Cr), aluminium (Al), Cadmium (Cd), Arsenic (As), Lead (Pb), Mercury (Hg), Selenium (Se), Nitrate (NO3), Nickel (Ni), and pH at 25˚C. The results indicate no significant difference between upstream and downstream in terms of water acceptance for drinking (Table 4.2). The results indicated the average values of Al (5.41 µg/ℓ), As (0.39 µg/ℓ), Cd (0.00µg/ℓ), Cr (1.08µg/ℓ), Hg (0.13µg/ℓ), Ni (1.34µg/ℓ), Pb (0.25µg/ℓ), Se (0.17µg/ℓ), N (1.89mg/ℓ), and pH (7.27) upstream from the quarrying point were within acceptable standards for drinking (Table 4.2) and meet the excellent status of WQI (Table 4.1). Downstream, the average values of, As, Cd, Cr, Hg, Ni, Pb, Se, Al, NO_3, and pH were also within acceptable standards despite the quarrying activities in the area. The results from the open pit water sample indicated a 25.0 WQI status which is on the borderline between excellent and good water quality statuses (Table 4.1). However, there is a high level of Nitrate (25.3mg/ℓ) exceeding the South African standards of drinking water limit by 14.3mg/ℓ (Figure 4.2). There was a significant difference ($p \leq 0.05$) of NO_3 in the water quality analysis sampled from the open pit. From previous research facilitated by the quarry it was indicated that the high level of Nitrate may be due to the type of explosive (Sodium Nitrate HQ untreated) used during the extraction of the material.

Agricultural activities are amongst activities that increase levels of metal concentration in surface water (Mudenda, 2018). However, in this study field observation was conducted and the results showed no intensive agricultural activities in the study area, which justify the lower levels of metal concentration in upstream and downstream sampled water.

Table 4.2 indicates the standard average pH for drinking water (≥ 5 and ≤ 9.7) by SANS241: 2015. The results show that the water from the river at all sampling points was at acceptable standards for pH, with no significant difference as the distance increased along the flow direction.

Table 4. 2 Mean ± Standard deviation and P-values of analysed elements on five sampling point against SANS241:2015

Parameters	Sites					P-Values	SANS241:2015
	Open pit	Upstream	Downstream1	Downstream2	Downstream3		
Al (µg/ℓ)	9.30 ± 3.63	5.40 ± 3.06	5.20 ± 4.15	6.60 ± 3.55	8.20 ± 7.02	0.76	≤300
As (µg/ℓ)	0.12 ± 0.04	0.39 ± 0.16	0.40 ± 0.16	0.38 ± 0.10	0.37 ± 0.08	0.07	≤10
Cd (µg/ℓ)	0.01 ± 0.1	0.00 ± 0.00	0.00 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0.51	≤3
Cr (µg/ℓ)	1.84 ± 1.60	1.08 ± 0.93	1.60 ± 1.61	1.71 ± 1.96	1.55 ± 1.46	0.98	≤50
Hg (µg/ℓ)	0.30 ± 0.31	0.13 ± 0.11	0.13 ± 0.10	0.14 ± 0.10	0.14 ± 0.11	0.70	≤6
NO_3 (mg/ℓ)	25.3 ± 11.73^{a}	1.90 ± 1.47^{b}	1.20 ± 1.60^{b}	1.20 ± 1.60^{b}	1.80 ± 1.36^{b}	<.001	≤11
Ni (µg/ℓ)	0.60 ± 0.84	1.40 ± 0.30	1.56 ± 0.56	1.48 ± 0.80	1.38 ± 0.06	0.43	≤70
Pb (µg/ℓ)	0.29 ± 0.37	0.10 ± 0.13	0.07 ± 0.07	0.16 ± 0.09	0.13 ± 0.06	0.66	≤10
pH at 25˚C	7.56 ± 0.15	7.44 ± 0.13	7.10 ± 0.61	7.34 ± 0.44	7.46 ± 0.34	0.67	≥5 and ≥9.7
Se (µg/ℓ)	0.13 ± 0.03	0.09 ± 0.07	0.12 ±1.60	0.16 ± 0.05	0.11 ± 0.01	0.52	≤40

^{abc} Means in the same row for open pit, upstream, downstream1, downstream2 and downstream3 with the same superscripts are significantly different (p<0.05), Al – Aluminium, As – Arsenic, Cd – Cadmium, Cr- Chromium, Hg – Mercury, NO_3 – Nitrate, Ni – Nickel, Pb – Lead and Se – Selenium.

Results from Table 4.2 indicated high level of NO_3 concentrate in the open pit compared to the four sampling points from the river (table 4.2). In a study that was conducted by Pant & Srivastava (2002) high NO_3 levels caused sperm abnormalities, low sperm counts, and sperm motility in male species, but these defects are pronounced at the 900 mg/L level.

The level of Arsenic in this study was at acceptable drinking levels and there were no significant differences observed ($p \geq 0.05$) between all sampling points (Table 4.2). High levels of Arsenic can result in low animal performance, and low immunity resulting in diseases (Roy *et al.*, 2013). However, in this study, there were no significant levels which may result in the low performance of animals utilising the river water in the area. Lead (Pb) is a well-documented heavy metal in animal and human health research due to its results of poisoning. In this study, its contents (Pb) were found to be within the acceptable drinking levels and there was no significant difference (Table 4.2) between all five sampling points. Lead can result in the dysfunction of testicles in humans and wildlife, and also, affect the renal, central nervous and reproductive systems (Vigeh *et al.*, 2011; Assi *et al.*, 2016). The severity of heavy metal impacts depends on the distance from the source, as the distance increase the impact decreases. Mercury was also at acceptable drinking standards and excellent water quality status in this study (Table 4.1) and there was no significant difference among all sampling points (Table 4.2). Mercury is used in the gold mining industry, more especially in small-scale gold mining to form the mercury-gold amalgam which is then heated to extract gold (Esdaile & Chalker, 2018). Mercury can collect in the body over time (bioaccumulation) and can cause poor neurological development in infants, and reproductive and embryonic defects (Bhan & Sarkar, 2005; Rice *et al.*, 2014). Selenium occurs naturally and is exposed to the surface through anthropological activities such as mining. Selenium is an essential element in small quantities to human and animal health but is harmful in large quantities (Dodig & ČEPELAK, 2004; Fordyce, 2013). In this study, Selenium was at acceptable drinking levels and excellent water quality status (Table 4.1) and there were no statistical differences among all sampling points (Table 4.2).

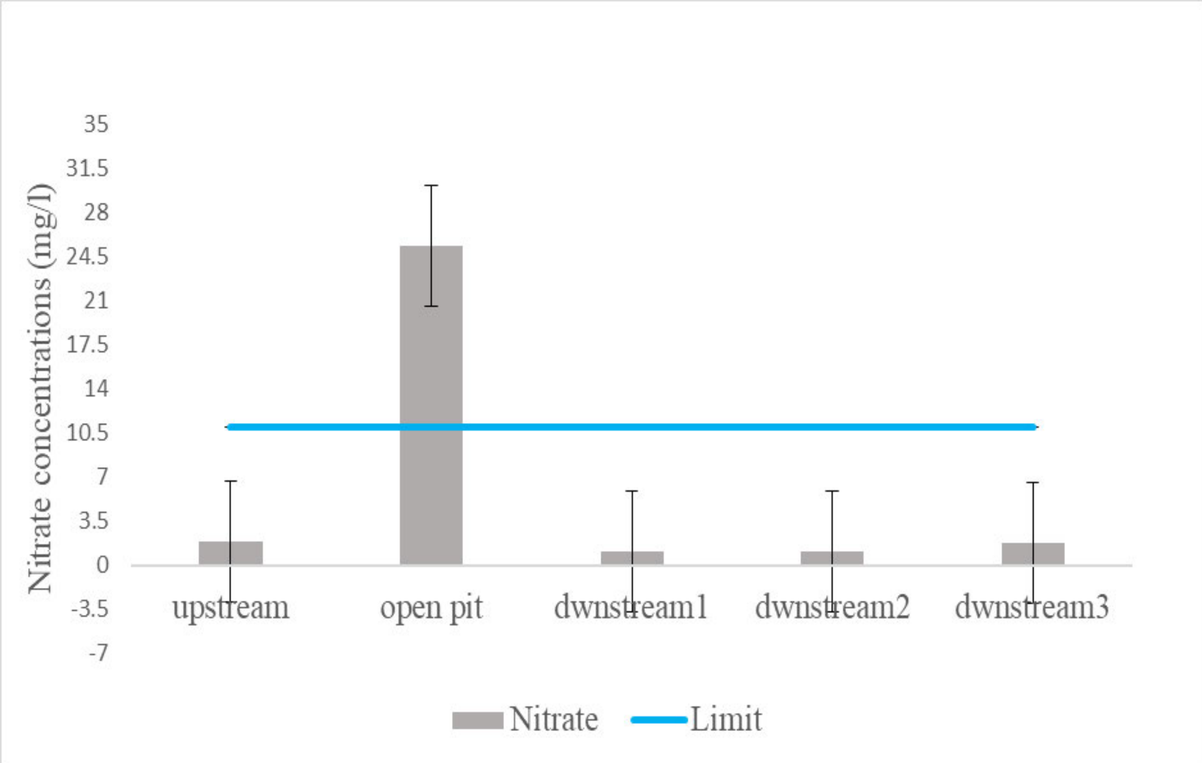


Figure 4. 2 Measured concentrations of Nitrate (NO3) (mg/l) in the upstream, open pit, downstream 1, downstream 2, and downstream 3 against the SANS241:2015 limit.

Field observation was conducted, and the results show that the quarrying mine sits approximately <50m from the riverbank measured at the closest point and the geographical position of the quarry is at the upper slope, allowing water runoff into the river during rainy seasons. The quarry has a silt trap in the direction of water runoff, to filter silt during flash floods. However, in the interview (Chapter 3) the quarry manager acknowledges that flash flood proves to be a challenge due to the geographical positioning of the quarry. To resolve the challenge, the quarry has dug tunnels that direct runoff into the bottom of the pit. Sand

and gravel mining are commonly associated with the destruction of landscapes, destroyed river banks, deforestation, water pollution and most importantly the reduction of grazing and farming land (Umar *et al.*, 2014a). There was no identified wastewater discharging point around the quarry and the quarry manager confirmed in the interview that "*there is not much wastewater produced by the quarry*" as the quarry recycles water from the pit and they have a septic tank on site.

In overall, according to the results obtained water at the lower Mpushini River is of good quality meeting South African drinking standards. However, the present study focused only on ten elements from the open pit and their presence in the nearby river, a more focused and specialised study is recommended that will look at all aspects of river water quality before any conclusions involving human consumption can be made.

4.5 Conclusion

Results from the current study proved that river water quality of the Lower Mpushini area meets the standards consumption set by SANS241:2015 despite the quarrying mine in the area. However, this is based on the selected element analysis. The study showed a high level of nitrate in the quarry's open pit which exceeded the national standard limit for drinking water. Therefore, there is a need for the quarry to strengthen measures that prevent wastewater/pit water from entering the river. To draw a solid conclusion on the quality of the river water, a more focused and detailed study is recommended that will focus on all aspects of water quality as the present study only focused on the selected elements with the focus to determine whether there is evidence of wastewater discharge into the river by the quarrying mine.

CHAPTER 5

HABITAT USE BY ANIMALS IN RELATION TO DISTANCE FROM THE QUARRYING MINE

5.1 Introduction

Despite the extensive research done to investigate the environmental impact caused by quarrying mines, there is paucity of research done to investigate the quarrying impact on animal habitat use and welfare. Human activities searching for economic benefits have caused environmental destruction and displaced most animals, and put some to extinction (Lameed & Ayodele, 2010; Endalew, 2019). Adaptation has been there in the animal and plant kingdoms to prevent extinction. However, some indigenous species struggle to adapt to the ever-changing environment, which has been the case for some animals residing in the vicinity of mines. Explosives and heavy machinery have been identified as significant sources of destruction that alter animals' land and habitat use (Lameed & Ayodele, 2010). Habitat use change involve blocking the free movement of animals, reducing grazing lands for wild animals, and reducing farming lands (Endalew, 2019). All over the world small to large mammals are threatened by habitat loss due to land development pressure for human benefits and hunting (Rovero *et al.*, 2014).

Habitat use by antelopes is affected by several factors, which can either be human or naturally induced. Physical factors influence habitat use by antelopes, such as mountain slopes, temperature, precipitation, type of vegetation, and surface water availability (Hensman *et al.*, 2014; Mongil-Manso *et al.*, 2022). Mining, urban development, and major roads that pass through natural reserves have been the human activities that cause habitat use changes in most parts of the world. Antelopes naturally avoid areas with human presence (Hensman *et al.*, 2014). Hence human activities are regarded as a factor that limits habitat use by antelopes. Reindeer reduce habitat use closer to the mining site due to high mine activities, with no changes in habitat use away from the mining site (Eftestøl *et al.*, 2019). The season is the major factor that changes antelope's habitat use, as it influences habitat conditions resulting in the migration of animals to more suitable grounds, hence influencing the occupancy rate by antelopes in a particular area (Börger *et al.*, 2006).

Lower Mpushini Valley Conservancy consists of abounded species of antelopes ranging from the most elusive shy Blue duiker (*Philantomba monticola*) to the most common visible and from small-sized to large sized antelopes. However, in this study, the focus was on the most common and abundant species Impala *(Aepyceros melampus)* and Nyala *(Tragelaphus angasii)* to determine the effect of quarrying activities on the habitat use around the quarrying mine. The use of occupancy modelling has been used widely in the field of ecology and conservation due to its cost-effectiveness and ease of application (Ramesh & Downs, 2014). This modelling estimate animal probability of occupancy and detection, where camera trap data is used to estimate the two probabilities in combination with habitat factors that can influence the presence or absence of the species such as bare ground, herbaceous cover, number of trees, leaves litter, grass cover, and distance to road, household, and water source. There is no doubt that environmental contamination affects animal wellbeing and changes habitat use, thus affecting the performance, abundance, and distribution of wildlife. Natural and manufactured chemicals contaminate the environment, and these chemicals can alter animal performance by disrupting endocrine functionality, causing reproductive disorders and poor development in animals (Kanda, 2019). Environmental contaminations such as pesticides, herbicides, and heavy metals have the potential to affect animal fertility, where exposure can lead to disorders in the reproductive system (Guvvala *et al.*, 2020). Nevertheless, it is feasible to minimise the impacts of quarrying activities on the animals and their environment with precise project planning and management, leading to new habitats for animals and land restoration after the project has been completed.

The objective of the study was to determine the effect of quarrying activities on habitat use by antelopes (nyala and impala) in relation to distance from the mine. The hypothesis tested in this study was that quarrying activities would reduce habitat use closer to the quarrying mine and increases as the distance increase moving away from the mine.

5.2 Materials and methods

5.2.1 Study animals

Habitat preference differs among antelope species, this depends on various factors such as competition, water availability, forage availability, quality, predation, and shelter (Pienaar, 2013; Veldhuis *et al.*, 2019). Impala uses open woodlands in all seasons more often compared to other types of habitats. However, other habitats such as open grasslands and floodplains are part of Impala habitat preference (Bonyongo, 2005). Nyala is mainly found in the Southern region of Africa and utilised mixed habitats between woodland and open plain grassland (Pienaar, 2013).

5.2.2 Study area

A camera-trap antelope survey was conducted between June and August 2022 in Lower Mpushini Valley Ashburton about 15km from Pietermaritzburg city centre (29˚38ˈ15ˈˈS, 30˚28ˈ25ˈˈE). Ashburton Mpushini valley is under the uMsunduzi municipality of the uMgungundlovu district in the KwaZulu-Natal province of South Africa. The area is in a protected nature conversancy with free-roaming wildlife. The quarrying mine is located within the nature conversancy. The area represents variations in habitat type and antelope abundance, with the Mpushini River passing through the nature conservancy.

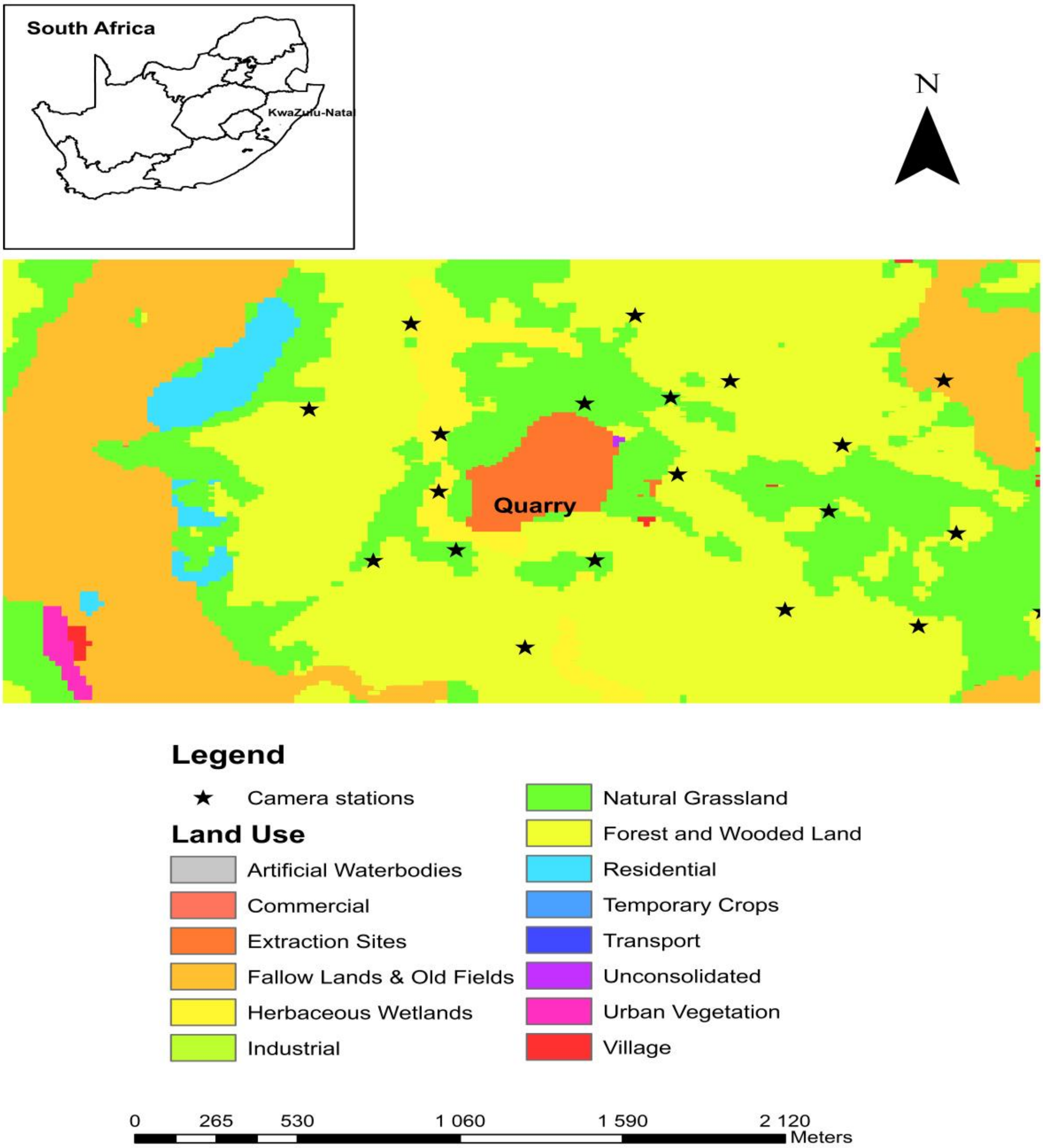


Figure 5. 1 Study site with camera trap stations on quarrying mine, KwaZulu Natal, Ashburton South Africa.

5.2.3 Measurements

Five motion-sensing infrared–triggered Trap cameras were used. Cameras were calibrated before installation on the field. The adjustment of daylight sensitivity and time delay was made to ensure the uniformity among all the cameras. For the period of 2 months, cameras were set to take 3 photos per trigger. We operated camera trapping for 56 days between 4 transects, 14 days per transect on an 8 MP picture size, with a 5-minutes delay between exposures at 20 sites. The photos had date and time of each exposure. Camera trap surveys were conducted between June 2022 and August 2022. Animal trails were used as a selection factor for camera trap placement and placed 30 cm above the ground. Vegetation was removed in front of the camera to prevent false triggers. Recorded data was collected every after 14 days, and batteries were changed. On the afternoon of the 14th day, the data were collected by downloading the pictures from SD memory cards into the laptop, and the camera was changed to the next transect. The camera trap sample design followed a standard 400m grid layout. The event rate was determined by the number of independent photographs in 24 hours camera trap cycle.

5.2.2.1 Habitat variables

Habitat characteristics variables were measured around each camera trap site in a 20m radius during camera trapping between June to August 2022. Five transects were utilised, the transect was 400m square grind, and five plots per transect. Variables were visual measured along animals' trails from each site: bare ground percentage, grass cover, number of trees estimate, leaf litter and herbaceous cover. Distance from the quarry, water, road, and household was measured using Google Earth Pro.

5.2.4 Experimental design and Statistical analysis

The camera positions were selected randomly considering animal trails. To increase the capture rate, cameras were positioned to open field of view. Therefore, based on the method by Bowkett *et al.* (2008), the chosen strategy was between a random sampling and subjective selection of the type of habitat used by antelopes. The recognised statistical procedure was to use presence/absence modelling to estimate the probability of detection and occupancy of Nyala and Impala antelope species as a measure of habitat use around the quarrying site. These species were selected as study species based on their distribution and abundance in the study area.

Habitat characteristics were visually determined in a 20m radius in the camera station. Programme PRESENCE 2.13 was used to estimate detection and occupancy probabilities with nine site covariates based on the single-season occupancy model (MacKenzie *et al.*, 2017). Covariates data was standardised by the z scoring each covariate, and detection history for each study species was created (1) indicating the presence and (0) indicating species absence. Models were generated for each study species and five top models were selected for each species (Table 5.1) based on Akaike weight and bootstrap to 100. Naïve occupancy was also determined, and it is used to highlights the importance of accounting for non – detected animals during camera trapping.

Table 5. 1 Summary of selected top models with occupancy and detection estimates of the two-study species.

Species	Models	AIC	deltaAIC	AIC wgt	Model Likelihood	no.Par.	2*loglike	ψ±SE	*p*±SE
Nyala	psi(DH+NoT),p(DH+DW+DR)	146.1	0	0.098	1	7	132.1	0.9±0.05	0.69±0.07
	psi(DH),p(DH+DW+DR+NoT)	146.41	0.31	0.062	0.856	7	132.41	0.9±0.05	0.69±0.08
	psi(DH+NoT),p(DH+DW+DR+NoT)	147.01	0.91	0.056	0.634	8	131.01	0.9±0.05	0.69±0.08
	psi(DH),p(DH+DW+DR+BG)	147.21	1.11	0.056	0.574	7	133.21	0.9±0.05	0.69±0.08
	psi(DR+DW),p(DH+DW+DR)	147.27	1.17	0.054	0.557	7	133.27	0.90±0.06	0.69±0.07
Impala	psi(DH+BG+NoT),p(DR+BG+DH+NoT)	62.84	0	0.164	1	9	44.84	0.40±0.11	0.77±0.04
	psi(DH+BG),p(DR+BG+DH+NoT)	63.66	0.82	0.109	0.663	8	47.66	0.38±0.11	0.77±0.04
	psi(DH+BG+NoT), p(DR+BG+DH+NoT+LL).	63.91	1.07	0.096	0.585	10	43.91	0.40±0.10	0.77±0.04
	psi(DH+NoT),p(DR+BG+DH+NoT)	64.45	1.61	0.073	0.447	8	48.45	0.39±0.12	0.77±0.04
	psi(DH+BG+NoT+DQ), p(DR+BG+DH+NoT+LL).	64.71	1.87	0.0647	0.3926	10	44.71	0.39±0.13	0.77±0.04

Abbreviations: Delta Akaike Information criterion (AIC), number of parameters (No.par), estimated occupancy (ψ), estimated probability of detection (*p*), Distance to household (DH), Distance to road (DR), Leaf letter (LL), Number of trees (No.T), Grass cover (GH), Bare ground (BG), Distance to quarry (DQ) and Herbaceous cover (HC). Nyala *(Tragelaphus angasii)*, Impala *(Aepyceros melampus)*

5.3 Results

Fifty-six days of camera trapping in total at 20 sites resulted in 1120 trap-nights with 2071 independent photos of five species of antelopes Impala (*Aepyceros melampus)*, Nyala (*Tragelaphus angasii)*, Kudu (*Tragelaphus strepsiceros*) four sighting on two different camera stations, Wildebeest (*Connochaetes*) one sighting on one camera station, and Bushbuck (*Tragelaphus sylvaticus*) three sighting on one camera station. However, only two species Nyala and Impala were considered as study animals based on the naïve occupancy of ≥0.20. The naive occupancy for Nyala was 0.09 and for Impala it was 0.30. Nyala's average estimated site occupancy and detection were 0.90±0.05 and 0.69±0.07 respectively and Impala average estimated site occupancy and detection 0.40±0.11 and 0.77±0.04 respectively.

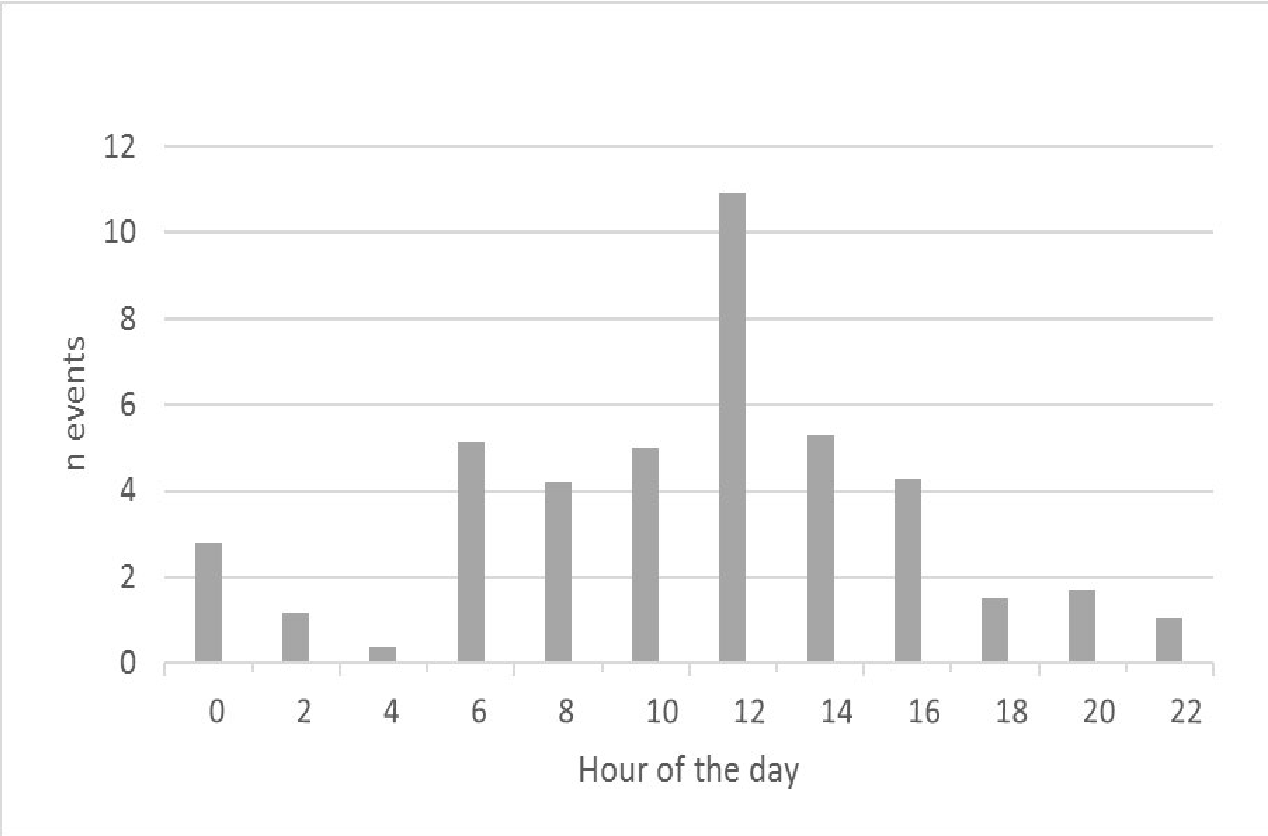


Figure 5. 2 Represents the distribution of camera trap events of antelope activity living around the quarry at 24 hour a day.

Camera events per 24-hour cycle were determined by calculating independent photographs in all five active camera trap stations run for 21 days, only antelopes were considered in the calculations. The aim was to determine the antelope activity around the quarrying mine, there was a high activity of antelope during the day between 11h00 and 13h00 (Figure 5.2).

Table 5. 2 Represents untransformed parameter estimates for top model for each study species occupancy and detection probabilities.

Species	Site occupancy			Site detection probability		
	Covariates	Estimate	Standard error	Covariates	Estimate	Standard error
Nyala	intercept (ψ)	18.72	11.89	intercept (p)	1.15	0.25
	DH	14.95	9.52	DH	-2	0.44
	No.T	4.37	5.23	DW	-1.41	0.04
				DR	0.86	0.28
Impala	intercept (ψ)	-4.37	4.56	intercept (p)	42.50	3.76
	DH	-6.37	5.90	DR	15.36	1.65
	BG	-2.81	2.85	BG	29.67	2.84
	No.T	2.93	2.14	DH	24.24	2.50
				No.T	-3.33	0.87

Abbreviations: Estimated probability of detection (p), estimated occupancy (ψ) for each top model, distance to household (DH), number of trees (No.T), distance to water source (DW), distance to the road (DR), and bare ground (BG).). Nyala *(Tragelaphus angasii)*, Impala *(Aepyceros melampus).*

Top models for each species were determined (delta AIC=0) area represented above, and untransformed estimated parameters for each species from top model site occupancy and detection probability (Table 5.2). The table represents the interaction of covariates and their influence on site occupancy and site detection of probability of each study species.

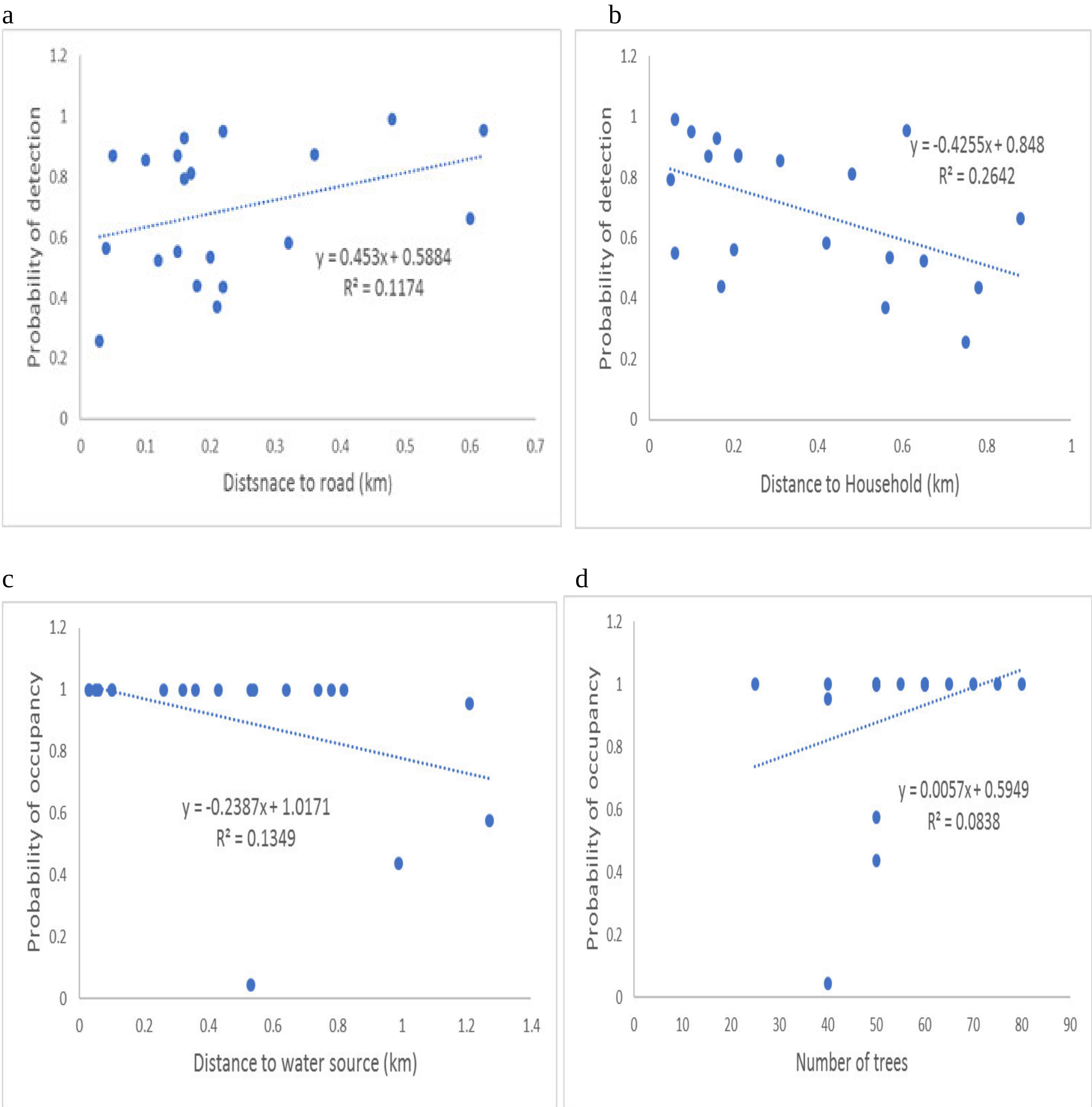


Figure 5. 3 Relationship of distance to the road (a), and household (b) with detection probability, and the relationship of distance to water (c), and number of trees (d) with occupancy probability of Nyala from the top model.

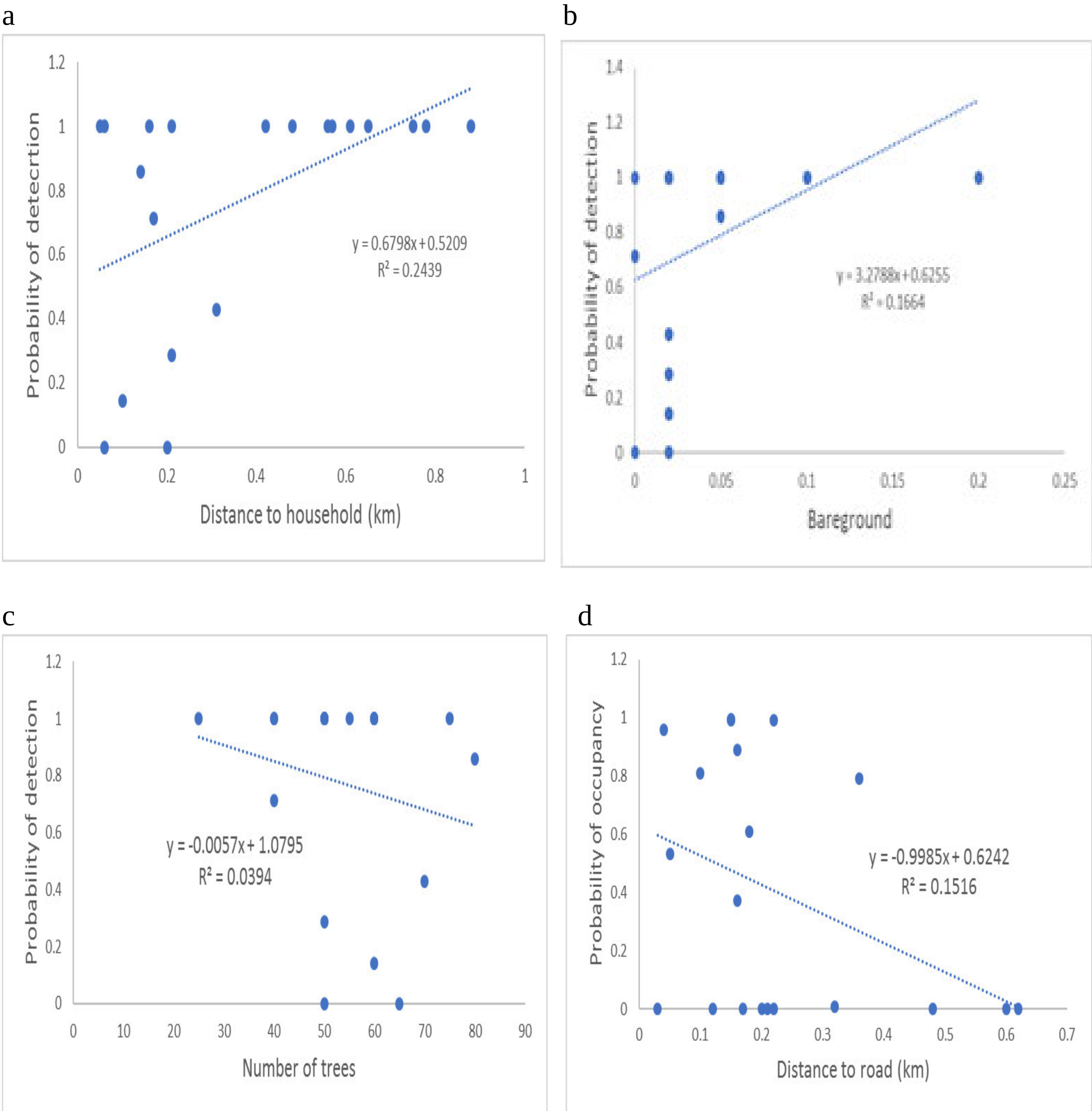


Figure 5. 4 Relationship of distance to the household (a), bare ground (b), and number of tress (c) with detection probability, and the relationship of distance to road (d) with occupancy probability of Impala from the top model.

The top model (delta AIC=0) for Nyala species was psi(DH+No.T),p(DH+DW+DR) with the highest AIC weight of 0.098 indicating that distance to road and household had positive and negative impacts on the probability of detection respectively (Figure 5.3a, b). Distance to the water source and the number of trees had a negative and positive impact on the probability of occupancy respectively (Figure 5.3c, d). The top model (deltaAIC=0) for Impala was psi(DH+BG+NoT), p(DR+BG+DH+NoT) with the highest AIC weight of 0.164. Distance to the household and the bare ground had a positive impact on the probability of detection, with the number of trees and distance to the road negatively influencing the probability of detection and occupancy respectively of the study species.

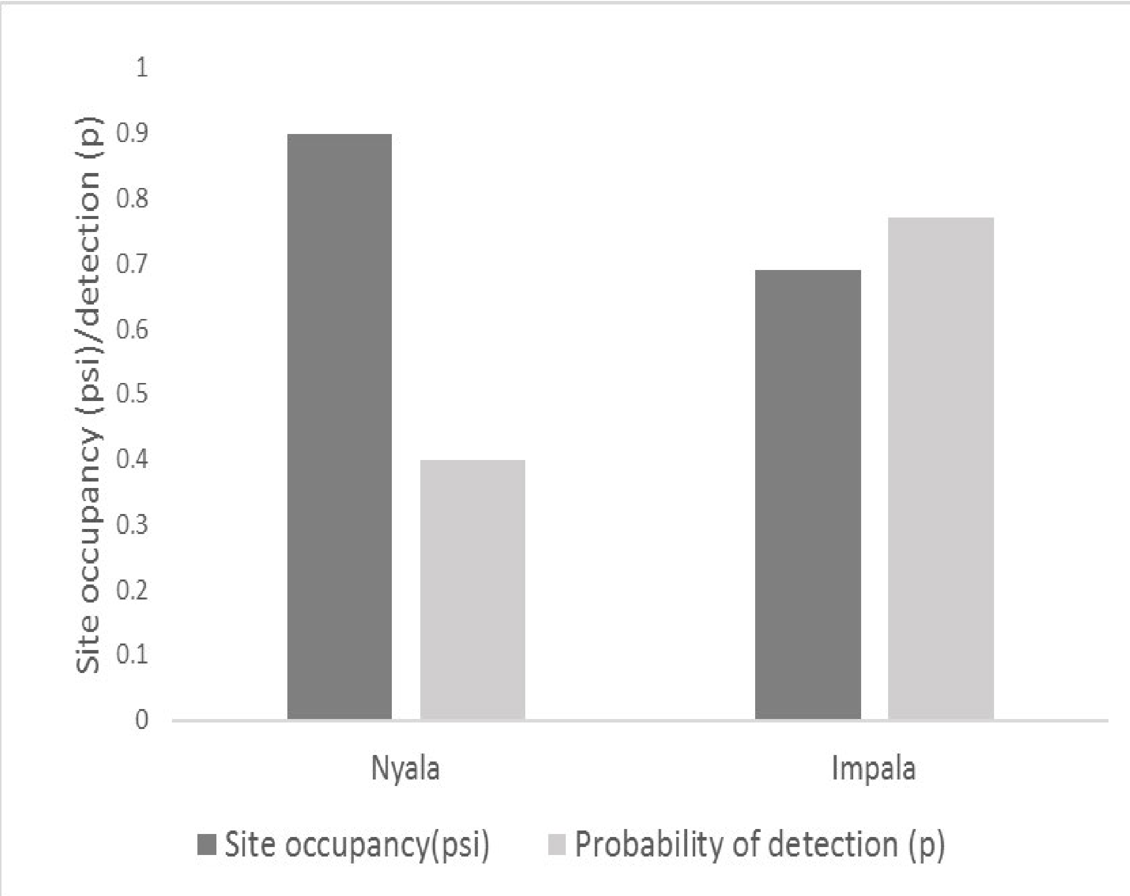


Figure 5. 5 Site occupancy (psi) and probability of detection (p) for two study species.

On average Nyala had high site occupancy and a lower probability of detection compared to Impala (Figure 5.5). This indicate that Nyala occupies more area around the quarrying site.

5.4 Discussion

The study focused on the two antelope species nyala *(Tragelaphus angasii)* and impala *(Aepyceros melampus)* to evaluate the impact of quarrying activities on antelope habitat use. These two species were selected due to their distribution and abundance among the vast number of animal species found in the study area. Nyala utilises mixed habitats such as open plains and woodlands, and Impala also utilised mixed habitats of woodlands and floodplains (Bonyongo, 2005). The study area is most bushveld ranging between densely and less dense woodlands in some areas perfectly suitable for the two species.

Distance to the quarry was expected to have a significant influence on the presence or absence of the two-study species. However, this hypothesis was rejected as the top models of the two species did not have the distance to the quarry as the factor influencing the occupancy and detection of the species. The geographical positioning of the quarry may have affected the presence and absence of the animals, as the quarry is located on the riverbank. The quarry has created a barrier by stockpiling on one side of the quarry to reduce noise, dust, and limit the visibility of quarrying activities from the neighbouring community as most homesteads are found behind the quarry. On field observation, antelopes spend more time behind the stockpile barrier, and that was also observed in the camera detection rate. However, that can also be influenced by the steepness of the area from the quarry entrance and more flat areas behind the quarry as the study species' habitat preference is for less steep areas (Spies, 2015).

Mining activities influence the presence or absence of antelopes in a particular habitat (Müller *et al.,* 2017). There was a significant difference in habitat used by reindeer close and further away from the mining site, utilising habitat further away from the mine (Eftestøl *et* *al.*, 2019). The Lower Mpushini Valley consist of landowners, and the effect of their presence was investigated in this study. Distance to the household was found to negatively influence the probability of detection of Nyala species (Figure 5.3b), however, positively influences the detection of Impala. The difference can be explained based on field observation, where the Impala occupies lit woodlands of the study area which were closer to the homestead of landowners, and inyala occupies more densely woodlands of the areas much further away from households. In contrast with results by Pardo *et al.* (2017) indicating a positive influence, the occupancy increase with the increase of distance from the nearest village. Protected areas provide sanctuary for free-roaming antelopes, thus becoming more used to human presence (Burton & Burton, 2002) in this case closer to households.

Altitude variation was not included in the factors affecting the presence or absence of antelopes in this study. Altitude variation and human presence have a significant influence on species distribution (Ramesh & Downs, 2014; Shah & Cummings, 2021). Large human populations adjacent to protected forests result in lower relative abundance and occupancy (Amin *et al.*, 2016). Road traffic has a negative impact on animal distribution and abundance in most nature protected areas (Underhill, 2003). In this study, distance to the road was evaluated, detection of nyala was positively associated with the distance to the road. The occupancy of impala was negatively influenced by the distance to the road (Figure 5.4d).

The best-fit model for nyala species indicated a negative association between distance to the water source and probability of occupancy, thus more animals were observed close to the water source. The number of trees had a positive influence on the detection probability of Nyala species and a negative influence on the detection of Impala and this can be explained based on habitat preference by both species (Krishna *et al.*, 2008). Multiple factors influence the presence and absence of animals in a particular area at a given time, and those factors vary with seasons. Thus, no valid conclusion can be drawn about the presence or absence of animals based on single-season modelling. The bare ground had a positive association with the detection probability of Impala species, indicating that the increase in bare ground resulted in more animal detection.

The animal population is directly influenced by the habitat conditions and the availability of resources for the survival of animals. The current study indicates that there is more than one variable that influences the distribution and habitat use by the study species. The objective of this study was to evaluate the impact of quarrying activities on antelope habitat use in relation to distance to the quarry. However, the distance to the quarry was not found to have a significant influence on the presence or absence of the study species. Further studies are required to closely evaluate the quarrying activities on animals' habitat use. In a study by Cristescu *et al.* (2016) which looked at mining activate status (working hours, weekends and public holidays) in relation to habitat used by a grizzly bear and concluded that there was lower habitat used during high active mining hours compare to low active mining, and such studies can help in determining the effect of the quarry on habitat use.

5.4.1 Field observation

The lower Mpushini nature conservancy is abundant with a wide variety of flora and fauna. On observation, animals are widely distributed in the conservancy occupying most of the riverside habitat and in areas surrounding the quarrying site. The antelope distribution differs with seasons, in the dry season animals migrate more closely to the river as a water source compared to the wet season. Access to surface water is the main force behind animal distribution. Vegetation canopy, human abundance, season, and recreational activities in the nature conservancy are among the factors that influence antelope habitat use.

Figure 5. 6 The picture of unleashed domesticated dogs in the antelope's habitat captured by remote triggered camera.

The lower Mpushini nature conservancy is part of the environment recreational, which promotes and protect nature. The Conservancy has recreational trails that allow people to observe and learn about local wildlife. However, these activities have a negative impact on wild animals' habitat use (Bleich *et al.*, 2009). The change in animal behavior and distribution of animals are among the negative impacts contributed by the recreational trails in the nature protected area (Larson, 2015). Figure 5.2 shows three unleashed dogs in the antelopes' habitat, on observation, this habitat is located in between households and the habitat shows a reduced number of antelopes and this can be the result of dogs' presence in the area. In most parts of the world, wildlife habitats are affected by human recreation activities, which result in fewer habitat uses and the displacement of wild animals. Domesticated dogs have been part of a recreation of natural reserves which has a direct effect on the mortality of wildlife (Lenth *et al.*, 2008). Detection of antelopes in the sites with the presence of dogs is reduced, which has resulted in altered habitat use by antelopes. The presence of pellets indicates the use of that particular habitat by certain species. However, in areas with dog presence, there were fewer pellets indicating disturbed habitat use.

5.5 Conclusion

The current study indicates the interaction of different factors that determine the presence or absence of the study species in the study area. Therefore, there is no valid conclusion that can be drawn from a single factor on occupancy and probability of detection of certain animals. In this study, five factors from top models influenced the presence or absence of study species, and distance to the quarry was not part of the factors from both top models of each species. This answers the research question of whether the quarrying activities in relation to distance have an impact on the presence or absence of the animals around the quarrying. More intense study is required to increase detection rates further improving the occupancy of animals found in the area and it can help in decision-making by the quarrying mine managers and neighbouring community to better manage the environment and improve the animal's habitat.

CHAPTER 6

GENERAL CONCLUSION

6.1 General conclusion

The quarrying industry plays a pivotal role in the South African economy by creating employment and infrastructure development in the country (Ofori *et al.*, 1996). Nevertheless, the benefits should not outweigh the importance of a healthy environment where they operate. Poor management and planning have caused drastic environmental impacts, dislocated many rural communities in Africa (Douglas, 2012), and caused the extinction of many indigenous animals and plants. The relationship between quarrying mines and neighbouring communities in Africa has been in the pick of discussed topics, because of poor management by the majority of mines in operation. The issues of land use, environmental management and community development have been the cause of company-community conflicts. This means quarrying companies are faced with ever-changing environmental policies and demands by more observant communities, hence the companies need to adopt and adapt by becoming responsible and responsive corporates to minimise conflicts with communities and the public in general.

The current study revealed differences between community and staff members' perceptions regarding the impacts of quarrying activities in the area, which must be dealt with to create healthy relationships. To the save company`s funds and the future of the business in the operation area, the quarrying mine needs to address issues in an open and sincere manner with the neighbouring community members. In this study, the impacts of quarrying activities on river water quality were evaluated by tracing noticeable elements found in the open pit water from the nearby river, determining the link between open pit and river water. In conclusion, there was no link between the open pit and river water quality based on the test conducted, thus the quarry was found to have no negative impact on the neighbouring river water quality. However, high levels of NO_3 in the open pit was found but much lower levels in the neighbouring river. The Lower Mpushini Valley is teaming with animals and a variety of plant species that depends on the quality of available water. The water quality of the river in the lower Mpushini Basin meets the drinking water standard (SANS241:, 2015) despite the existence of quarrying operating in the area. However, a more focused study is recommended that will focus on all aspects of water quality as the present study only focused on the selected elements with the focus to determine whether there is evidence of wastewater discharge into the river by the quarrying mine.

Antelope plays a crucial role in Lower Mpushini Valley ecology, and their presence especially welfare in the area must be valued. To determine the impact of quarrying activities on antelopes' habitat use in the area, PRESENCE 2.13 programme was used where nine factors including distance to the quarry were tested. Combinations of these factors were evaluated to select those that best represent the study species' presence or absence in the particular area. In this study, about five factors; distance to the road, distance to household, distance to water, number of trees**,** and bare ground from top models influenced the presence or absence of study species, and distance to the quarry was not part of the factors from both top models. This answers the research question of whether the quarrying activities in relation to distance have an impact on the presence or absence of the animals around the quarrying.

The Lower Mpushini Valley Conservancy has a task in hand to monitor and manage landowners' activity such as preventing domesticated dogs from accessing antelope natural habitat, which can affect the abundance and distribution of antelopes in the area. As well as the quarrying company in the area has the task of establishing a more stable relationship with the neighbouring community by involving members in decision-making and more effort on public participation, as indicated by the research that the current dispute between the two stakeholders can be resolved by strengthening the public participation of the neighbouring community.

6.2 Recommendations

1. Regular environmental impact assessments and mitigation measures by technical initiatives in collaboration with research institutions should be encouraged.

2. Antelopes are diurnally active, and more active around 11h00 to 13h00 in the study area. The quarry can adjust blasting activities whether before or after these hours, however, this is based on a single season experiment further study is needed to draw any conclusion.

3. The plantation of heavy metals filtering plants, which can be planted around the riverbank to improve river water quality.

4. The local area should have a permanent office for monthly meetings of community representatives, local government appointed officials, and company representatives.

5. Supervised the external trucks in and out of the quarrying site. The quarry put systems in place or internal supervisors who regulate trucks coming in and out, to reduce accidents and to ensure truck standard compliance.

6. Effective wildlife management and conservation requires reliable surveillance to obtain ecological data on species, including various methods such as unmanned aerial vehicles (UAVs) and traditional ground transect surveys.

7. Wide spectrum river water quality analysis and monitoring including all seasons.

8. The importance of fast forwarding the EMPs and EIA application, as it is needed for the quarry operating in the area to have a signed certificate on site.
9. Widening the notification radius to include more community members.

6.4 Future study

1. Studies with more accurate measurements of habitat use, such as the use of a GPS tracking system that accurately monitors antelope movements in the area, thus indicating where the animals move during different times of the day in relation to the quarrying activities.
2. Studies that focus on animals with much surface area and close to the group, to understand the impacts of blasting activities on animals. More focused study on river water quality monitoring, evaluating all the aspects of water quality in all seasons and the ecosystem.

6.5 Study limitations

1. More funding is required to conduct more specific and specialised research evaluating more complex systems in the study area.

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Appendix 1 Community perceptions of quarrying activities – interview guide

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Important information

This survey is designed to gather information about the impact of quarrying activities on nature conservancy, community and animal wellbeing surrounding the quarrying mine. It is not meant to implicate anyone but rather, to gather data for academic purpose only. Your response and cooperation will be immensely appreciated.

INFORMED CONSENT

I hereby agree to participate in research regarding……………………….................................. I understand that I am participating freely and without being forced in any way to do so. I also understand that I can stop this interview at any point should I not wish to continue, and that this decision will not in any way affect me negatively.

I understand that this is a research project whose purpose is not necessarily to benefit me personally. I have received the contact number of a person to contact should I need to speak about any issues which may arise from this interview.

I understand that this consent form will not be linked to the interview, and that my answers will remain confidential. I understand that, if possible, feedback will be given to my community once the results of the research have been compiled and completed. I hereby also agree to the tape recording of my participation in the study.

Signature of participant …………………….

Date:…………………..

UNIVERSITY OF
KWAZULU-NATAL

Important information

This survey is designed to gather information about the impact of quarrying activities on nature conservency, community and animal wellbieng surrounding the quarrying mine. It is not meant to implicate anyone but rather, to gather data for academic purpose only. Your response and cooperation will be immensely appreciated.

Enumerator name : ....

Contanct number:..	
Study supervisor: Dr. ZT Ran. Emial: raniz@ukzn.ac.za Contact number: 033 260 5478/060 478 0981	Organisation: UKZN PMB Campus
Name of community	Date: ………………………

Time allocation	Task: **Community perceptions towards the quarry activities, environment, and the wellbeing of animals surrounding the Ashburton quarry.**	Section covered

on		(tick)
	SECTION A: DEMOGRAPHY	
	Age group (<25, 25- 35, 45- 55, >55), Gender (M/F) Level of education (No school, primary, secondary, tertiary) Any experience in mining or nature conservancy, Years of residence (<5yrs, 6 to 10yrs, or 10 to 15yrs, or >15yrs?) Population group: Black, White, Coloured, Indian	
	SECTION B: PERCEPTIONS TOWARDS THE QUARRYING IMPACTS	
	NATURE CONSERVANCY AND THE QUARRY	
	History of the nature conservancy, and quarry relationship. How big is the conservancy and how many landowners in the conservancy? Does the conservancy have recreational activities? What type of recreation visitation? Any family member working at the quarry? Or at conservancy? Any health complications due to quarrying activities in the community? Any perceived Quarry Benefits to the community? Or any infrastructure development done by the quarry for the	

	community?	
	ANIMALS	
	Wildlife variations, what type of animals are of abundance in the area? Any changes in the abundance since Quarry started? Animal visibility changes, increased or decreased? Any obstacles blocking animal movement in the area due to quarrying? Have you observed animals during blasting operations? What behavioural changes? (Suddenly running, vigilance, stop feeding) Animals' death in the area due to quarrying activities	
	LIVESTOCK FARMING	
	Do you have livestock in your homestead or any other form of farming? What type of livestock (cattle, goats, pigs, poultry) ….**if no, skip this section** Any changes in your livestock performance as quarrying started? Increased or decreased performance? The water source for your livestock? How far are your grazing fields from the quarry? Death of livestock due to quarrying	
	PETS	

	Do you have pets in your homestead? (Dogs, cats, horses, birds etc.) Does the quarrying affect the wellbeing your pets? Have you noticed any changes in pets' health? If yes, what changes? Any performance changes (e.g. fewer babies born at a given time) Any behavioural changes during the blasting? If yes, what changes? Does the homestead have dogs? Where do you walk your dogs? Leashed or unleashed? What is the conservancy policies regarding dogs?	
	WATER SOURCES	
	What is the water source used by the community? Water quality (would you say bad, good, acceptable, or excellent)? Water availability Does the household uses river water for daily purposes? And what is the use?	
	ENVIRONMENTAL EFFECT OF MINING OPERATIONS	
	Do the operation methods used by the quarry affect the natural environment? ….How? Land degradation due to quarrying activities? River water pollution due to quarrying activities?	

	Noise pollution due to quarrying activities (bearable or not bearable)? Are you happy with the environmental management program in place (EMPs)? Is the community involved in decision making concerning the environment management and wellbeing of their livelihood?	
	DUST	
	Presence of dust in the air? When is the dust more intense? Comparing working days, weekends or blasting days? How long does dust persist after blasting? Does the seasons affect the duct presence, more or less in winter or summer? Air pollution due to dust, air quality (dry, comfortable, humid)?	
	BLASTING OPERATIONS	
	Does the quarry notify the community before blasting? What are the forms of notification? Are you given enough time before blasting? Have you observed animal death caused by the blasting? Or Any other effects caused by the blasting operations in animals.	

	Any buildings destroyed by blasting or vibrations? If yes, have you been compensated for the damage?	
	DISPUTES BETWEEN COMMUNITY AND THE QUARRY	
	Are you aware of any dispute between the community and the quarry? If yes, what is the form of dispute? ……….. What has been done by both parties to resolve the dispute?	

ADDITIONAL INFORMATION

1. Have there been positive changes done by Quarry for the community?
2. How often does the quarry company meet up with the community representatives?
3. Does Company do any work to enhance the environment?
4. Is there a permanent office where community, company or government officials meet?
5. Could you like for the quarry stop or remain operating and what is the main reason