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Effects of mining on vegetation cover, species richness and abundance in Makuti Sand and Gravel Mine Pits.

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Declaration

I hereby declare that all sources of material used for this thesis have been properly cited and that this project is my own work. It has not been submitted to any other degree university for a degree.

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Dedication

I dedicate my work to my parents Richard Mupandare, Leniah Denhere as well as to my siblings and the rest of Mupandare family.

Acknowledgements

Firstly, I just want to thank the Lord for His blessings, His favor and strength that He provided through my studies. I very much appreciate all the people who made it possible for me to accomplish such a great achievement as well as institutions that allowed me to complete my studies.

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Abstract

Sand and gravel mining is a widespread activity that has significant impacts on the environment. The research aims to inquire the effects of sand and gravel mining on vegetation cover, species richness and vegetation abundance. The research utilizes a combination of field surveys and statistical analysis to assess the impacts of sand and gravel mining on vegetation. Experimental surveys were done through data collection of different vegetation species which was later on processed using Microsoft Excel and presented in tables and graphs. The results of the study indicated that sand and gravel mining have negative effects on vegetation cover, species richness and vegetation abundance. This study was necessary because it indicated the extent to which mining can cause unreversed consequences to the environment. The results of showed that due to extreme degradation of soil tree species have seized to regenerate. Transects and quadrats used helped to determine the extent of impacts of sand and gravel mining at large and that not only vegetation was disturbed but also with rest of wildlife thereby creating imbalances within the ecosystem. The removal of vegetation and the alteration of soil characteristics, that resulted in habitat and biodiversity loss. The study highlights the need for effective management practices and policies to mitigate the negative consequences of sand and gravel mining on vegetation and the environment.

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Acronyms

EMA… .... Environmental Management Authority

GDP… ....Gross Domestic Product

UN.. United Nation

US...United States

CHAPTER ONE
INTRODUCTION

1.1 Background of the study

Soil is the loose surface layer that covers the majority of land and it comprises inorganic particles and organic matter and vary greatly in physical and chemical properties, (Dolley and Thomas, 2021). Soil provides the structural support, water and nutrients to plants used in agriculture. Besides agricultural production, soils have various uses in pottery and construction. However, leaching, weathering, and microbiological activities all work together to create wide variety of soil types that are either good or bad for plant growth, construction and manufacturing. The combination of mineral such as gravel, sand, silt and clay particles and organic matter gives the soil its texture, and determines its use.

Sand is used to enhance the structural integrity, solidity and firmness of other materials such as asphalt, concrete, mortar, render, cement and screed, (Dolley, and Thomas, 2021). Sand and gravel typically are mined in a moist or wet condition by open pit excavation or by dredging and used in construction for various purposes. Draggan, (2008), stated that, soil is a very cheap resource henceforth humans in most cases overuses it without sustainability. Soil is a crucial component of the global ecosystem, serving as a source of water and nutrients, a medium for filtering and breaking down harmful waste and participating in the cycling of carbon and other elements. It is of the primary foundations of life on earth.

According to Dhany Semarang, (2013), humans require both renewable and non-renewable natural resources to fulfil their needs. These resources are essential for sustaining human life and well-being however; the extraction must be carefully managed so that the existing environmental carrying capacity will not be disturbed. Therefore, mining activities must be seriously controlled. According to Schaetzl, (1990), the extraction of sand and gravel from the underground geological sources that originate from eroded mountain rocks carried by rivers is a beneficial economic activity for the local community.

Plant species have a non-random and distinct distribution across the world that is affected by various biotic and abiotic factors such as soil types, species migration and habitat characteristics, (Purnomo and Utomo, 2021). Riparian environments play a significant role in determining the diversity, richness and composition of plant species. Mining and related activities can create inequalities in ecosystems by reducing habitat and biodiversity, (Jadav and Thakar, (2018). One of the most significant effects of mining is known as "green removal," which modifies the availability of food, water, and wildlife habitat through the clearing of land for roads and mining areas. Top soil is also removed during mining processes, which results in the loss of soil nutrients.

Makuti sand and gravel mines are within the protected area thereby disturbances within the ecosystem occurred especially on vegetation through the removal of top soil that resulted in removal of vegetation (trees, grasses, herbs and shrubs), land degradation, erosion of soil, nutrients, alteration of soil structure and presence of materials released during mining. On the basis of several impacts caused by sand and gravel mining activities on re-vegetation capacity, vegetation species diversity, richness and abundance, this project will concentrate on mining and the impacts of sand and gravel mining on vegetation diversity and species richness.

1.2 Justification

Soil plays a crucial role as a foundation for supporting life on earth, (Jeffrey, 1987). It serves as a reservoir for water. In Zimbabwe, sand and gravel mining has led to air pollution, land degradation, erosion, soil infertility, loss of habitat and destruction of vegetation henceforth the continuation of this activity has been leading to changes in the environment such as death of the species, stunted growth. Therefore, the researcher saw it necessary to do a project concerning the impacts of sand and gravel mining in Hurungwe Safari since Makuti is part of the protected area with wildlife and vegetation to be affected. This project will provide evaluation to both negative and positive impacts on vegetation diversity and abundance as well as providing recommendations on sustainability and ways to reclamation.

1.3 Problem Statement

Makuti sand and gravel mine pits are located within the protected area of Hurungwe National Park and it’s been five years since mining took place. No efforts of reclamation were made till present day, henceforth there have been consequences posed to the environment and its habitats.

1.4 Research Goal

To assess and evaluate the impacts of sand and gravel mining on vegetation species diversity and abundance within Makuti in Hurungwe Safari Area.

1.5 Objectives

- To evaluate the effects of sand and gravel mining on vegetation cover in Makuti from 2019 to 2022.
- To determine the effects of sand and gravel mining on species richness and abundance in Makuti protected area.
- To assess general vegetation regeneration in all pits.

1.6 Research Questions

- What are the effects of sand and gravel on vegetation cover in Makuti from 2019 to 2022?
- What are the impacts of sand and gravel mining on species richness and abundance?
- What is the general vegetation cover of the area after the pits were developed?

CHAPTER 2

Literature Review

2.1 Sand and Gravel mining in Africa

Sand and gravel mining is one of the activities that has a positive effect on the regional economy. According to the Global Environment Alert Service (2014), sand and gravel are crucial resources for both industrialized and developing nations' economic development efforts. The global demand for sand and gravel is increasing due to population growth, economic development and infrastructure expansion. Sand is consumed 6 to 7 times more in the infrastructure industry's concrete processing than other materials, including cement. This is a clear indication that sand and gravel are crucial components of construction materials, according to the (UN Environmental Program of Global Environmental Alert Service) and (Mwangi, 2007). Sand and gravel mining activities also bring up a number of environmental concerns in other African nations including South Africa, Botswana, Malawi, and Kenya, as well as on a physical and social level.

Moreover, Botswana is one of the countries that extract sand and gravel. (Mbaiwa, 2008) stated that the country is dependent on mining for resources such as sand and gravel which provides 34,2% of Gross Domestic Product, (GDP). For many years, sand and gravel have been extracted in different regions for the construction of roads and structures as part of Gaborone’s urban development inclusive and demand has grown today. (Mwangi, 2007), described soil mining as a threat to Kenya’s ecosystem, with both good and bad consequences.

2.2 Sand and Gravel mining in Zimbabwe

In Zimbabwe, sand mining is not a common business, (Lupande, 2012). Since the introduction of the US dollar in the country, there has been a notable increase in the construction of new building, additions to existing structures and renovations in Harare and adjacent areas. As a result, youth organizations formed cooperatives to mine sand from adjacent farms such as Stoneridge dig and remove sand then transport it for processing in nearby Chirundu. Prior to commencing mining operations, it is necessary to obtain a sand abstraction license from Environmental Management Agency as per the guidelines provided by Environmental Management Agency, the mining process involves the removal of top layer of soil, extraction of sand and gravel up to depth of one meter as well as restoration of the land to its original state. According to, (Chimbodza, 2012), Zambezi river in Zimbabwe has an abundant supply of sand, earth moving equipment is used to dig and remove the sand which is then transported to a processing facility located in nearby Chirundu.

2.3 Negative Impacts of Sand and Gravel Mining

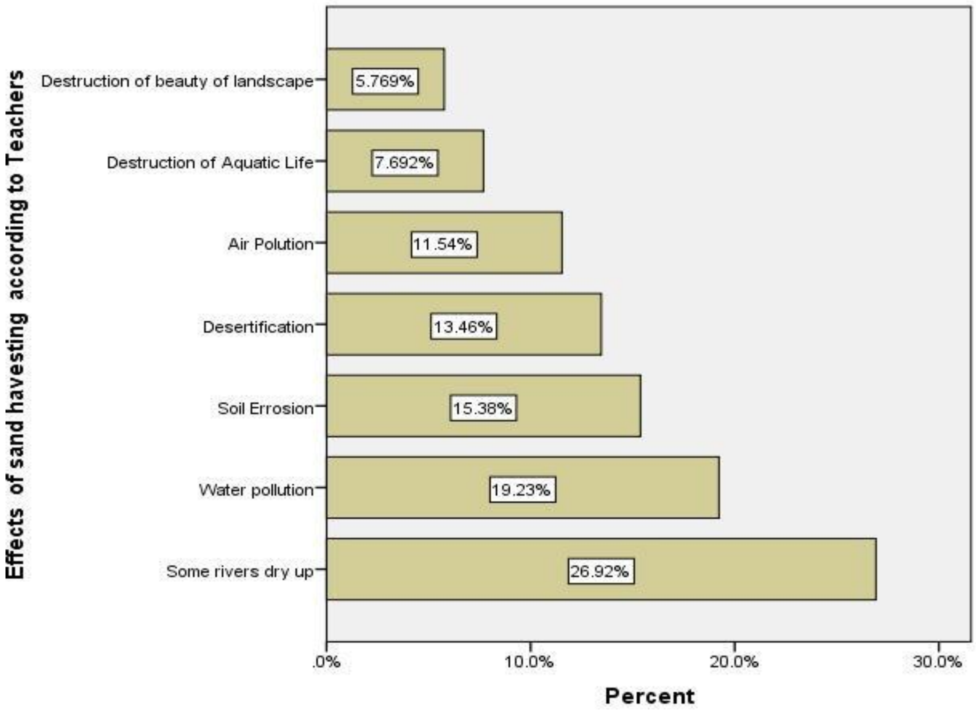


Fig 2.1 shows the effect of sand harvesting according to Teachers

Extraction activities have a negative impact on resources settings and have negative environmental and socioeconomic consequences that manifest during and after mining. Sand and gravel mining alters the natural terrain, contributes to biodiversity and indigenous vegetation loss, diminishing farming areas, damages infrastructure and destroys habitat. A lack of understanding of these consequences has resulted in a lack of planning and management solutions to address the issue**,** **(**McKenna and Robertson, 2003).

2.4 Vegetation Loss

These activities of mining result in the loss of soil properties and quality including lower concentration of organic matter, nitrogen and phosphorous, higher soil bulk density, poor structure lower porosity and reduced water holding capacity as well as lower productivity of biomass. According to research by (Indorante et al, (1981) and (Boerner et al, (1998), mining can lead to unpredictable changes in soil properties and quality that can negatively impact plant growth and richness. The acidic pH, moisture stress and nutrient deficit can result in lower density of trees and shrubs species, resulting in reduced vegetation abundance. The pH plays a crucial role in restoration of plants and the effect of pH change depends on the tree species and site, (Shwalteret al, (2005). Shrubs tend to dominate due to tolerance to low nutrients and low moisture conditions. However, mining of gravel within a protected area leads to loss of vegetation and the extreme impacts can deprive regeneration due to loss of soil nutrients and loss of topsoil henceforth creating condition that are inevitable for vegetation regeneration.

2.5 Damages on Soil

According to research by, (Bussler et al, 1984), mining activities can cause significant changes to soil properties. When fertile soil is removed, it is often replaced by large rock fragments and course gravel that lack organic matter and do not retain water, resulting in low soil fertility. Mine spoils typically have low moisture, high bulk density and low porosity when compared to native soils. The chemical characteristics of mine spoils such as high pH and soluble salt content or low nutrients levels can also have a negative impact on tree growth as noted by, (Torbert et al; 1998). These factors may contribute to loss of vegetation in mined areas. Ultimately, mining activities can lead to soil deterioration and harm the native geological formations and ecosystems.

2.5.1 Deforestation and Erosion

Unregulated mining of sand and gravel quantities can result in erosion. Deforestation may occur during the creation of access roads and mining space leading to soil erosion as trees are removed that protect the soil from the harsh elements and anchor it to the ground. This can cause an aesthetic degradation of the land, (Khanna, 1999and Seyoum, 2006). Trees play crucial role in holding soil together as their roots provide stability and their leaves and branches form a canopy that protects against environmental impacts, the overburden and topsoil that are excavated are often piled up around the mining site causing gullies.

2.5.2 Positive Impacts of Sand and Gravel Mining

However, according to, (Journal of Cleaner, 2020), sand and gravel mining can have positive effects on environmental systems if it is carried out with remediation measures such as water treatment and ecological restoration to address potential environmental impacts.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Study Site Description

The research was conducted in Makuti (figure 3.1) located in Hurungwe Safari Area, Mashonaland West Province Zimbabwe. The latitude is -16.32253^o and the longitude is 29.07605^o. This research was carried out in Makuti sand and gravel mines situated within Makuti Safari Area north-west towards Chirundu. The geographic coordinates of the pits from Makuti are**:** ***Pit 1*** -16.299134, 29.203451 ***Pit 2*** -16.295798, 29.200618 ***Pit 3*** -16.297857, 29.198687 ***Pit 4*** -16.298640, 29.19571, (@ 2011 Maphill). Makuti is part of the protected game area of Hurungwe National Park where a variety of wildlife species are found and specifically for game hunting. The four mine pits are within the range of 4,78km from Makuti Service Station towards Marongora. However, due to some construction needs, mining was carried out within the protected area.

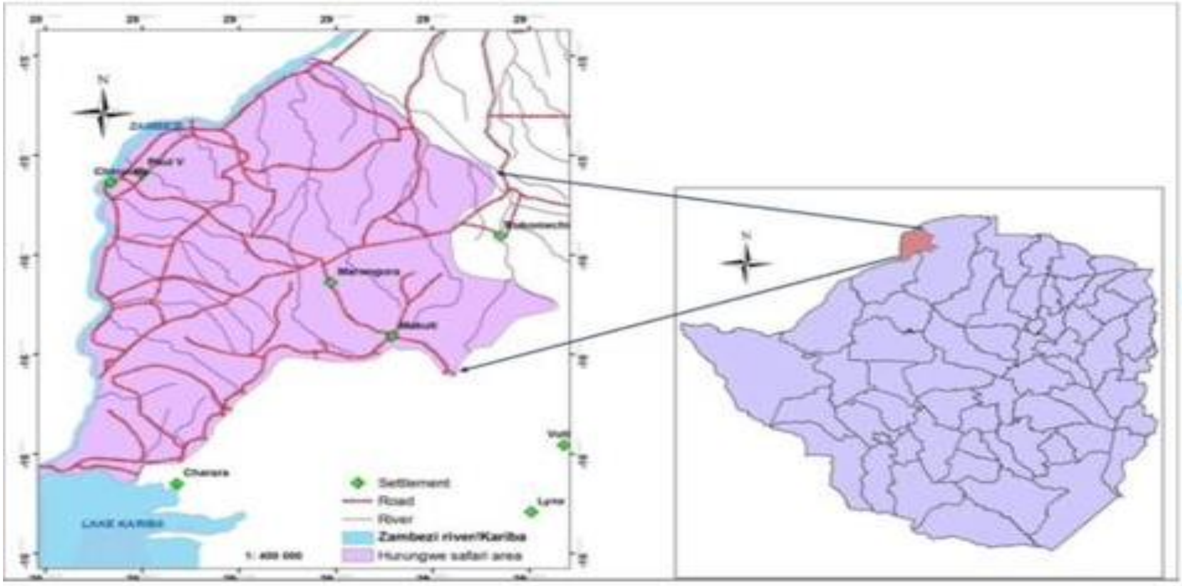
Makuti has a humid subtropical climate with warm, wet summers and cool, dry winters, (Sibanda and Murwiri, 2012). Average annual temperature is 23.05 degrees Celsius (73.49 degrees Fahrenheit). October is the warmest month and its average temperature is 32.54 degrees Celsius (90.57 degrees Fahrenheit). The coldest month is July, with an average temperature of 9.6 degrees Celsius (49.28 degrees Fahrenheit). The average annual rainfall is

118.19 millimeters (4.65 inches). The wettest month is January, associated with an average rainfall of 391.81 millimeters (15.43 inches). (Baudron et al, 2010) stated that, the driest month is August, with an average rainfall of 0.45millimeters (0.02 inches). However, the rainfall in Makuti is heaviest during the summer months November and March.

The vegetation in Makuti is a tropical dry forest. This type of forest is characterized by short wet season as well as a long dry season, (Sibanda and Murwira, 2012). The trees are typically deciduous meaning that they lose their leaves during dry season. The vegetation in Makuti is also diverse with a wide variety of trees, shrubs and grasses. Some of the common trees found in Makuti includes the baobab trees (*Adansonia digitate)*, marula trees *(Sclerocarya caffra*) and the fig trees *(Ficus carica)*. Common shrubs include, acacia, thorn tree and moringa. The common grasses found in Makuti includes, elephant grass *(Pennisetum purpureum*), the broom grass (*Miscanthus junceus)* and thatching grass *(Hyparrhenia hirta and Hyperthelia dissoluta).* Vegetation in this area is very important because it provides food and shelter for a variety of animals such as elephants (*Loxodonta Africana)*, lions (*Panthera* leo), and monkeys (*Cercopithecidae).* It also helps to regulate the climate and prevent erosion, (Dicko et al, 2014). However, it is also important to the local people for timber, fruits, vegetables and thatching grass.

The soil type in Makuti is sandy loam. This type of soil is well drained and relatively fertile. It is also diverse, with a wide variety of minerals and nutrients such as nitrogen, phosphorus and potassium. According to (Fey and Broderick, (1990), some of the minerals found in Makuti include, feldspar, quartz and mica. Moreover, the geology is also diverse. The area is made up of a variety of rocks including sandstones, shale and limestone. The sandstone in Makuti is a very hard rock that is used for building materials, (Cairncross, 2004).

Figure 3.1 Location of Makuti in Hurungwe Safari Area (*Periodic Review Biosphere Reserve – December 2020)*



blue triangles indicate the mine pits. (@ 2011 Mapinfi)

3.2 Research Design

It is the selection of research methods and techniques that constitutes the structure or framework of research design done by a researcher to conduct a study, (Durrheim, 2004:29). The research used quantitative data collection methods such as experimental survey, where by quadrats and transects were chosen at random selection. The primary data collected was further compiled in values through Microsoft Excel and the impacts were analyzed through presented data on tables and graphs.

3.3 Sampling Methods

It is when population subsets are selected for a purpose of research study, (Turner, 2020). Transects and quadrats were used as sampling methods for the four vegetation species, which are grasses, herbs, trees and shrubs.

3.4 Transects Sampling

Transects are quadrats that are long and narrow in shape, they are utilised for sampling purposes in areas with narrow ecotones, (Krebs, 1989 and Caughley, 1977). Both the insides and outsides of the mine pits were divided into four quarter transects.

3.5 Quadrat Sampling

Sampling with quadrats, plots of a standard size can be used for most plant communities, (Cox, 1990). He further suggested that, a quadrat is tool used to define a specific area for the purpose of estimating vegetation cover, counting plants or listing species. Quadrats can be established randomly, regularly or based on subjective criteria within a study site. However, quadrats were chosen randomly through systematic sampling whereby four points were picked on a regular interval within the transect in a measure of 1 m by 1 m per each quadrat. Sixteen quadrats were made inside each pit. This sampling method was chosen because it is easier to apply.

3.6 Vegetation Cover

Point intercept technique was used to estimate vegetation cover. It is a method designed to sample within-plot variation and quantify changes in plant species cover and height, and/or ground cover over time, (Bonham, 2013). This method was used to measure the ground cover of the vegetation only by calculating both grass, shrubs, trees or bush and herbaceous species within each point pinned on the tape measure from the center to the end of the transect. Twenty points were made per each transect, species were calculated and cover measured in percentage. This was used to determine how much ground cover has been restored from 2019 to 2022 since vegetation was totally removed and only bare and degraded land was left.

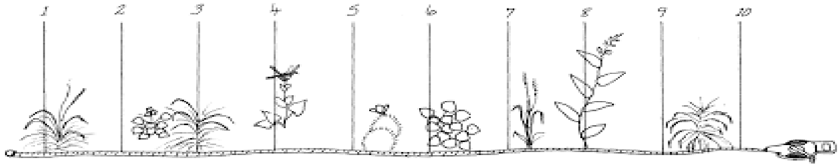


Fig 3.2 shows an example of how ground cover was measured using a tape measure using point, (USDA Forest Service image).

The formula for measuring vegetation cover using point intercept method is:

Vegetation Cover= (number of species ÷Total number of points) × 100

Pit.

3.6.1 Species Richness

Species richness is a measure of species present in a given area or community (Magurran, 2004). It is one of the simplest and most widely used measures of biodiversity. Species richness does not take into account the abundance of each species but only the number of different species present. Species richness was assessed through experimental survey by collecting grass, herbal, trees and shrubs species within selected quadrats and were counted all together.

To assess the general revegetation, I used visual assessment method and vegetation sampling. This involves simply looking at the area to see if there is any new vegetation growth, (Aduda and Ochieng 2014). I also collected each vegetation species from each quadrat as well as noting down total number per each species for vegetation samples.

3.6.2 Data Analysis

The data collected for the experimental study was interpreted, presented and analyzed using Microsoft Excel. Descriptive methods of data presentation such as tables and clustered columns were used. Basing on the analyzed data, conclusions on vegetation cover, species richness and abundance were made and recommendations were drawn to address challenges that are caused by sand and gravel mining.

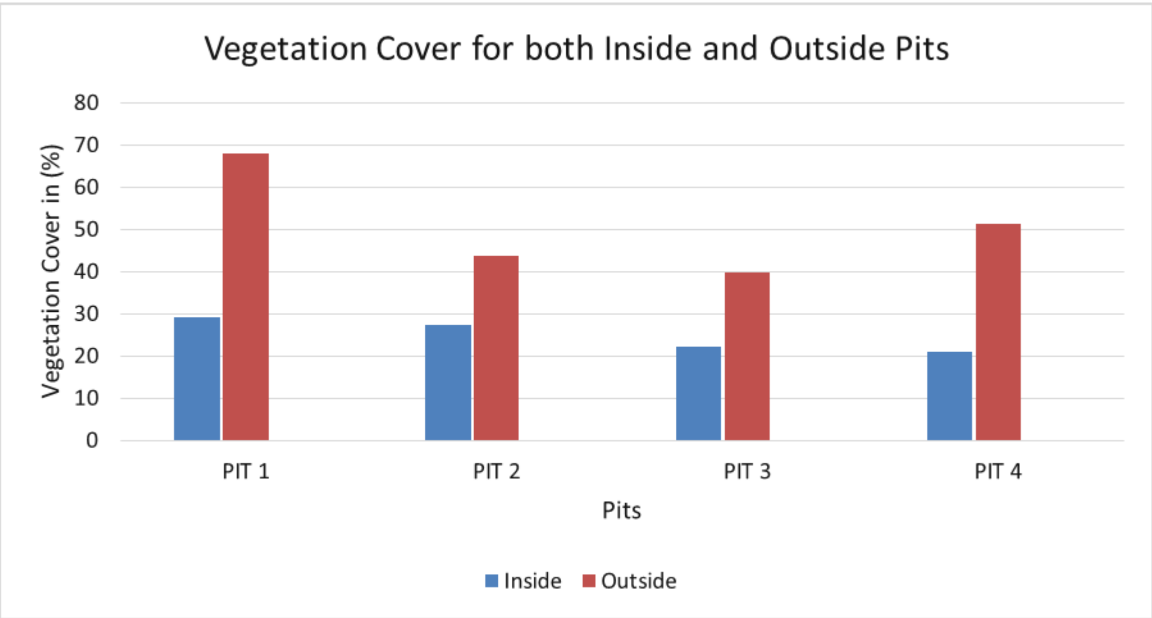
CHAPTER 4

Results

4.1 Vegetation Cover in Makuti Sand and Gravel Mine Pits

Fig 4.1 shows data collected for vegetation cover in both outside and inside Makuti mine pits. The pie charts below indicate that since four years back when mining was done vegetation did not successfully regenerate as was expected. 68.1% of the first pit shows that there is dense vegetation cover surrounding the area that goes for pit 2, 3 and 4 with 43.6%, 39.7% and 51.3%. All the insides of the pits indicate that there is less vegetation cover hence, minimum vegetation regeneration has taken place.

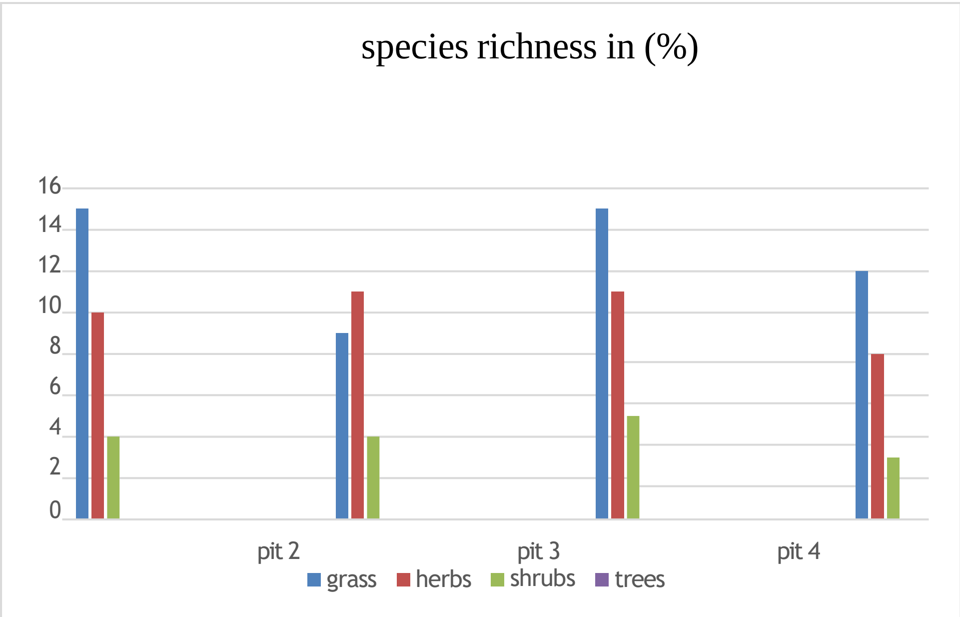
Fig 4.1 shows total vegetation species collected per each pit.



4.2 Species Richness

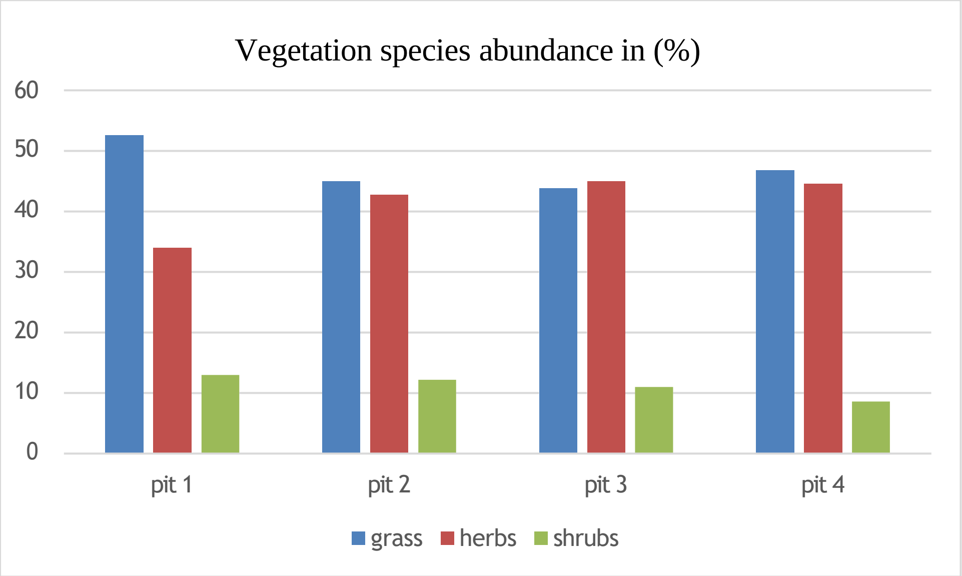
The graph below indicates that there is zero percent regeneration of trees in the mined pits from 2019 to 2022 whereas grasses have managed to regenerate better than other species. Revegetation of shrubs as well seems to be low with less than 6%. In all pits an average of 9.6% of herbs have managed to revegetate from year 2019 to year 2022. The percentage of revegetating of the species varies from one species to another.

Fig 4.2 indicates how species richness differs from one species to the other and from one pit to the other.



4.3 Vegetation Abundance in Makuti Mine Pits

Fig 4.3 shows differences in species abundance for four mine pits in Makuti.



Pit 1 has the highest abundance of grass (52.6%) and the lowest abundance of shrubs (13%) whereas Pit 2 has the highest abundance of herbs (42.8%) and the lowest abundance of shrubs (12.2%). Pit 3 has an equal abundance of grass and herbs (43.8% and 45%, respectively) and a lower abundance of shrubs (11%). Pit 4 has the highest abundance of herbs (44.6%) and the lowest abundance of shrubs (8.6%). However, the distribution of different types of vegetation varies between the pits, which may be due to differences in environmental factors such as soil quality and water availability.

Chapter 5

Discussion

5.1 Impacts of Mining on Vegetation Cover in Makuti Sand and Gravel Mine Pits

The data presented on *fig 4* shows that grass species has got the highest percentage of revegetation since 2019 to 2022 whereas herbal and shrubs species are revegetating at a minimum and trees have not managed to grow at all. The plant cover is lower inside the pit because of mining activities during extraction of sand and gravel whereas its higher outside the pit due to stable conditions and most grass species have managed to grow because of their tolerance to harsh conditions. In pits 2 and 3, inside vegetation cover is higher than the outside vegetation cover, this might be due to regeneration of new plant species which are tolerant and adapted to the environmental conditions. However, the differences in plant species cover between inside and outside the pits vary depending on the specific pit.

There are also other studies that have investigated the impacts of sand and gravel mining on vegetation cover in different regions around the world for example, a study of sand mining in the Mekong River in Cambodia found that mining activities led to reductions in vegetation cover and diversity, particularly in areas with high levels of sand extraction (Baird et al., 2019). Also in a study of gravel mining in the Indus River in Pakistan, researchers found that mining activities led to reductions in vegetation cover and biodiversity, as well as changes in soil properties and water availability (Khan et al., 2019).

5.2 Impacts of Sand and Gravel Mining on Species Richness

Sand and mining impacted differently on species richness of grasses, herbaceous plants, shrubs and trees, henceforth, in all sampled transects of the four mine pits no tree species were found. This might be due to clearing of land for the mining process that caused the soils to be arable. Species richness was very lower for pit number 2 and higher for pits 1 and 3. Herbaceous species for all the 4 pits was minimum whereas shrubs were lesser in pit 4 than the other 3 pits. However, other factors that may contribute to the low species richness in the Makuti mine pits, in addition to the impacts of sand and gravel mining, includes soil quality. The quality of the soil in the mine pits could be a contributing factor to the low species richness. Mining activities can often result in soil compaction, erosion, and contamination, which can make it difficult for vegetation to grow and thrive. Water availability in the mine pits could also be a factor affecting species richness. Mining activities can disrupt natural water systems and reduce the amount of available water in the area, which can make it difficult for vegetation to survive.

5.3 Impacts of mining on Vegetation Abundance in Makuti Mine Pits

Pit 1 has the highest abundance of grass and the lowest abundance of shrubs whereas Pit 2 has the highest abundance of herbs and the lowest abundance of shrubs (12.2%). Pit 3 has an equal abundance of grass and herbs (43.8% and 45%, respectively) and a lower abundance of shrubs. However, the distribution of different types of vegetation species varies between the pits, which may be due to differences in environmental factors such as soil quality, water availability and the extent of extraction that was done.

In a study of vegetation species abundance in a coal mining area in India, researchers found that the abundance of grasses and herbs was higher in areas with lower levels of mining activity, while the abundance of trees and shrubs was higher in areas with higher levels of mining activity (Mandal and Maiti, 2016). Also, another study of vegetation species abundance in a mining area in Poland found that the abundance of grasses and herbs was higher in areas with lower levels of soil disturbance, while the abundance of shrubs and trees was higher in areas with higher levels of soil disturbance (Kujawska and Waldon-Rudzionek, 2016).

5.4 Chapter Summary

The chapter encompassed the results of the study and analyzed the impacts of sand and gravel mining in Makuti mine pits and how they have affected vegetation cover, species richness and species of grasses, shrubs, trees and herbs. The results provide a clear understanding of the environmental consequences that have harshly impacted maximum regeneration of vegetation since 2019 to 2022.

CHAPTER 6

Conclusion

The research showed that sand and gravel mining in Makuti area within Hurungwe National Park impacted negatively on vegetation cover, species richness and vegetation abundance from year 2019 to 2023 through alteration of soil structures, removal of plants in preparation and implementation of mining. However, through natural restoration, regeneration have partially taken place in the mine pits without trees emerging. This has caused erosion and formation of gullies thereby creating unstable conditions that are unsuitable for plant growth.

Recommendations

- Conduct a detailed environmental impact assessment (EIA) prior to starting any mining activities, it is important to conduct a detailed EIA to assess the potential impacts of mining on the environment, including vegetation. The EIA should include a baseline assessment of vegetation cover and species richness, as well as an assessment of the potential impacts of mining on these variables
- Implement measures to minimize soil disturbance. Mining activities can lead to soil disturbance, which can have negative impacts on vegetation cover and abundance. To minimize soil disturbance, it is recommended to use methods such as selective mining and backfilling, which can help to reduce the amount of soil that is disturbed during mining activities.
- There is need for implementing measures to restore vegetation. After mining activities have ceased, it is important to implement measures to restore vegetation cover and abundance in the affected areas. This can include measures such as re-vegetation with native plant species that can adapt easily to the conditions of the environment especially in Makuti where climatic condition can be very hot, soil amendment, and water management.
- Monitor vegetation recovery. To assess the effectiveness of restoration measures, it is important to monitor vegetation recovery over time. This can involve regular vegetation surveys to assess changes in vegetation cover, species richness, and abundance in the affected areas. Also, it is important to maintain natural revegetation by prohibiting mining with a game area
- Collaboration with local communities can play an important role in the management and restoration of vegetation in mining areas. It is recommended to collaborate with local communities to develop strategies for managing and restoring vegetation in the affected areas since these impacts are due to human activities.
- Implement sustainable mining practices to minimize the impacts of mining on vegetation, it is important to implement sustainable mining practices that prioritize environmental protection, restoration and sustainable goals.

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APPENDICES

PIT 1

quadrant	Grasses	Herbs	Shrubs	Trees	Elevation m	Grass Height cm
Q1	7	6	3	0	1120	254
Q2	5	6	2	0		
Q3	6	7	0	0		
Q4	4	6	0	0		
Q5	5	6	0	0		
Q6	5	5	2	0		
Q7	4	3	1	0		
Q8	6	7	1	0		
Q9	4	4	3	0		
Q10	2	4	1	0		
Q11	7	3	0	0		
Q12	6	4	3	0		
Q13	2	5	0	0		
Q14	5	2	2	0		
Q15	6	4	1	0		
Q16	7	5	3	0		
Total=	**81**	**77**	**22**	**0**		**180**

PIT 2

quadrant	Grasses	Herbs	Shrubs	Trees	Elevation m	Grass Height cm
Q1	5	2	0	0	1113	149
Q2	7	8	0	0	1120	0
Q3	8	4	2	0	118	109
Q4	7	7	3	0	255	0
Q5	7	3	0	0	1052	60
Q6	9	6	0	0	1051	0
Q7	8	5	5	0	1053	60
Q8	7	3	5	0	1050	0
Q9	6	6	3	0	1101	184
Q10	10	3	3	0	1087	292
Q11	7	3	1	0	1089	130
Q12	7	3	0	0	1090	105
Q13	3	5	1	0	1094	0
Q14	6	2	0	0	1097	68
Q15	2	6	2	0	1098	0
Q16	2	0	0	0	2006	0
TOTAL	**101**	**66**	**25**	**O**		**192**

PIT 3

quadrant	Grasses	Herbs	Shrubs	Trees	Elevation m	Grass Height cm
Q1	4	7	0	0	1086	265
Q2	6	6	0		1086	132
Q3	7	7	1			
Q4	5	0	0			
Q5	1	1	0			
Q6	4	4	0			
Q7	5	4	0			
Q8	3	2	4			
Q9	4	5	0			
Q10	3	5	4			
Q11	5	4	4			
Q12	6	5	0			
Q13	1	4	1	0		
Q14	2	5	0			
Q15	5	7	2			
Q16	3	0	0			
TOTAL=	**64**	**66**	**16**	**0**		**146**

PIT 4

quadrant	Grasses	Herbs	Shrubs	Trees	Elevation m	Grass Height cm
Q1	3	5	0	0		103
Q2	5	7	0	0		102
Q3	6	4	0	0		118
Q4	5	3	0	0		130
Q5	5	7	0	0	1051	247
Q6	6	7	0	0	1048	123
Q7	5	3	0	0	1049	242
Q8	3	3	5	0		100
Q9	4	9	2	0	1051	78
Q10	5	5	3	0	1051	128
Q11	4	2	1	0	1052	171
Q12	4	3	0	0	1053	142
Q13	2	4	0			132
Q14	3	0	0	0		143
Q15	5	0	1	0		151
Q16	0	0	0	0		88
TOTAL=	**65**	**62**	**12**	**0**		**139**

INVENTORY

COMMON NAME	SCIENTIFIC NAME
Yellow thatching grass	Hyerrhenia hirta
Herring bone grass	Pogonathria squarrossa
Common thatching grass	Hyperthelia dissoluta
Elands bean	Elephantorrhiza elephantina
Water pea	Vigna inteola
Cornflower blue vernonia	Vernonia glabra
2 unidentified	
Dwarf nut grass	Bulbostylus hispindula
Natal red top	Melanis repens
Boat thatching grass	Hyparrhenia cymbria
Golden bristle	Seteria spheculosa
Common thatching grass	Hyparrhenia hirta
Water pea /wild morning glory	Impomoea bolusiana
Yellow cosmos	Bidens schimperi
Cornflower blue vernonia	Vernonia glabra
4 unkown	
Golden bristle	Seteria spheculata
Natal red top	Melanis repens
Shiney sadge	Cyperus fulgens
Herring bone grass	Pogonathria squarrossa
Boat thatching grass	Hyparrhenia cymbria
Common thatching grass	Hyparrhenia hirta
Wondering dew	Commelina benghalensis
Wild dagga	Acrotomy inflata
Yellow cosmos	Bidens schimperi

	Pubiscens	Xerophyle equisetoides
	Golden bristle	Seteria spheculata
	Common thatching grass	Hyparrhenia hirta
	Common craw foot grass	Dactyloctenium aegyptium
	Herring bone grass	Pogonathria squarrossa
	Hairy love grass	Eragrostis pilosa
	Wondering dew	Commelina benghalensis
	Elands bean	Elephantorrrhiza elephantina
	Water pea	Impomoea bolusiana
	Common thatching grass	Hyparrhenia hirta
	Boat thatching grass	Hyparrhenia cymbria
	Cat's tail grass	Peritis patens
	Smuts finger grass	Digiterioa eriantha
	Sw	Diplane fusca
	Pubscens	Xerophyle equisetoides
	Water pea	Impomoea bolusiana
	Yellow cosmos	Bidens schimperi
	Twiggy Kohautia	Kohautia virgata
	3 unidentified	
	Golden bristle	Seteria spheculata
	Herring bone grass	Pogonathria squarrossa
	Long awn three awn grass	Aristida stipitata
	Natal red top	Melanis repens
	Spear grass	Heteropogon contortus
	Snowflake grass	Andropogon eucomus
	Elands bean	Elephantorrhiza elephantina
	Wild dagga	Acrotomy inflata
	Shiny sadge	Cyperus fulgens
	4 unidentified	
	Golden bristle	Seteria spheculata
	Common thatching grass	Hyparrhenia hirta
	Annual three awn grass	Aristida adescensionis

Natal red top	Melanis repens
Long awn three awn grass	Aristida stipitata
Water pea	Impomoea bolusiana
Elands bean	Elephantorrhiza elephantina
Twiggy Kohautia	Kohautia virgata
Hairy finger grass	Digitaria sanguinalis
Yellow thatching grass	Hyperthelia dissoluta
Jungle rice	Echinochloa colona
Wondering dew	Commelina benghalensis
Small rattle pod	Crotalia podocrapa
Water pea	Impomoea bolusiana
Popgun tree	Steganotaenia araliacea
Rubber tree	Hevea brasiliensis
3 unkown	
Golden bristle	Seteria spheculata
Hiary finger grass	Digitaria sanguinalis
Jungle rice	Echinochloa colona
Boat thatching grass	Hyparrhenia cymbria
Mutsvairo	
Pubscens	Xerophyle equisetoides
Wild dagga	Acrotome inflata
Elands bean	Elephantorrhiza elephantina
Water pea	Impomoea bolusiana
Yellow cosmos	Bidens schimperi
Wondering dew	Commelina benghalensis
3 unkown	
Popgun tree	Steganotaenia araliacea
Mnondo	J. globiflora
Golden bristle	Seteria spheculata

	Feather top grass		Pennisetum villosum
	Boat thatching grass		Hyparrhenia cymbria
	Yellow thatching grass		Hypathelia dissoluta
	Common thatching grass		Hyparrhenia hirta
	Coach panicum		Panicum repensis
	Pubiscens		Xerophyle equisetoides
	Elands bean		Elephantorrhiza elephantina
	Yellow cosmos		Bidens schimperi
	Wondering dew		Commelina benghalensis
	Morning glory		Impomoea bolusiana
	Prince of Wales feathers		J. globiflora
	Mubhondo		Combretum molle
	Tar-berry		Ozoroa inisgnis
	Common thatching grass		Hyparrhenia hirta
	Natal red top		Melanis repens
	Herring bone grass		Pogonathria squarrossa
	Golden bristle		Seteria spheculata
	Wondering dew		Commelina benghalensis
	Water pea morning glory		Impomoea bolusiana
	Mnondo	Prince of Wales Feathers	J. globiflora

IMAGES OF DATA COLLECTION

Image 1

Fig 2

Image 3

Image 4