Impacts of Sand Mining on the Environment in Mjanaheri-Ngomeni Areas of Magarini division, Kenya

By

Paul Muiru Nguru

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Declaration

This research project is my original work and has not been presented for a degree in any other university. It describes work undertaken as part of a program of study at the University of Nairobi.

Paul Muiru Nguru

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This research project report has been submitted for examination with our approval as University supervisors.

Dr. D. E. Kapule (PhD)

Date: 14.09.07

Mr. J.K. Musingi

Date: 14/09/07

Dedication

This work is dedicated to my parents and family especially Virginia, Muriu and Wambogo for their willingness to support me whenever I needed their help.

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Acronyms

ASM	Small-Scale Mining
CBO	Community Based Organization
CBS	Central Bureau of Statistics
CDF	Community Development Fund
DEC	District Environment Committee
DEO	District Environment Officer
DEM	Digital Elevation Model
DRSRS	Department of Resource Surveys and Remote Sensing
ESA	Environmentally Significant Areas
FAO	United Nations Food and Agriculture Organization
FGD	Focus Group Discussions
GIS	Geographical Information System
GPS	Global Positioning System
ICRAF	International Centre for Research in Agro-forestry
IUCN	International Union for the Conservation of Nature
IK	Indigenous Knowledge
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
KFS	Kenya Forestry Service
KWS	Kenya Wildlife Service
LTF	Local Authority Trust Fund
NEMA	National Environment Management Authority
NGOs	Non-Governmental Organizations
NMK	National Museums of Kenya
SPSS	Statistical Packages for Social Sciences
SMU	Smallest Mapping Unit
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

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Abstract

Sand mining is the major economic activity in the Mjanaheri-Ngomeni areas of Magarini Division. The operations are indiscriminately carried out without post mining treatment and management of the mined areas, leaving behind large abandoned mines and causing massive damage to landscape and biological communities. The stony nature of the sand mines is nutrient deficient and makes the natural re-vegetation process difficult.

The sand mines are located near natural waterways and the permeability of the material in the floors and walls increases their water retention capabilities. They get filled up with water during the rainy seasons, becoming a threat to humans, livestock and wildlife by drowning. The presence of water in the mines has attracted concentrations of livestock in search of water around the mines and cause-localized degradation through overgrazing,

The main aim of this study was to (1) determine and map changes in vegetation cover in the mining areas using time series remote sensing data (ii) examine the extent of sand mining activities and their impacts on distribution and composition of vegetation and (iii) make recommendations on sustainable measures for sand mining practices.

Time series, Remote Sensing data and GIS technology were used to determine changes in vegetation cover over a period of 14 years. Plant species were sampled using the line transect method in the mined and adjacent un-mined areas. GPS readings were taken around the sand mines and used to develop a map of the mined areas. Questionnaires were administered to collect data on sand mining activities their benefits and adverse impacts, utilization/uses of plant species, and conservation needs. Focused groups discussions were also held with people responsible for natural resources management in the area.

Secondary data was obtained by reviewing both published and un-published documents, reports, maps and other related materials from local data centers in the study area. The area coverage's of the various land cover / use classes for the 14 years study period were generated using Arc view 3.2 software. A total of eight (8) cover classes were identified and mapped for the year 1992. In the year 2006 nine (9) different cover types were` identified and mapped. The ninth cover class shrub-land was found to have developed around the sand mining areas as a result of vegetation disturbances by sand mining activities.

Shrubby grassland was the most dominant cover class covering 61.1 % of the total area in1992 and 54.5% in the year 2006. During the same period sand mines area increased from 2.56 % to 8.92 %; Woody shrub land decreased from 18.8% to 15.7%; Grassland areas reduced from 3.65 % to 1.97 %; Shrub land cover type emerged in the year 2006 and occupied 15.12% of the total area; Mangrove forests increased from 0.61 % to 1.08 %.

The number of tree and shrub species got reduced due to mining activity. Herbaceous species colonizing the mined areas was found to be much higher than in un-mined areas. Some of the colonizing species are invasive. This research established that sand mining contributes to natural resources reduction. The mining activities have also attracted miners from outside the district who have interfered with the cultural richness of the area.

The study highlights a need to regulate the mining activities so as to avoid further damage to the vegetation as well as the environment. Appropriate rehabilitation measures need to be undertaken with involvement of the local communities and other stakeholders.
Key words: sand mining, land use change, mines rehabilitation

CHAPTER ONE

1.0 Background

Mining is the art of the extracting useful materials from earth by humans for economic and industrial development both for local and export markets (ICES 2003). Platts *et al.*, (1981) highlight the existing methods of mining. Generally, mining processes can be grouped into two main methods, underground mining and open cast mining. Underground mining encompasses all sub-surface vertical or horizontal excavations that are made for the extraction of minerals. This method has little effect on the vegetation and the ecosystem in general (ICES 2003, Noble *et al.*, 1996). Opencast mining refers to uncovered excavations made on the ground for the purpose of mineral or rock exploitation such as the open quarries, pits, and trenches among others. During the mid-twentieth century, transportation and construction infrastructure expanded, thus accelerating sand mining processes to satisfy the demand (Sreebha and Padmalal 2006).

Mining activities started in Mjanaheri-Ngomeni areas of Magarini division now known as Timboni wells in 1956. Then, the mining activities were only done to meet domestic demands and their impacts on local vegetation and the environment in general were minimal and least felt. With time the demand for sand increased and sand mining activities acquired a commercial status. Sand mining activities have expanded and spread to the neighbouring areas of Wayani and Mwangani. The three mines are currently operational and have large abandoned portions that the local communities attach no significant use.
This study investigates the impacts of sand mining on the environment in Mjanaheri-Ngomeni areas with a bias towards vegetation.

1.1 Legal Framework

Searching, exploration and exploitation of mineral resources in Kenya is regulated by the Mining Act Cap. 306 of the laws of Kenya. The Act was established in 1940 and revised in 1987 and is silent on rehabilitation of mined out areas. The recently enacted Environment Management and Coordination Act, (EMCA 1999) demands rehabilitation of mined areas but enforcement has remained a key challenge. Mining is therefore carried out without adequate control by the mining acts, rules or any other legislation. This has resulted in sand being indiscriminately mined, causing large-scale damage to the natural ecosystems.

1.1.2. Sand Mining Regulations

Currently Kenya does not have a national policy or law that regulates sand mining or harvesting. This is of major concern as sand is a resource that substantially contributes to economic growth of the rural areas. However, the second schedule of EMCA (1999), stipulates the projects that must undergo an Environmental Impact Assessment. This includes mining, quarrying and open cast extraction of sand, aggregates and gravel among others.

Sand is not classified as a mineral under the mining Act Cap 306 or subsidiary legislation there under. This means that the Commissioner of Mines through the Act does not regulate sand extraction. Consultations with officers from the Mines and Geology Department reveals that sand mining /harvesting as an activity is not captured by the Act. This gap has been identified by the Department of Mines and Geology and captured in the draft National Mineral Resources and Mining Policy and Mining Bill. However, this Policy and Bill are yet to be finalized and tabled before parliament for approval and enactment. National Environment Management Authority (NEMA) has developed some draft guidelines for extraction of the sand resource but these can only be a temporary solution, as the new Mining Act will address the same once it is enacted. It is worthy noting that guidelines cannot be enforced, as they are tools that are used to help ensure compliance with and enforcement of environmental laws by providing direction, general information and practical guidance to the enforcing officer and community at large.

1.2 Problem Statement

The coastal areas of Kenya are known to be extremely valuable as they concentrate a rich diversity of natural habitats and a large variety of natural resources (Matiru, 2005; Nyandwi and Msuya, 1997). They are an integral component of the concept of sustainable development because they provide long-term benefits to society by maintaining ecological processes and by providing useful products.

The livelihoods of the local communities in the study area depend on free and open access to a great of variety of the natural resources for food, fuel, medicine for human and/or livestock, construction of houses, land conservation, items of culture importance and economic security (Pers. Comm., Mutta- KEFRI). They wholly depend on the vegetation resources for their basic subsistence and are counting on them for their future prosperity. However, the access to the natural resources is being threatened by sand mining activities that are carried out unsustainably and hence degrading the area.

The cutting down of indigenous species adversely affects the ecological balance (Karime 1990). The Process also diminishes and endangers the supply of natural resources available to the local communities and thereby increasing their poverty levels, affects the natural topography, scenic beauty, hydrological functions, water quality and increases soil erosion in the area. The vegetation loss reduces the absorptive capacity of the soil. Most of the rainwater is therefore lost through surface runoff and reduces the water storage capacity. The removal of vegetation cover and sand also allows pollution of fresh water by solid impurities and any other contaminant carried by surface runoff. Underground water aquifers are exposed to direct sun heat and wind that increases water evaporation rates causing water yield reduction.

Mjanaheri-Ngomeni areas of Magarini Division have rich natural vegetation as well as large deposits of quality sand. Over the last few decades, there have been increased sand mining practices that have resulted in vegetation destruction and deterioration of the environment. The plant species are the greatest victims of the sand mining activities, which can be quickly gauged from the denudation of the vegetation cover in the mining areas.

Sand extraction is done by open cast mining method. In this method, the ground vegetation is cut to clear the land. The topsoil is then removed. Pits are then dug into the ground to reach the quality sand deposits. Finally, the sand is loaded into Lorries for transportation and trading purposes. Off road movement of trucks and other vehicles in the area causes further damage to the vegetation and ecology of the area. Hence, a large extent of the land is degraded and denuded of vegetal cover not only by mining but also by the associated vehicular movement. Once the sand deposits are mined and exhausted the mines are abandoned without any rehabilitation.

The sand mines are located near natural waterways and the permeability of the material in the floors and walls increases their filling with water. The water in these mines is greatly increased during the rainy seasons and attracts concentrations of livestock in search of water around the mines. The populations of livestock overgraze the sand mining areas that leading to plant species depletion.

Sand mining activities have contributed to land use and land cover changes that are impacting on ecosystem goods and services. Of primary concern are impacts on plant and animal species, soil degradation that reduces the ability of biological system to support the needs of the local communities. Natural plant communities get disturbed and the habitats become impoverished, mostly resulting in retarded plant growth, reduced vegetation cover, erosion of soil and pollution of air and water. Other impacts are social in nature, as mining requires the use of land for which there is mostly, competing community demands.

The natural vegetation recovery on abandoned sand mines is often problematic due to the nature of mining that removes all the sand up to the bedrock level. It may take several decades or more for the vegetation to recover on these sites. These large de-vegetated areas are a major threat both ecologically (e.g. both flora and fauna) and economically (e.g. less attractive for tourism). Human interventions to re-vegetate the sand mines are facing flooding challenges enhanced by surface runoffs especially from higher grounds during the rainy seasons.

Mining operation, undoubtedly has brought wealth and employment opportunity in the area, but simultaneously has led to extensive environmental degradation and erosion of traditional values in the society. Environmental problems associated with mining have been felt severely because of the area's fragile ecosystems and richness of biological and cultural diversity. The indiscriminate sand mining activities, absence of post mining treatment and management of mined areas are making the fragile ecosystems more vulnerable to environmental degradation, leading to large scale land cover/land use changes and species loss

With the local communities' limited economic and technical resources, they will not be able to afford alternatives to the existing natural resources or to pay the cost of restoring the environment to its former levels of productivity. A need therefore arises to collect baseline data for documenting status, monitoring trends and informing policy development for sustainable utilization of natural resources.

1.3 Literature review

The United Nations conference on Environment and Development held in Rio Jenairo. Brazil in 1992 recognized the value of biological diversity as a key component of the environment.

In this connection, the conference formulated Agenda 21, a programme of action for sustainable development worldwide. The programme provides the background to the Convention on Biological Diversity (CBD), which Kenya signed in 1992 and ratified in 1994. Article 6 of the Convention calls on parties to develop national strategies and action plans for the convention and sustainable utilization of bio-diversity.

A conspicuous omission in Agenda 21 is that it has no specific chapter dealing with the mineral sector as there is for agriculture, protecting and promoting human health among others. However, there are a host of provisions of direct and indirect relevance to minerals development. In particular Chapter 10 presents a program for integrated planning and management of land resources. It's broad objective is to facilitate allocation of land to the uses that provide the greatest sustainable benefits. Its specific objectives are "to review and develop policies to support the best possible use of the land and the sustainable management of land resources", "to improve and strengthen institutions and coordinating systems," and "to create mechanisms to facilitate the active involvement and participation of all concerned, particularly communities and people at the local level, in decision making on land use and management".

To implement even a portion of these suggestions would radically change the resource planning and allocation process in any country. Other examples include Chapter 4 (Changing Consumption Patterns) which advocates for reduction in unsustainable demand for natural resources, greater efficiency in the use of energy and resources, minimizing generation of wastes, and environmentally sound pricing; Chapter 13 (Mountain Development), that suggests alternatives to minerals development to prevent soil erosion, landslides, and loss of habitat and genetic diversity; Chapter 17 (Protection of Oceans), addresses also the degradation of the marine environment from oil and gas activities and Chapter 26 (Strengthening the Role of Indigenous People) that calls for protecting indigenous people's lands from activities which are environmentally unsound or that they may consider to be socially and culturally inappropriate. Agenda 21 also proposes responsible entrepreneurship that encourages self-regulation, environmental research and development, worldwide corporate standards, and partnerships in clean technology.

Despite mounting efforts, the loss of the world's biological diversity mainly from habitat destruction, over-harvesting, pollution and inappropriate introduction of foreign plants and animals has continued. This has lead to Ecosystem disturbances that lead to events or series of events that alters the relationship of organisms and their habitat in time and space. With increasing demand for sand for construction and other industrial development and lack of appropriate substitutes, sand mining is bound to continue the world over into the future. Several studies have been carried out in different parts of the world on the impact of mining industry on the environment. Generally mining processes cause enormous damage to the flora, fauna, hydrological relations by way of mechanical destruction, pollution and introduction of disease and pests. The following section reviews studies done which are relevant to the present study.

Sand mining impacts; an overview

Globally, the value of mineral wealth is recognized, but the concept of biological wealth has been slower to be accepted (Beattie 1992). Studies by Platts and Susan (1981), Nyandwi and Msuya (1997) observe that sand mining activities have a synergistic effect on land erosion and contribute to vegetation destruction and calls for the management of the mining process. This is in agreement with the findings of Lei and Aaron (2004), who studied the role of Artisan and Small-scale Mining (ASM) in China's economy. Their paper defines mining as a robber process that alters physical-chemical properties of the mined areas, creating special habitats where conditions are extremely unfavorable for plant growth and establishment and requires human interventions to reverse the trends.

From a global perspective there are adequate studies done on impacts of sand mining on flora, fauna and the general environment. The mining of sand for construction materials or heavy mineral sand deposits has been practiced for centuries. Sand deposits are actively mined on every continent except Antarctica. In the United States of America (USA) mining has been carried out in Florida, Georgia, North and South Carolina, Virginia, and New Jersey and is typically followed by revegetation practices and long term monitoring (Saunders and Clemons, 1991). In Australia, sand mining has been carried out on both its East and West coasts. In Europe sand is mined Norway, Russia, and the Ukraine. There are also limited mining of sand deposits along the coast of Brazil in South America. In Asia, India and Malaysia lead in exploitation of sand deposits (Garnar and Stanaway, 1994).

Africa has significant sand mining in the Republic of South Africa and Sierra Leone in West Africa. The mined areas have been abandoned with little or no reclamation effort. The Eastern Coast of Africa is only reported to have sand deposits.

Impacts of sand mining on vegetation

Regeneration, establishment and maintenance of vegetation on the mined out areas is difficult. Buckney and Morrison (1992) compared the floristic composition of mined and un-mined sand dunes in Myall Lakes National Park from 1982 to 1990. They found that the vegetation in mined area was different from both in adjacent un-mined dunes and the pre-mining condition. The vegetation showed a decreasing similarity over time to the vegetation previously on the site. However, the study did not look at the contribution of the people surrounding the area to resources degradation through access and utilization of the resources. In another study, Fox *et al.*, (1996) compared regeneration of 44 sites at Tomago, New South Wales in relation to burning, clearing and mineral sand mining. The study noted that regeneration of cleared or mined sites at Tomago was substantially slower than regeneration following the endogenous disturbance by fire. The study further found that the severity of the impact of disturbance on vegetation structure increases from fire to clearing with mining causing the most severe impact. Further the study observes that seventeen years of regeneration on cleared and sand-mined sites at Tomago has not been enough to return the vegetation structure or the soil characteristics to the pre-disturbance state. The under-storey height and the amount of vegetation on cleared or mined sites have not achieved the levels in the original forest, although canopy cover does seem to have reached pre-disturbance levels. Farmer et al., (1976) in a study of abandoned Blackbird Mine, found little vegetative growth. Twenty years after mine closure, soil in the dump was still infertile and extensive rehabilitation efforts were necessary to reestablish vegetation in the area.

Lloyd *et al.*, (2002) did a study on the impacts of the Australian minerals industry on biodiversity. He notes that past mining practices have been responsible for some severe local impacts on both terrestrial and aquatic biodiversity. The impacts have involved direct clearance of vegetation, destruction of faunal habitats and creation of open pits due to lack of rehabilitation practices. In another related study on Asbestos mining in South Africa Mmcculloch (2003) findings in his study on mining in southern Africa who observes that in the absence of legislative encouragement, the mines operators chose not to apply known mining knowledge but go for profits above the health of the environment and people. The result has been a legacy of disease and environmental pollution.

Ward *et al.,* (1990) did a study on mine rehabilitation in Western Australia. Their study proposes anthropogenic intervention in returning mined areas to as similar a state as possible to the pre-mining condition. They propose interventions that include using freshly stripped soil rather than stockpiled soil and returning log debris as habitat. They report relatively high proportions of flora and fauna species returning to rehabilitated sites.

Techniques of Assessing Vegetation Cover

There have been several major developments in the assessment of vegetation cover condition by visual methods over the past decades. Remote sensed data and GIS techniques has provided an important basis for vegetation mapping, monitoring and understanding ecosystem functions, primarily through relationships between reflectance, vegetation structure and composition (Lambin et al., 2003, Bell, 2001, UNEP, 1990, Lillesand and Kiefer 1979*)*. Remote sensing provides multi-spectral and multi-temporal synoptic coverage's for any area of interest. GIS on the other hand has the ability to integrate multi-disciplinary data for varied interpretations in an easy and logical manner that is also time saving and cost-effective.

Grant (2003) did a study that analyzed the post-burn vegetation development of rehabilitated bauxite mines in Western Australia by using multi-time remote sensing data. The study recommends that airborne multi-spectral techniques are the most effective way to detect and monitor vegetation damage at mine sites.

The monitoring of vegetation cover conversions can be performed by a simple comparison of successive land cover maps (Lambin *et al.,* 2003). Remote Sensing data and GIS techniques offers potential to denote land-cover modifications and land cover changes for rapid monitoring purposes. This study was limited to general vegetation cover and not the vegetation types.

Mwalyosi (1982) used aerial photographs to map land use changes and resources degradation in south- west Masailand Tanzania. The study associated degradation to cleared vegetation cover areas and is silent on species lost.

Akotsi *et al.,* 2005, Midika 2005, Serneels *et al.,* 2001, Nguru 1989, Nguru 1998 and Oduori 1990) in their studies, discuss the use of multi-time data in detecting changes in the vegetation cover. Lamprey (1984) used satellite data to examine the relationship between vegetation change, livestock distribution and settlement distribution in the Mara region. Karime (1990) mapped the Land use changes in Ngorengore-loita plains in Kenya using remote sensing data. These studies looked land use / cover changes and associated degradation to absence of cover.

Mining in Kenya

Minerals found in Kenya include; Soda ash, Fluorspar, Barite, Gypsum, Salt, Dimension stones, Silica sand, Kisii stone (Soapstone), Manganese, Zinc, Wollatonite, Graphite, Kaolin, Copper, Nickel, Chromite, Pyrite, various Clays, Rare Earth Elements and Phyrochlore, diatomite, feldspar, gypsum, lime, silica sand, and vermiculite. Building materials produced include cement, sand, coral, granite, limestone, marble, and shale. Kenya produces small amounts of gold, iron ore, lead, secondary aluminum, and steel. The country also produces carbon dioxide gas and gemstones, and refined petroleum products (Kariuki 2002). However, the country has no known records of sand mining. The only studies done are on sand harvesting along the rivers especially in Machakos district, but the techniques employed are different. This study will attempt to fill in these gaps.

Summary of Literature Review

From this literature this study concludes that:

- Sand may not have an alternative in the near future and this call for sustainable exploitation.
- Policies regulating sand mining in Kenya cannot be enforced since they are currently being drafted.
- Sand mines in Kenya are not exhaustively documented
- Remote Sensing and GIS techniques offer an important and rapid basis for vegetation mapping, monitoring and understanding ecosystem functions, primarily through the relationships between reflectance and vegetation structure and composition.

1.4 Justification and Significance of the study

Local communities in the study area are generally poor and are dependent on natural resources especially plants for their livelihoods. The Malindi District Poverty Assessment Report (2000) argues that 62.5 percent of the total population of Magarini division is considered to be in absolute poverty. Poverty leads to over-use and destruction of the environment where short-term goals and practices are pursued at the expense of long-term sustainability. This degradation enhances poverty because the resource base is unable to support the population. Sand mining activities have posed a threat to the vegetation in the study area, which is cleared to create room for mining processes.

There are limited studies done on sand mining around the study area and the coastal region in general. Dale (1939) and Birch (1952) are quoted by Moomaw (1959) to have done the only known early vegetation studies in the coast region area. In his study Dale mapped the coastal forests but he did not describe them either in form of composition or status. Birch did a study on the common trees and shrubs as indicators of possible climax vegetation of the coastal region. Herbs and grasses were not included in the study and neither did he relate the study to other land use activities. Moomaw (1959) studied the climax vegetation on the coastal coral strip. Dakala (1989) did a checklist of the plants of Kilifi district before Malindi district was curved out. The checklist does not indicate the location of particular plant species and neither does it indicate their threats. Karanja (1996) did a study on the impacts of salt works on mangroves. The only other study carried out in the area is by Opiyo *et al.*, (2004) on the impacts of salt and sand harvesting on Timboni wells water quantities. A need therefore arose to undertake a comprehensive study in the area to assess the impact of sand mining activities, to fill in some of the details lacking in the already done research work in the study area. The current study gives clear evidence of the natural resources status and conservation problems with a view to mobilizing institutions, local communities and stakeholders to find sustainable solutions. The process will enhance sustainable utilization and management of the natural resource base that the local communities are dependent upon for economic development and poverty reduction. The generated information will also contribute to the development of the mining policy being prepared by the Ministry of Environment and Natural Resources (MENR) spear headed by the Department of Mines and Geology. It will also contribute to the development of the draft land policy by the Ministry of Lands (MoL). The collected data / information will also benefit development of the guidelines on sand mining / harvesting being developed by the National Environment Management Authority (NEMA) for specific areas by providing a case study.

1.5 Objectives of the study

The project aims to assess the impact of sand mining activities on the environment in Mjanaheri-Ngomeni areas.

1.5.1 Research questions

The main research questions were: -

1.) What is the impact of sand mining on vegetation?

2.) What are the variations in vegetation distribution and composition in the mined and un-mined areas?

3.) What is the extent of the sand mined in areas?

4.) How do sand mining activities impact on the livelihoods of the local communities?

5.) What measures need to be put in place to make sand mining sustainable?

1.5.2 Specific objectives

The specific objectives are:

(i) To determine and map changes in vegetation cover in the mining areas using time series remote sensing data.

(ii) To examine the extent of sand-mining activities and their impacts on distribution and composition of vegetation.

(iii) To suggest measures for sustainable sand mining.

1.6 Research Hypothesis

The hypotheses of the study are stated as follows:

H_O: Sand mining does not influence the distribution and composition of vegetation.

H_1: Sand mining influences the distribution and composition of vegetation.

1.6.1 The Scope and Limitation of the Study

The study was limited by a number of factors that were methodological in nature. Three approaches were used in assessing the impacts of sand mining activities in the study area. These included interpretation of aerial photographs, sampling of plant species in the mining and un-mined areas, questionnaires administration and discussions with focus groups. It would have been ideal to work with satellite imageries as large surface areas are covered in one scene. This would have saved on interpretation time. However, the satellites that serve the area are sun-synchronous and pass around 10.am when the coastal areas are mostly cloudy. All the available imageries (Land sat and SPOT) were not cloud free. The study was therefore limited to interpretation of Aerial Photographs of 1992 and 2006.

The study focused on vegetation changes in assessing impacts of sand mining. The other limitation was the rough terrain of some areas that posed a challenge during plant sampling.

1.6.2 Assumptions

The study was based on the following assumptions:

i. The population in both the mining and un-mined areas is homogeneous;

ii. The local communities in the mined and un-mined areas have equal opportunities and constraints for sand mining and utilization.

iii. Changes in vegetation cover that are not induced by sand mining activities are homogeneous.

iv. The research assistants helping in the questionnaires administrations were not biased.

1.7 Theoretical Framework

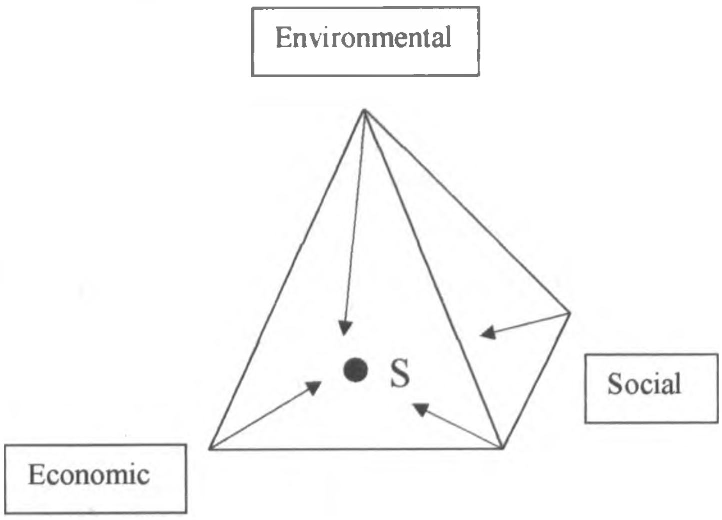
Sustainable development highlights the need of meeting the demands of the present generations without compromising the ability of the resource base to meet those of the future generations. However, development processes are at a stage which land use interests such as mining, agriculture, tourism, ranching, wildlife management, forestry, water conservation, manufacturing, human settlements and infrastructure development are conflicting. This is exacerbated by the mismatch between population and economic growth together with inadequate policies governing land use. Additionally, existing policies and programmes are either poorly implemented or lack harmonization and coordination. The Convention on biological Diversity (CBD) is an international convention that has recognized that the conservation of biological diversity is a common concern for mankind and is an integral part of the development process. It links traditional efforts to the economic goal of using biological resources in a sustainable manner. Its implementation has suffered some inadequacies especially those governing management of the resources base resulting in wide spread environmental degradation.

For a long time ecosystems have been viewed as closed, self-regulating, equilibrium system with constant average composition (Bartha *et al.*, 2004, Jackson *et al.*, 1995, Bradshaw 1997,). If disturbance caused changes in their composition, ecosystems were expected to return spontaneously to the pre-disturbance equilibrium state. Burrows 1990, Prach *et al.*, (2001) and Orloci *et al.*, (2002) view ecosystems as unstable systems that are subject to harm by human activities and other various causes including weather fluctuations, the change of climate, events of biotic invasions and other disturbance regimes.

Development of "sustainable" economies is the new guidepost to deal with issues of growth, economic and community development, and environmental protection. Sustainable growth and natural resource development will help communities use natural resources more prudently and sensitively than in the past and ensure their continued survival.

Sustainability contains the appeal of an attractive model for action. It is an attractive ideal for both scientists and activists, but operational details, objectives, or actions provided by advocates are scarce. Dixon and Fallon (1989) conclude that the sustainability debate involves "how to pursue the goal and how to measure progress toward it. Gale and Cordray (1991) portray the discussion about sustainability as answers to four defining questions: What is to be sustained? Why sustain it? How is sustainability measured? And what are the politics? One of their approaches emphasizes the economic sustainability of natural resource-dependent social systems. This is a narrow approach, however, and does not address other relationships communities have with natural resources that make them dependent on these resources, such as access to habitats for recreational, educational, and spiritual purposes. A related approach, also defined by Gale and Cordray, is the sustainability of human benefits that flow from natural resources. Again, this approach is narrowly focused on specific product benefits. Often, discussions of sustainability are presented within the context of stability, particularly about communities (defined in a territorial versus an interest sense). We generally want our communities to be stable and predictable and to provide a sense of belonging. Sustainability goes beyond economic considerations and biophysical issues; it must deal with important concepts of social order, such as hierarchy, territory, and norms (Dixon and Fallon 1989). Sustainability is a concept decision makers can use to assess the consequences of actions on human communities. A human focus is deliberately taken here because it is the human population that places values on social structure, cultural values and traditions, economic opportunity, and ecosystems and their species. Maintenance of ecosystems and the protection of individual species are human-based values and, therefore, can be described from only a human viewpoint.

The general concept is that sustainability is not only a goal for specific developments, but it is also an objective for the human communities that benefit and that are impacted from various economic development scenarios. Sustainable development demands embracing of three interlocking and interdependent spheres, namely the environmental (ecological), the social (welfare, people) and the economic dimensions (Figure 1). The emphasis is on the need to negotiate towards mutual gains between all stakeholders (individuals and society), the environment and the economy. This discourages individual interests that override the common good and bring about the "tragedy of commons", a collective ruin that follows open access to common resources, in the long run.



Key

S = Sustainability

Figure 1: The sustainability Pyramid (Source: Modified from Fuchaka (2005)).

1.8 Conceptual framework

The degradation and loss of terrestrial ecosystems are major threats to biodiversity. Healthy ecosystems contain a diverse set of organisms and an array of vegetation types that provide habitats for living creatures. Reducing and fragmenting the habitat available can lead to the extinction of species. Degradation affects the provision of critical ecosystem services, such as clean air and water, the recycling of nutrients and the availability of food and fibre. Incremental changes to ecosystems may have long- term cumulative impacts, which severely degrade ecosystem health (Mwaura *et al.*, 2005). The loss of ecosystems and their services is strongly linked with many other environmental problems such as land degradation, poor water quality and climate change (Cooke and Johnson, 2002, Pressey *et al.*, 2000, Fraedrich et al., 1999, Pielke et al., 1996).

Local communities derive a significant fraction of their total income from ecosystem goods and services that provide cultural, ecological and economic gains. Even though they do not currently capture most of the wealth created by the natural systems, their livelihoods are built around these systems. It is this dependence that makes local communities vulnerable to ecosystem degradation. Adverse impacts of climate change are also significantly felt, as their capacity to adapt to a changing climate is limited.

The productive capacity of the natural resource base continues to decline due to accelerating degradation resulting from over exploitation. Some of the factors contributing to this degradation include population growth, poverty, land tenure systems, development policies, poor economic strategies and inadequate conservation status as is illustrated in the conceptual model (Figure 2).

Increases in population and poverty levels have put pressure on exploitation of natural resources. The last three decades have seen population growth increase from 3.41 % in 1979 to 3.9 % in 1999 in Malindi district (Malindi District Development Plan, 2002-2008).

There has been limited strategies to address population growth that may include developing and implementing the active policies aiming at reducing immigrants from other areas by limiting the population-pull factors; adopting family planning measures (to minimize the problem of natural increase); and formulating special policies to depopulate the area. The end result has been increased demand on natural resources. Poverty is a common phenomenon in study area. The decline in the tourism industry, poor returns from the agricultural produce and adverse weather conditions have exacerbated the poverty situation in the recent past, forcing the local communities to over rely on available natural resources. Many of the natural resources are being over utilized and cannot sustain their present rates of use.

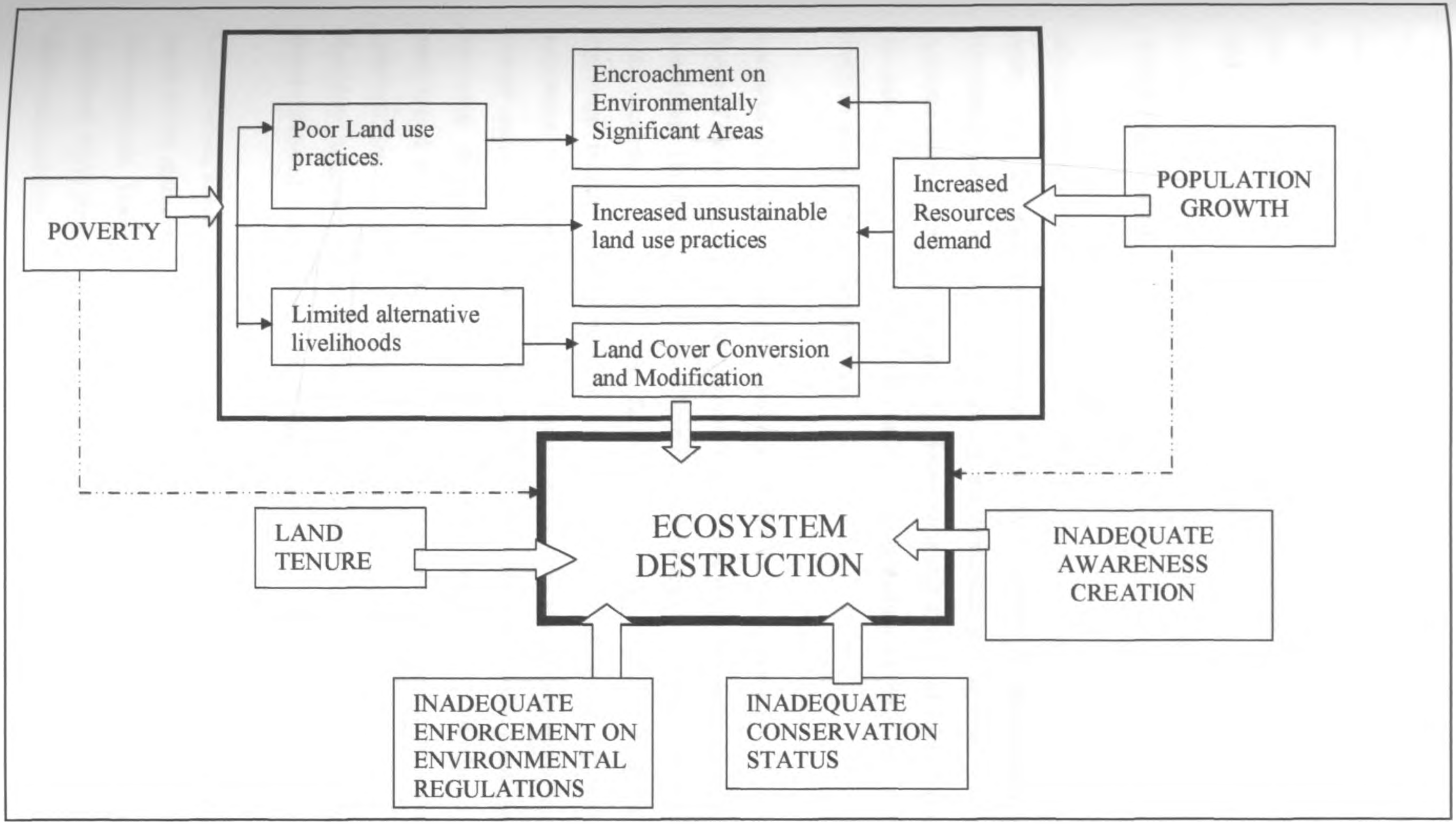


Figure 2: Conceptual Model depicting the factors contributing to Landscape destruction in Mjanaheri- Ngomeni areas.

(Source: Modified from Jafari *et al.*, (2006)) The land tenure system, land use policies and market conditions may have detrimental impacts on biodiversity. Ownership provides an incentive to manage ecosystems sustain ably by assuring that an owner will be able to capture the benefits for long term investments like soil improvements, tree planting or rehabilitation processes. The Land tenure systems have had detrimental impacts on natural resources use. Most of the land in the study area is held in a communal type of tenure (Personal Communication. DEO Malindi District). This has contributed to habitat destructions

When important decisions about local natural resources are made, rural communities are rarely heard or their interests represented. Their wealth of information on indigenous knowledge for natural resources planning and management is ignored. The right for local resource users to participate in resource decisions is still a relatively new concept. Language, ignorance of their legal rights and inadequate information on how resource decisions are likely to affect them are key barriers.

Lacks of alternative livelihoods have contributed to overexploitation of natural resources. Some of the land uses practiced like sand mining is ecologically destructive but economically rewarding. The local people do not have much to choose from. Lack of control for prices of sand worsens the scenario. Other factors that contribute to over exploitation of natural resources include inadequate enforcement of regulations governing natural resources utilization. It is a result of this that natural ecosystems that protect the soil, store water, or shelter unique plant and animal species have been degraded. Some plants and animals are becoming threatened and a few have become endangered. Introduced species have proliferated and are a threat to indigenous species. Where ecosystems are degraded their potential, as a source of environmental income get limited. Intervention measures are therefore necessary to restore and maintain their productivity through executions and development of existing conservation frame works.

Conservation status in the study area is generally very low. This has impacted adversely to some of the natural resources. The water wells in the study area are critical areas that need to be conserved. These are the only sources of fresh water for the local communities and this therefore highlights the need to provide adequate conservation status of the wells to ensure their sustainability.

Inadequate awareness on environmental conservation has contributed to the unsustainable land use practices. This has lead to destructive activities on biodiversity in the area. The local communities therefore fail to consider the long-term consequences of their actions. Provision of appropriate conservation education is, therefore, important. Emphasis should focus on educating people about the value of ensuring sustainable development, and the consequences of habitat destruction/loss and ways of mitigating the problem.

Additionally, a research programme is vital in generating useful information for controlling and reversing the trend of habitat destruction. The research should focus on: establishing the reasons on why local people exhibit a particular unsustainable behavior, identifying the (alternative) livelihood strategies with minimal impact on habitats; evaluating the efficacy, implementation constraints and social acceptability of the alternative land uses and strategies against those threatening the ecological integrity.

1.7 Operational definitions

1. **Sand Mining** refers to the open cast method of accessing the sand where vegetation and topsoil are removed (Platts and Susan 1981). The practice is a non-renewable resource activity that has significant and irreversible environmental impacts on fragile ecosystems (SoE 2003). It causes severe impacts to landscapes and biological communities of the earth through loss of vegetation, soil, pollution of water sources and aesthetic value of the mining areas. The impacts severities are dictated by various factors. These include; whether the mine is working or abandoned, the mining methods used, and the geological conditions of the area (Fox 1996, UNESCO, 1985).
2. **Land degradation** refers to a decline in the usable resource base through human activities in turn affecting water and biological resources (Lambin 1997). It is simply defined as "the temporary or permanent lowering of the productive capacity of land" (UNEP 1990). Activities that contribute to land degradation include soil erosion, denudation pollution, loss of organic matter, fertility and vegetation cover, invasive species, habitat conversion and aquifer degradation. In the study area the main drivers are increasing human population, high poverty levels and poor marketing systems of sand that encourage continuous mining all the time. Other factors include over-reliance on sand mining activities and inadequate alternative livelihoods to mining.
3. **Environmentally Significant Areas (ESA)** refers to natural areas that have been identified as important areas worthy of protection based on criteria such as ecological,

socio-economic or historical functions, or other specified functions and features (NEMA 2006).

4. **Mine rehabilitation** (also referred to as reclamation) refer to the process of converting mined land to its future valuable use - not a process of burying wastes, smoothing out the landscape and applying a green mantle of relatively valueless vegetation (Lockwood *et al.*, 1999).
5. **Ecological restoration** is intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability. The practice includes reforestation, erosion control and habitat and range improvements (Young *et al.*, 2005). The process should be driven by ecological knowledge and research and not just the means of producing a product (Cooke and Johnson 2002).
6. **Aerial photograph** refers to a vertical photograph made with the optical axis of the camera approximately perpendicular to the earth's surface and with the film as nearly horizontal as is practical (Shrestha 1996. Horn 1992,).
7. **Pre-testing** refer to the testing of a survey instruments for biases before the actual data collection. It is recommended to familiarize the data collectors / technical assistants with the data collection tools, procedures and also to give a hands-on practice (Ferguson *et al.*, 1987).
8. **Vegetation** refers to the overall arrangement and appearance of plants. It is dependent on floristic composition, properties, conditions and distribution of the species present. The vegetation at any given place also represents a point of time in the interactions among available plants, physical and biological disturbances that vary in severity, frequency and duration, changeable weather and large scale climate changes (Kent and Coker 1992, Cooke and Johnson 2002).
9. **Succession** is the process of re-vegetation after disturbance. Complete successions begin on bare surfaces. Usually the pioneer plants form open communities that, except in the harshest of environments, are soon replaced by denser, taller communities, which are dominated by a different set of plant species. In the absence of further massive disturbances or environmental changes, steady state or climax vegetation eventually establishes which may change locally in time and space (Young *et al.*, 2005).
10. **Regeneration** is the process whereby species remain in a community. The death of an individual is compensated by the establishment of seedlings that could also be through vegetative reproduction (Adams *et al.*, 2005).

11. **Land cover** refers to the attributes of the earths land surface and immediate subsurface, including biota, soil, topography surface and ground water, and human structures (Lambin *et al.,* 2003).
12. **Livelihoods** refer to the whole complex of factors that allow families to sustain themselves materially, emotionally, spiritually and socially. Central to this is income, which could be in form of cash, or in the form of natural products directly consumed for subsistence such as fuel or building material (Shepherd 2005).
13. **Poverty** is a state of deprivation associated with lack of incomes and assets, physical weakness, isolation, vulnerability and powerlessness (UNDP 2000)

CHAPTER TWO

2.0 Study Area

2.1 Location of the Study Area

The study area is situated in Magarini division of Malindi District, one of the seven districts in Coast Province. The district borders Kilifi District to the South, Tana River District to the North and Northwest, Indian Ocean to the East and Taita Taveta to the South West. It lies between latitude 2^0 2^1 and 4^0 South and longitude 39° and 40° 41^1 East. The district is divided into three divisions namely Malindi, Marafa and Magarini.

Magarini division has three locations Fundisa to the north, Magarini to the south and Ngongoni in between. The present study covers the southern parts of Magarini division and has an area of approximately 327 Ha. It stretches from Mambrui to Ngomeni areas and extends from Latitude 2° 58' and 3° 3' S and longitudes 40° 9' and 40° 15' E (Figure 3). The area is endowed with sand deposits that cover the southern parts of Magarini and Ngongoni locations

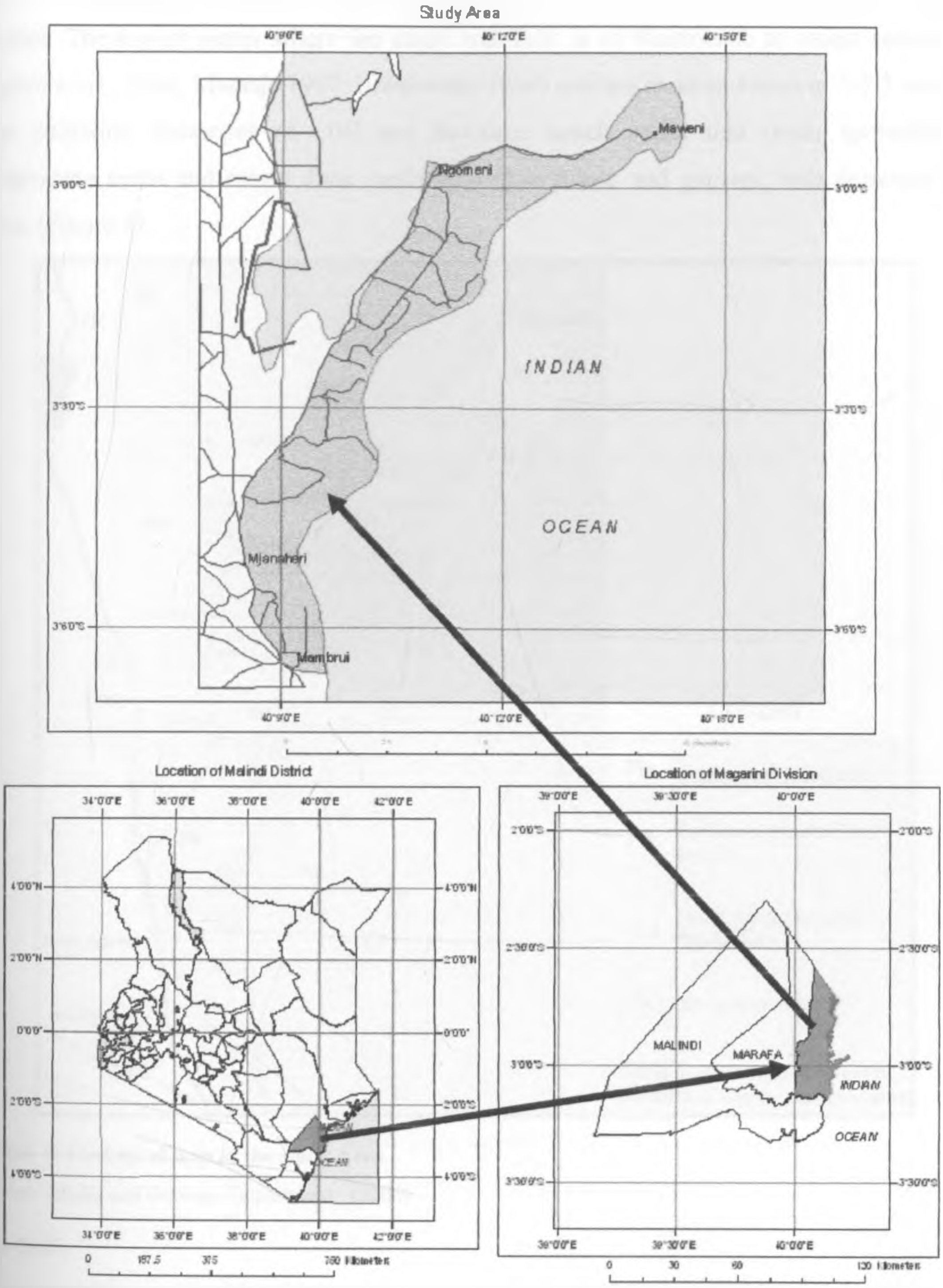


Figure 3: Location of the Study Area

(Source: Modified from Malindi District Development Plan 2002-2008)

2.2 Geology.

Thick sedimentary deposits of Permo-Triassic to recent deposits cover the entire Malindi district. The lowest sector where the study area falls is of Pleistocene to recent sediments (Opiyo *et al.*, 2004, Mwanje 1997, Braithwaite 1984) and lies at an elevation of 0-2O metres. The shoreline comprises of cliff and holocene beach sands that occur sporadically. Pleistocene sands and recent dune sands with sand stones and gypsum beds dominate the areas (Figure 4).

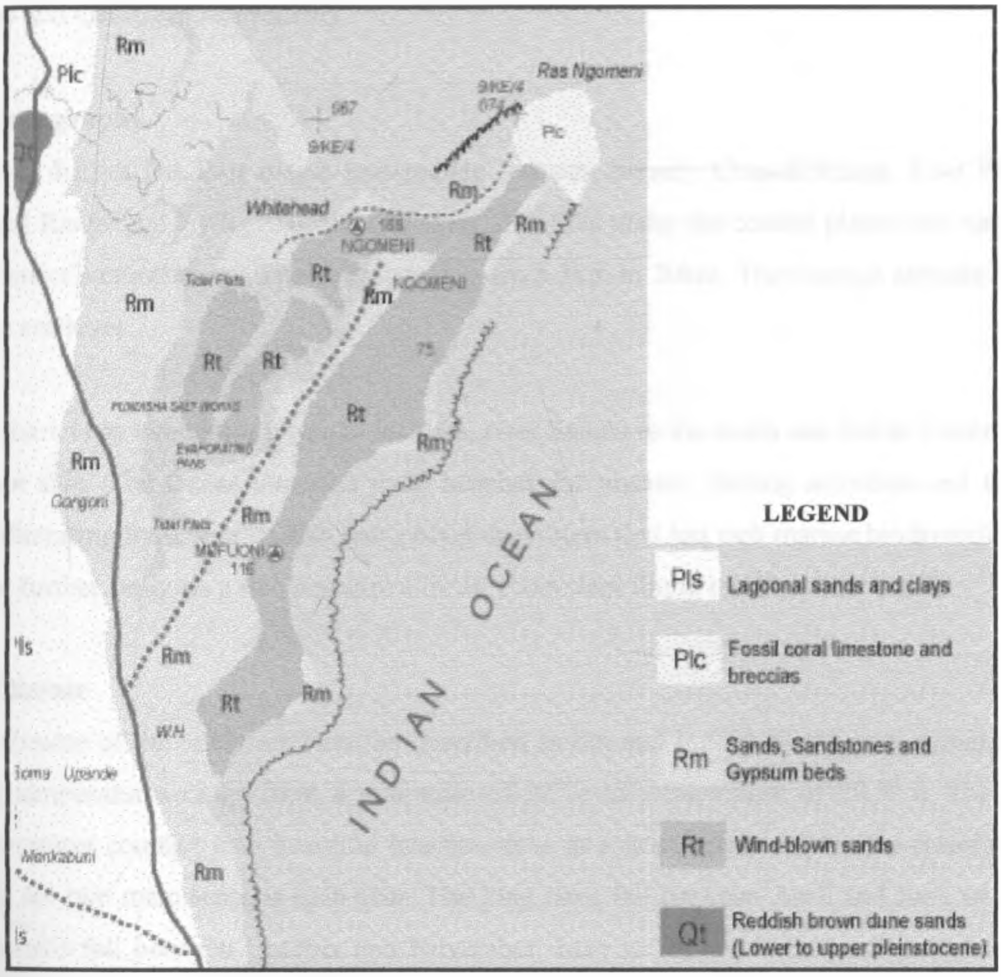


Figure 4: Geological map of the study Area
Source: Mines and Geology Department (2006)

2.3 Soils

The study area is characterized by sand, sand clay, sandy loam and limestone soils with very high infiltration rates. Some areas are covered with thick topsoils, which are loamy sand-to-sand loam. The areas between the hinterland and the coastal belt are characterized by sandy loam, moderate calcareous, sandy clay to clay with lump topsoils. Other areas have brown sandy clay loam soils

The sand deposits are the result of the weathering and erosion of igneous or sedimentary rock. These weathering products are transported and sorted by moving water and concentrated as placer deposits (Lynd and Lefond, 1983, Stanaway 1992 and Garnar and Stanaway, 1994). In the study area, the deposited sand gets compacted to form sand stones that produce sand as a result of weathering. Gypsum which is also present in the area is an evaporate and does not contribute to the formation of sand. Just like trona or fluoride, it forms from crystallizations of salts in the soils. (Personnal communication – Mr. Kimamo S., Mines and Geology Department).

2.4 Topography

Malindi district has four major topographic features, namely Coastal Plains, Foot Plateau, Coastal Range and Nyika Plateau. The study area falls under the coastal plains that run along the district's coastline with its width varying from 3km to 20km. The average altitude is 30m above sea level.

The district has two major physical features, river Sabaki to the south and Indian Ocean to the eastern side. The Ocean supports good beaches for tourism, fishing activities and the salt manufacturing industries. It also has a coral ecosystem that has rich marine biodiversity. The ocean further supports a rich mangrove forest ecosystem found mainly in the creeks.

2.5 Climate

The climate of the study area can be described as hot and humid all the year round. Mean daily temperatures range from a minimum of 22^0 c to a maximum of 29.5^0 c. The warm temperatures coupled with beautiful beaches serve as tourist attractions for the entire region. There are two main seasons each year. The long rains fall between April and June while the short rains fall between October and November. June to August is the coolest period. The average rainfall is over 1,200mm caused by the effect of the monsoon winds and topography. The area has an average relative humidity of about 65% that decreases towards the hinterland (Jaetzold and Schimdt, 1983).

2.6 Vegetation

The vegetation of the study area is dominated by closed to open woody vegetation, open low shrub lands and grasslands. Herbaceous vegetation and mangrove trees dominate the flooded areas. The other vegetation cover includes rain fed herbaceous and tree crops

There is general vegetation degradation emanating from severe human pressure. This results from a need to provide for the welfare of numerous poor rural dwellers. The major causes of vegetation degradation in the area are:

Human population growth

High population growth in the study area has resulted in increases in vegetation resources demand as the livelihoods depend on natural resources. Other activities that cause vegetation degradation and are related to population growth include agricultural expansion that clears vegetation for room to grow crops, resettlement that clears vegetation for building space and sand mining.

Grazing

Livestock in the study area also impact negatively on the vegetation. They reduce regeneration through grazing, browsing, and trampling.

Energy Supply

Lack of alternatives energy sources lead to overreliance on fuel wood and charcoal as energy sources by the local communities. This contributes to vegetation degradation.

Occurrence of plant species over time illustrates the area's ecological dynamics. Plant parameters like cover and composition can be used to describe and monitor environmental condition and trend, which could inform development planning.

2.7 Wildlife

The Major wildlife types in the study area terrestrial animals, aquatic animals and birds. Most of the terrestrial mammals include bushbucks, porcupines, dik diks, squirrels and a variety of snakes. Aquatic animals are mainly found in the Indian Ocean and include: marine fishes, dugongs, dolphins and porpoises. 10% of Kenya's important bird areas, considered internationally important for bird conservation, are found within a 30 km radius of Malindi (UNEP 1998). These include spotted ground thrush (*Turdus fischeri fischeri*), Clarkes weaver (*Ploceus golandi*), Sokoke Scopes owl *(Otus oreneae)* and Amani sunbird (*Anthreptes pallidigaster*). Amani sunbird and spotted ground thrush are recorded as rare while Sokoke Scopes Owl is recorded as endemic to the area.

2.8 Population distribution

The population of Malindi District was recorded at 281,552 (Central Bureau of Statistics population census 1999), and projected at 369,931 for the year 2006. Out of the three divisions of Malindi district, Malindi division had the highest population that stood at

168,606 followed by Magarini division, where the study area falls, which had 68,603 and 7,291 households.

Marafa division had the lowest population of 44,143 people (Table 1). The high population in Malindi division is associated to employment opportunities both in the formal and informal sectors in the two towns of Malindi and Watamu. The many tourist hotels continue attracting many job seekers (District Environment Action Plan 2006-2011).

Employment opportunities in the sand mining and salt farming industries, good soils coupled with high rainfall for agriculture are some of the contributing factors to the high population in Magarini division.

Table 1: Population size and distribution in Magarini division, Malindi District

Source: Central Bureau of Statistics office, Malindi. (2006)

		1979		1989		1999		2005	
Division	**Location**	**Number**	**Density**	**Number**	**Density**	**Number**	**Density**	**Number**	**Density**
Magarini	Magarini	20,564	92	22,769	94	30,536	126	38,587	159
	Ngongoni	7,123	55	11,474	93	18,167	130	22,297	164
	Fundisa	5,467	30	11,046	30	19,900	55	25,147	69
	Total	**33,154**	**177**	**45,289**	**217**	**68,603**	**311**	**86,691**	**116**

2.9 Economic Activities

The study area has two economic/livelihood zones, which fall under two distinct management systems. The areas that lie from Mambrui to Timboni mines carry out sand mining as the main economic activities. The other areas, from Timboni mines to Ngomeni, practice agriculture* as the main economic activities. The main crops grown are maize, cassava, Cotton, beans, potatoes, spinach, passion fruits, coconut, cashew nuts, mangoes, bananas, paw paws and mangoes.

Sand mining is the principal livelihood for the locals in the study area. It offers attractive employment to many people, particularly those living around the sand mining areas. It also resettles those who have lost their jobs in the cities due to newly adopted structural adjustment programmes in the recent past, by offering them new employment opportunities in sand mining related jobs. The sand mining industry has created social amenities that include:

* Crop farming and grazing

- A primary school and a health clinic that serve the employees of the sand industry, their families. as well as local villagers.
- Small shopping center has also come around the area to serve both local people and miners.
- Infrastructures such as roads, water, electricity and telephone systems have been developed.

Sand mining in the area has generally transformed the economic welfare of the local communities. Their standard of living has greatly improved from what they were before. However, there are some adverse impacts that could be associated with sand mining practices (Personal communication, DEO Malindi District). Top of the list are fatal accidents caused by unprotected excavations in terms of unfenced pits that are a concern to safety of human beings and even wild animals. These abandoned excavations, lack of protective clothing and unsuitable sanitary conveniences are the main source of safety hazards in the area. Accidents have also been attributed by undercutting and steep high walls, which have led to slope failures that mostly affect children and drunken people.

The trucks that ferry sand to other destinations accelerate soil erosion in the mining areas. The trucks do not follow specific routes and new routes are opened now and then. Surface runoff is therefore increased.

The open mines serve as depository units for waste / pollutants (animal and human excretes, herbicides, fertilizers, fungicides, pesticides and detergents among others) collected through surface runoffs which eventually find their way into the water wells and act as pollutants. The surface runoffs also carry soil particles, rock debris, organic material (dead animals and plants) which contributes to the silting and polluting of the water wells.

CHAPTER THREE

3.0 Research Methodology

3.1 Data collection design and Procedure

3.1.1 Data Types and Sources

In this study data was required on the sand mines and their impact on the environment of Mjanaheri-Ngomeni areas. To get data on sand mines Remote Sensing and GIS techniques were used to collect spatial data on land cover types. The required spatial data were remote sensing images and topographic maps of the study area. Images were available as satellite imageries (SPOT and Land sat) and aerial photographs. The use of satellite imageries was discarded due to the undesirable cloud cover problems. Aerial photographs were therefore the preferred source of spatial data on land cover types of the study area.

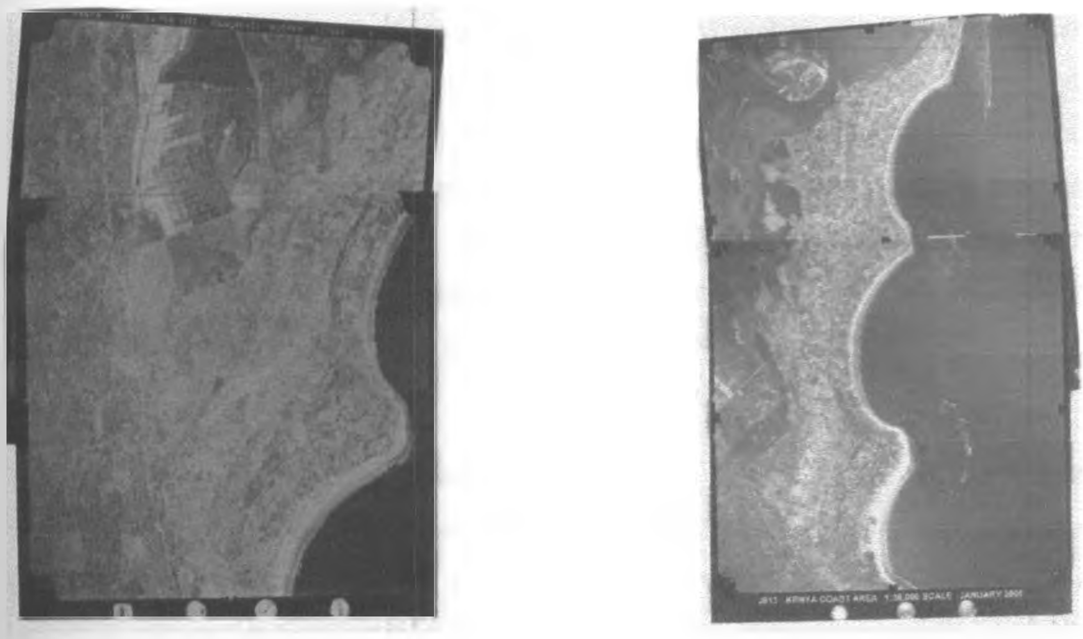
Vegetation data was collected through the line transects method. Two transect each 5 kilometres long were laid at 1 kilometre apart both in the mined and unmined areas. Vegetation data was then collected in quadrats of 20 by 20 metres that were set at every 100 metres.

A questionnaire was used, as a data collection instrument on sand mining activities, natural resources utilization and conservation needs. Other data was collected through face to face discussions with key informants / Focus Groups (FGD) that included heads of Departments responsible for natural resources management at the district level, Non Governmental Organizations (NGOs) and other stakeholders.

3.1.2 Primary Data Collection

To collect the primary data, there was a need to generate spatial database for Mjanaheri-Ngomeni areas. The study therefore sourced the topographic map sheet 1:50,000, which is part of the Kenya National database as the source (base) map. This was then overlaid with aerial photographs for the period 1992 and 2006, which were the ones available in terms of land cover needs. The satellite imageries of the study area were not suitable due to the more than set limits of cloud-cover acceptable for land cover mapping.

Plate 1 (a&b) represents photographs used for the years 1992 and 2006. The 1992 photography was done using a Nikon camera with a wide-angle 152 millimeters lens fitted in a Partenavia aircraft and flying at an average height of 1,250 feets above meters above seal level. The year 2006 photography was taken using a similar Nikon camera but with a super wide angle of 88 millimeters at a reduced attitude of 1,080 feets above sea level. In both years a 60% overlap of the photos was ensured. The method is fully described by Epp, Killmayer and Peden (1983).



(a) **(b)**

Plate 1: Sample Mosaic of Aerial photographs of the study area of (a) 1992 and (b) 2006. Source: Kenya Photomap (2006)

The aerial photographs used were then mosaic (Photos. Kenya FAO, 1,2,3,4,5,6,7) for 1992 at scale of 1:25,000 and the mosaic (Photos: J613, 1,2,3,4,5,6,7,8) for 2006 at the scale of 1:35,000

Interpretation of the aerial photographs were done according to procedures of photo interpretation by Serneels (2001, Shrestha (1996) and Muyodi (1989). Tonal differences, colour intensity, texture and pattern was used to identify and delineate various vegetation cover types (Lillesand and Kiefer 1979, Looijen 1997). The different cover types were classified according to procedures of vegetation classification in Kenya by Grunbealt *et al.*, (1989).

To reconcile the scale differences between the two mosaics so as to allow comparative analysis in change detection, a scale transformation was used based on image overlay procedures provided in the Arc View image analyst tool. Once the scale transformation of the mosaic was complete, another transformation was done to reconcile the topographic-map scale and the generated mosaic scale for an overlay required in land cover identification to succeed. Once that had been done. the smallest mapping units (SMU) were delineated in mapping out the various types of cover on the surface of Mjanaheri- Ngomeni areas. The land cover data types data was therefore the primary data collected using Remote Sensing and GIS techniques as indicated above. The Land cover types that resulted from the above procedures were woody shrub land, shrubby grassland, grassland and mangrove forests, sand mines, agricultural land, bare, water body and shrub land. Of the above cover types the study focused on the excavated surfaces that were identified as sand mines. The sand mines were then delineated to form clusters of degraded surfaces according to this study.

The two preliminary vegetation cover maps of the years 1992 and 2006, produced from the aerial photographs were field checked and corrections on the cover types made. The topographic maps of the study area at scale of 1: 50,000 were used as the geodatabase of the study area. For navigation purposes, a GPS was used. A small-scale topographic map of scale 1: 250,000 was also used for convenience.

A comparative analysis of 1992 and 2006 land cover maps resulted in land cover change data. The land cover change data included values on land cover types and land cover degradations. The degraded surfaces constituted the sand mines areas about which data were collected on areas differences on land cover types.

An accuracy test was performed for the year 2006 cover map. Test samples were selected for every cover class of the year 2006 cover map. These were later verified in the field. The accuracy test was calculated according to procedures by Shrestha (1996), Horn (1992) and Agastiva and Mwendwa (1992). A two-dimensional / contingency table, also known as confusion or error matrix was developed. In one axis (row or column) the classification classes were shown while the true classes were shown on the other axis (Table 2). The values along the diagonal elements represent the percentage of correctly classified cover class and the values along a given row or column show how the misclassified cover classes are spread among other classes including the unknown classes. Adding all the diagonal elements and dividing it by the number of classes computed the average accuracy. Map accuracy is important as it gives levels of reliability and suitability of the map. It also highlights errors of the map and their sources.

Table 2: Polygons used for calculation of map accuracy

Field / Photos.	Sand mines (SM)	Woody shrub land (WS)	Shrubby grassland (SG)	Gras land (GL)	Shrub land (SL)	Mangrove forest (MF)	Agricultural land (AG)	Bare (BA)	Total
Sand mines	6	0	0	0	0	0	0	0	6
Woody shrub land	0	8	0	0	2	0	0	0	10
Shrubby grassland	0	0	8	1	1	0	0	0	10
Grassland	0	0	2	12	0	0	1	0	15
Shrub land	0	1	0	0	8	0	1	0	10
Mangrove forest	0	0	0	0	0	5	0	0	5
Agricultural land	0	0	0	2	0	0	12	2	16
Bare	0	0	0	0	0	0	2	10	12
Total	6	9	10	15	11	5	16	12	84

The identified sand mines on the generated spatial coverage were ground truthed using GPS to mark their actual location on the ground. The generated location database was then added to the spatial coverage to reconfirm the identified sand mines. In total six sand mines were identified on the surface of Mjanaheri-Ngomeni areas.

Using the measuring tape, the mines depths were measured and average depths computed. (Plate 2). Of the six, the three prominent mines were selected for the study purpose.

Plate 2: Measuring of sand mines depths

The line transect method (Warder *et al.,* 2004, Kent and Coker 1992, Muchoki, 1988) was used to collect plant species data. Plant species was sampled both in the mining and un-mined areas to determine changes in plants composition and distribution. To sample the mined areas or degraded surfaces, they were first covered by two transects which were of size 5 kilometres stretch and 1 kilometre spacing. Each transect was then subdivided into quadrates of size 20X 20 metres located 100 metres apart, from which plant species were collected.

The variables on which data were required are: species types and number of species per quadrate. A data collection sheet with the following characteristics: transect, quadrate, mined/ un mined area, species and species numbers. The species numbers were captured as observed frequencies (Annex 2).

The actual counting of species within a quadrat is usually a field problem. To overcome this problem in this study a species abundance-scaling tool was created (Table 3) whose characteristics included frequency range and an assigned frequency value. The frequency range in this study meant the number of species within a quadrat. The highest value in the range was used as the assigned frequency value

Similarly in the un-mined areas that served as the control, two transects measuring 5 kilometres were also set at one kilometre apart. Plots measuring 20 metres X 20 metres were also located at an interval of 100 metres along the set transects. Plant species occupying each plot were identified and their frequency recorded.

Table 3: Species abundance scale

Frequency range	Assigned frequency value
1-7	7
8-15	15
16-25	25
26-35	35
36 $\geq$ 50	50

In the mined areas 94 quadrates were sampled while in the un-mined areas only 80 quadrates were sampled. Some inaccessibility in the areas to be sampled caused the differences in quadrates numbers.

During plant sampling some plant species could not be readily identified. The unidentified plants were collected and immediately arranged in drying papers for preservation following procedures by Elzinga *et al.*, (1999), Kent and Coker (1992) and Ferguson *et al.*, (1987). They were flattened and spread out on sheets of newspapers and placed between drying-papers. For easy preservation, succulent plants /parts were killed by immersing them in methylated spirit, before spreading them on dry paper. The papers were regularly changed to avoid rotting of the specimen. The non-succulent specimens were treated with available preservatives (Para dichlorobenzene) to preserve them. The entire specimens were then pressed using field presses. The dried specimens were mounted on mounting sheet papers (42 cm by 27 cm) using cello tape. Labels containing site of collection and my name, as the collector were placed below each specimen, after which they were forwarded for identification at National Museums of Kenya.

Prior to the data collection exercise, the research assistants underwent a training exercise on use of relevant data tools to be used and data collection procedures. An area was identified where data collection tools were pre-tested. This is important, as it gives the data collectors a hands-on practice (Ferguson *et al.*, 1987).

Finally, open-ended questionnaires were administered to collect data from the sampled respondents (Annex 1). Data collection was based on single-visit approach so as to avoid repetitive interviews. To complement the primary data collection, photos were taken and observations on what is naturally occurring were noted. The other methods that the study used to collect data included extensive discussions with key informants. These included heads of departments responsible for natural resources management at the district level who provided data on different communities' uses of the environmental goods and services.

3.1.3 Secondary data

In order to assess the impacts of sand mining in Mjanaheri–Ngomeni areas, there was a need to collect some secondary data. This included natural resources statuses, availability and utilization, sand mining impacts on vegetation, accrued benefits, measures for sustainable sand mining and any conservation needs. . The study sourced the data by reviewing both published and un-published documents, reports, maps and other related materials from local data centers in the study area. Other related information was sourced from key Government Departments that include Kenya Forest Service (KFS); Kenya Wildlife Service; Ministry of agriculture; Ministry of Environment and natural Resources; Ministry of water and Irrigation; Ministry of Lands; DRSRS; National Museums of Kenya; KEFRI; KARI and ICRAF. Additional information was also collected from the Private Sector, NGOs and CBOs dealing in natural resources management in the area.

3.2 Questionnaire Data

3.2.1 Sampling Technique

This study had some financial and time constraints that governed its scope. A margin error of 0.05 was therefore preferred. According to Strokes *et al.*, (2004), Mugenda, and Mugenda (2003), Elzinga *et al.*, (1999), Ferguson *et al.*, (1987) a margin error of 0.05 is acceptable provided the sample size is over 10% or 30-50 observations. Studies by Elzinga *et al.*, (1999), on relationship of sample size to precision level, indicate that precision increases with sample size but not proportionally. Statistical benefits of increasing sample size diminish once one reaches about 30 samples. Any benefits to using more than sampling units relate to adequately capturing the variability in the population being sampled.

3.2.3 Determining the Sample Size

The sample frame consisted of all the households in the three settlement areas. An appropriate sample was obtained using the following formula (Ferguson *et al.*, 1987, Strokes *et al.*, 2004).

$$n = \frac{N}{1 + Ne^2}$$

Where: n = Sample size for the study area;

N = Total number of households in the area; and

e = Desired margin of error.

There are 7,291 households in the study area. This together with the margin error of 0,05 was computed into the formula. A sample size of 379 was therefore targeted for the study area. The sampling intensity was based on the distribution of human settlements. Systematic random sampling was used to achieve the desired representation. The District Environment Officer, area chief, elders and some members of the district environment committee provided additional information on settlement distribution and other population data in the area.

An open-ended questionnaire (Annex 1) was administered to gather data from local communities on issues relating to sand mining. Systematic Random sampling method was used in the selection of the respondents. A starting point was randomly chosen, and this was the first homestead in the first path encountered as one entered the study area from Mambrui town. Each and every other second homestead was visited. If a visit was made on the left side, then the next visit was made on the right side. A total of 187 questionnaires were administered. The data collection was based on single-visit approach so as to avoid repetitive interviews. Face-to-face interviews and discussions were also held with key informants / Focus Groups (FGD). These included Heads of Departments responsible for natural resources management at the district level, Non Governmental Organizations (NGOs) and other stakeholders.

3.3 Digital Elevation Model (DEM)

The study areas' DEM also known as digital terrain model (DTM), that is a representation of ground surface terrain was built using GIS techniques. Contours from Malindi District contour maps developed by the survey of Kenya were scanned and then screen digitized.

Shape files were generated and converted into Grid files using procedures provided in the Arc-View 3D analyst to generate the DEM.

A DEM highlights attributes of the terrain, such as elevation at any point, slope, aspect and other landforms that influence flow of water and other debris like soil. The DEM could be used in identifying suitable location for putting mitigation measures for desired out puts like flood control. Such measures include building of gabions or walls to deflect the surface runoff to designated areas.

3.4 Data Analysis Procedure

This study generated different land cover types for the study area. Testing of spatial data accuracy was done for the 2006 land cove map. Plant species were identified and their distribution noted in the mined and unmined areas. The sand mines were mapped and some properties like mines depths documented. A digital elevation model was also generated.

3.4.1 Statistical Data Analysis

The statistical data analysis was carried out to test for the differences in sand mines impacts. The species types and numbers were entered into a model for different tests with quadrats forming classes. The appropriate statistical test for differences in this study was Chi-Square test, which is a frequency difference statistical test tool. Before applying the statistical test, a descriptive statistics using graphical representations was applied to give a general tendency of the distribution of data collected. The SPSS software was used to run the Chi-Square analysis procedure and the results were tested in all cases at $\propto$=0.05.

CHAPTER FOUR

4.0 Results

This Chapter presents the results obtained from the field survey and is divided into three main sections. The first section presents the findings on changes in vegetation cover in the mining areas using time series remote sensing data. The second section looks at the status of the sand mines and their growth over time. It also discuses the impact of sand mining on plant composition and distribution in the mined area and compares them with those of the adjacent un-mined area. The third section looks at the social impacts of sand mining activities on the local communities.

4.1 Land Cover Changes

This study developed different land cover/use maps for the years 1992 and 2006. A total of eight (8) cover classes were identified and mapped for the year 1992, while nine (9) different cover types were identified and mapped for the year 2006. The land cover types identified were: Woody shrub land, Shrubby grassland, Grassland, Mangrove forests, Sand mines, Agricultural land, Bare, Water body and Shrub land. Table 4 gives a summary of the dominant plant species in the different cover classes.

The Woody shrub land areas were dominated by *Thespesia danis, Azadirachta indica, Dichrostachyus cinera, Julberdia magnistipulata, Brachystegia speciformis, Commelina benghalensis* and *Manilkara sulcata* plant species. Shrubby grassland areas were dominated by *Cordia sinensi, Capparis tomentosa, Croton pseudopulchelus, Solacia madagasceriensis, Flacourtia indica, Hensia crinita, Hoslundia opposita* and *Dactyloctenium*. Grassland areas were dominated by *Cynodon dactylon, Themeda triandra, Dactyloctenium scindicum, Indigofera colutea and Commelina benghalensis.* Shrubland areas were dominated by *Heinsia crinita, Cordia sinensis, Capparis tomentosa, Salacia madagasceriensis, Croton* species and *Commiphora linduesis* Mangrove forest areas were dominated by *Avicennia marina, Ceriops tagal* and Rhizophora *mucronata***.** Small-scale agriculture farms dominated the agricultural areas. Maize, beans cassava, sorghum, passion fruits, coconut, cashew nuts, mangoes, paw paws, bananas and spinach are grown in these areas.

Table 4: Cover classes and dominant plant species

Cover Class	Dominant Species
Woody shrub land	*Thespesia danis, Azadirachta indica, Dichrostachyus cinera, Julberdia magnistipulata, Brachystegia speciformis, Commelina bengharlensis, Manilkara sulcata.*
Shrubby grassland	*Cordia sinensis, Capparis tomentosa, Croton pseudopulchelus, Solacia madagascariensis, Flacourtia indica, Hensia crinita, Hoslundia opposita* and *Dactyloctenium* species
Grassland areas.	*Cynodon dactylon, Themeda triandra, Dactyloctenium scindicum, Indigofera colutea* and *Commelina bengharlensis*
Shrubland areas.	*Heinsia crinita, Cordia sinensis, Capparis tomentosa, Salacia madagasaeriensis, Croton species and Commiphora linduesis Dichrostachyus cinera, Abutilonn mauritianum, Strychnos madagascansis, Croton talaeporos Hoslundia opposita* and *Commelina bengharlensis.*
Mangrove forest	*Avicennia marina, Ceriops tagal and Rhizophora mucronata*
Water Body	Not captured
Sand mines	*Casuarina equistifolia, Azadiracta indica, Sienna siamea, Prosopis juliflora and Cantharanthus roseus.*
Bare	Not captured
Agricultural Land	*Zea mays* (maize), *Phaseolus vulgaris* (beans), *Manhot esculenta* (cassava), *Sorghum vulgare* (sorghum), *Passiflora edulis* (passion fruit), *Cocos nucifera* (coconut), *Anarcardium occidentale* (cashew nuts), *Mangifera indica* (mangoes), *Carica papaya* (paw paws), *Musa sapientum* (bananas) and *Spinacia oleracea* (Spinach)

Most of the sand mines were bare but the vegetated portions were dominated by *Casuarina equistifolia, Azadiracta indica, Sienna siamea, Prosopis juliflora* and *Cantharanthus roseus.* No plant species were noted in the bare and water body covers classes.

Changes in land cover from 1992 to 2006 are as represented in the two maps (Figures 5.0 and 6.0) below.

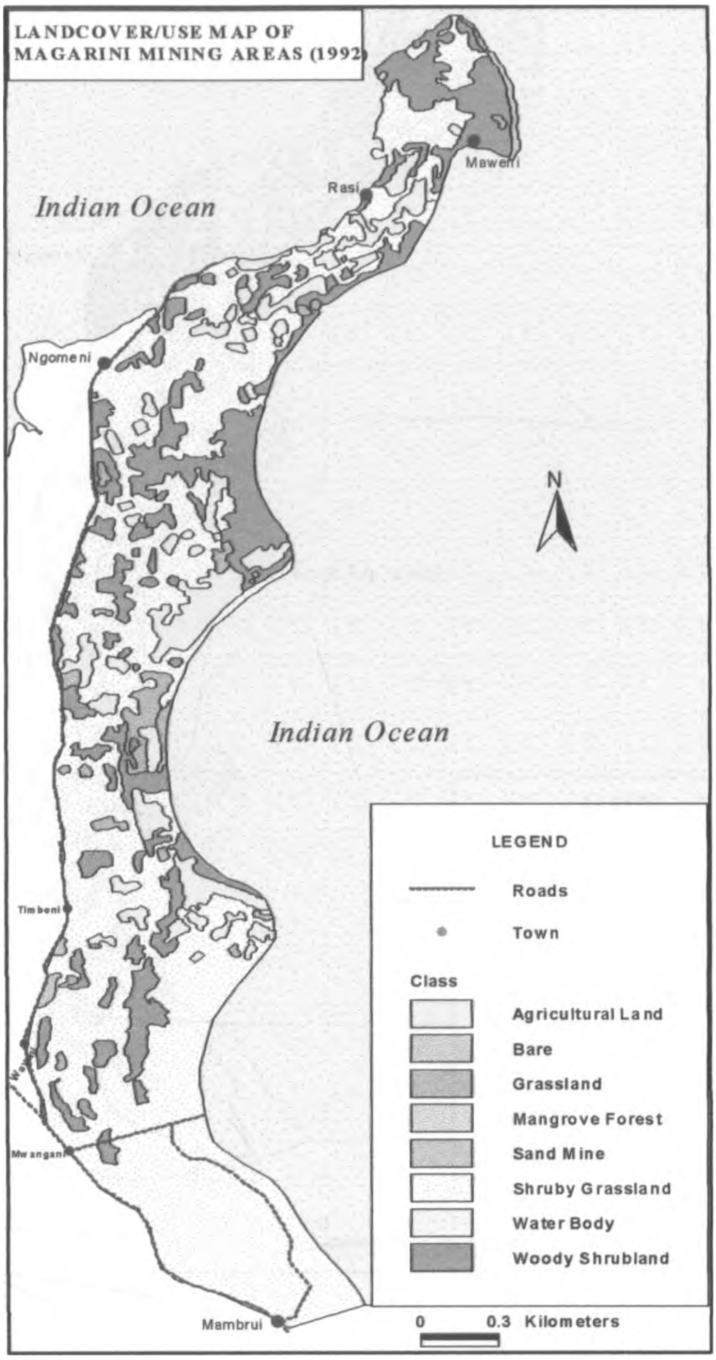


Figure 5: Land cover map of the year 1992

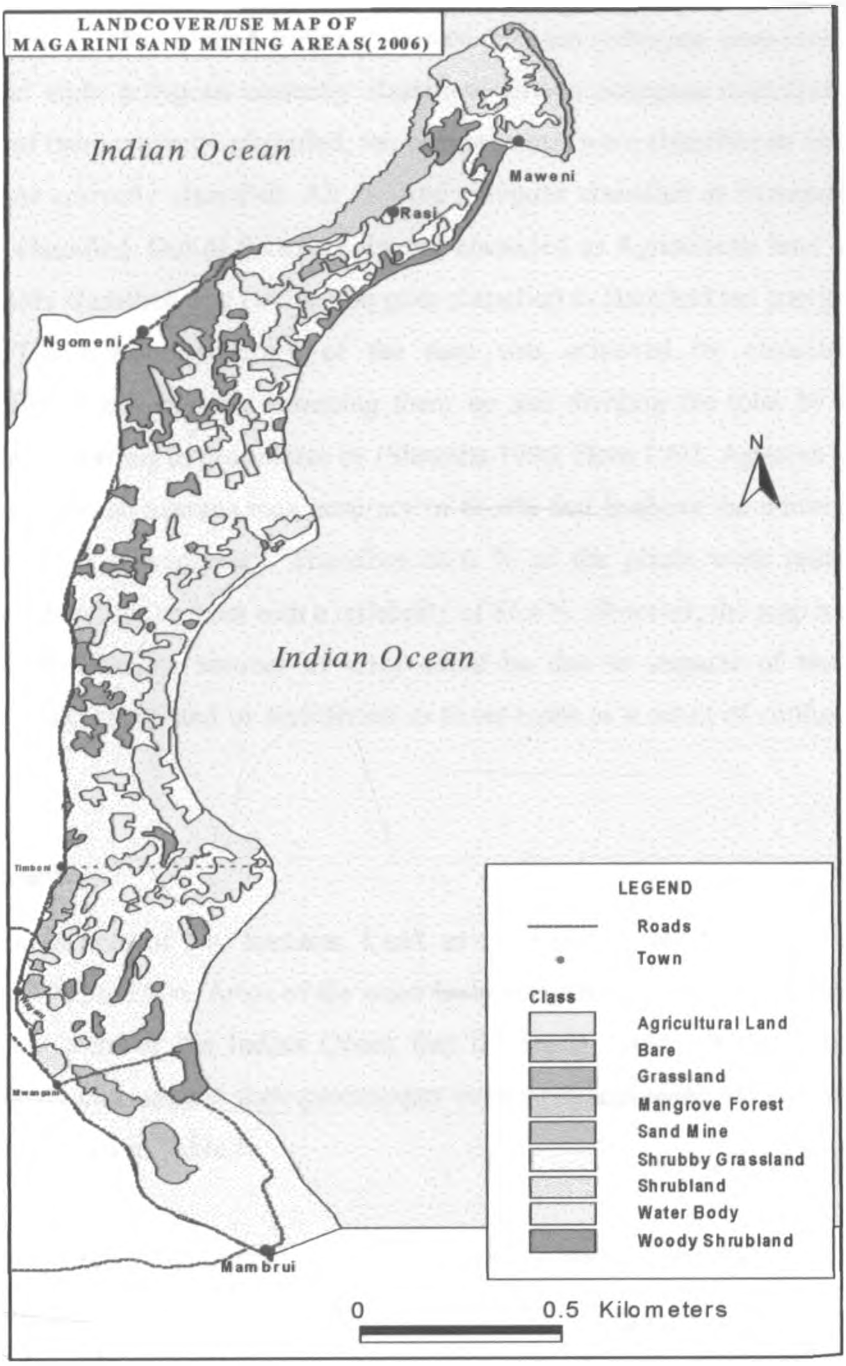


Figure 6: Land cover map of the year 2006

4.1.1 Map Accuracy

In calculating the accuracy of the land cover map of the year 2006, 84 samples were used. All the six polygons classified as sand mines during the photo interpretation were found correct during the ground truthing. Out of the ten polygons classified as woody shrub land eight were correctly classified. Further ground truthing showed that ten polygons classified as Shrubby grassland had eight polygons correctly classified; fifteen polygons classified as Grassland had twelve of them correctly classified; ten polygons that were classified as Shrub land and eight polygons correctly classified. All the five polygons classified as Mangroves forests were correctly classified. Out of Sixteen polygons classified as Agricultural land had twelve polygons correctly classified; the twelve polygons classified as Bare had ten polygons correctly classified. The average accuracy of the map was achieved by calculating percentages of the different cover types, summing them up and dividing the total by the number of cover classes according to procedures by (Shrestha 1996, Horn 1992, Agatsiva and Mwendwa 1992). This gave an average map accuracy of 86.6% that is above the minimum 80% required for this type of mapping. Therefore 86.6 % of the pixels were reliably classified. The map can therefore be used with a reliability of 86.6%. However, the map has a margin error of 13.4 %. Possible sources of error could be due to impacts of terrain characteristics on the photography and or similarities in cover types as a result of confusion among others.

4.1.2 Land cover changes

The study area covers an area of 340 hectares. Land cover changes were found to have occurred from the year 1992 to 2006. Areas of the water body cover type were not considered in the analysis, as they were of the Indian Ocean that the study could not put a clear boundary. The land cover changes and their percentages were computed using the Arc view software and the results shown in Table 5.

Areas under sand mining were found to have increased from 8.713 hectares in 1992 to 30.335 hectares in 2006 denoting a cover change of 6.36 %. Woody Shrub land areas reduced from 64.04 hectares to 53.451 hectares denoting a change of 3.1 %. Shrubby grasslands area reduced by 6.58%, from 207.79 hectares to 185.404 hectares. Grassland areas reduced by 1 68 % from 12.405 hectares to 6.679 hectares. Bare land areas increased by 1.82 % from 9.34 hectares to 15.543 hectares. Agricultural land declined by 1.7 % from 35.739 hectares to 29.43 hectares. A new cover type Shrub land, covering 15.117 Hectares was found to have evolved near the sand mines within the period 1992 to 2006.

Table 5: Land Cover Changes for the years 1992 and 2006

Class	Hectares Year 1992	Percentage of total area (%)	Hectares Year 2006	Percentage of total area (%)	Cover Change (HA)	Percentage Change (%)	Positive or Negative Changes
Sand mines	8.71	2.56	30.34	8.92	21.62	6.36	+ve
Woody shrub land	64.04	18.8	53.45	15.72	10.59	3.1	-ve
Shrubby grassland	207.79	61.11	185.41	54.53	22.39	6.58	-ve
Grassland	12.41	3.65	6.68	1.97	5.73	1.68	-ve
Shrub land	-	-	15.12	4.45	N/C	*N/C	* ve
Mangrove forest	2.09	0.61	3.67	1.08	1.58	0.46	+ ve
Agricultural land	35.74	10.51	29.94	8.81	5.796	1.7	-ve
Bare	9.34	2.75	15.54	4.57	6.20	1.82	+ ve

* N/C No change.

Mangrove forests cover increased by 0.46 % from 2.09 hectares to 3.674 hectares. This study associated this increase to ongoing reforestation programmes around Ngomeni town through collaborative efforts of NGOs, local communities and other stakeholders (Plate 3). The salt farms that the local communities blame for destruction of the mangroves, especially Mombasa salt works are praying a key role in the rehabilitation programmes.

Plate 3: Reforestation of mangrove areas around Ngomeni town

4.2 Digital Elevation Model

A Digital Elevation Model (DEM) of the study area was developed (Figure 7). It formed a digital representation of the area giving a clear visualization of the topographic surface. DEM is useful in terrain stability analysis necessary for planning and management of soil erosion and flooding risk. Studies by (Skidmore 1989) establish DEMs as efficient tools for mapping landslide risk, debris flow and flooding risk. Surface runoff is one of the limiting factors to the rehabilitation process of the sand mines through choking of the seedlings. The DEM highlights the attributes of the terrain, such as elevation at any point, slope, aspect and other landforms that influence flow of water and other debris like soil. The DEM revealed that the sand mining areas fall in a region whose elevation is 0-20 metres above the sea level (ASL), and the highest points in Malindi District are 130 metres. It generally gives information on where high and low lands areas are. This information could be used in planning for flood control to allow rehabilitation of the abandoned sand mines.

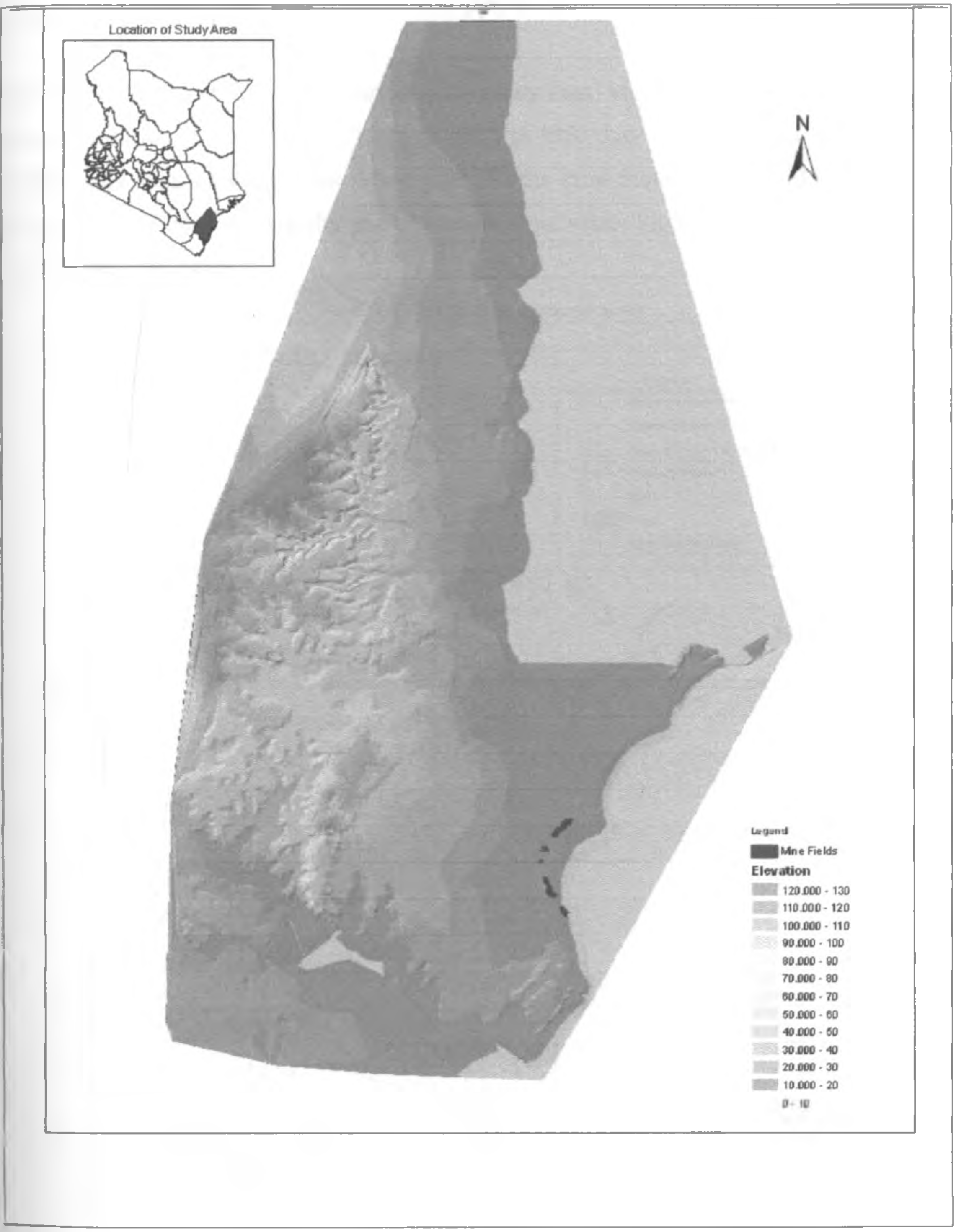


Figure 7: Digital Elevation Model of the study area (Elevation in meters)

4.3 Extent of the sand mines

There are three major sand mining areas in the study area. Mining activities were started in Magarini division at what are now Timboni wells in 1956. Later, the activities spread to the neighbouring areas of Wayani and Mwangani. All the three mines are currently operational but have big abandoned areas that are of no economic value. Figures 8.0 below, shows the extent of the sand mines.

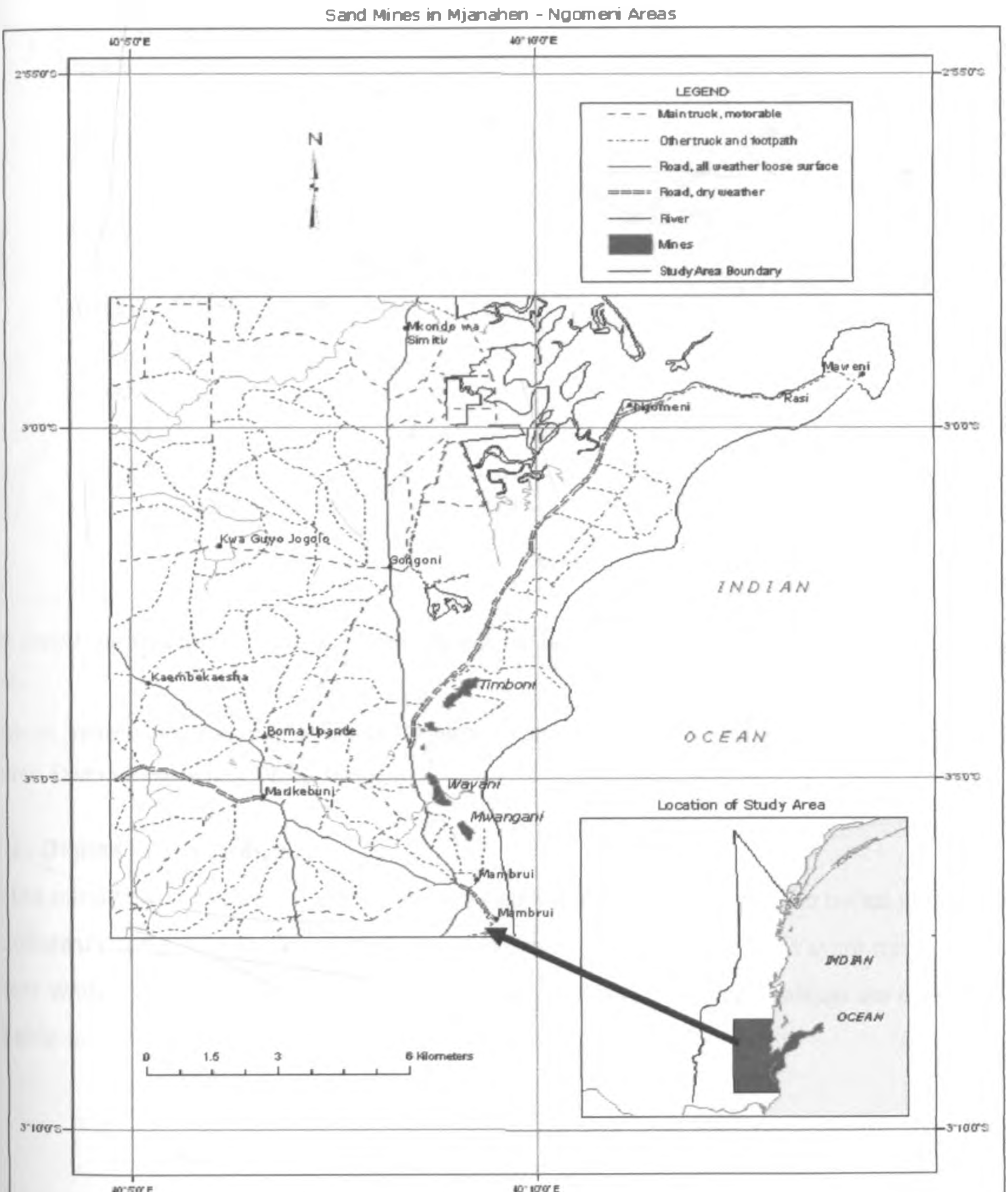
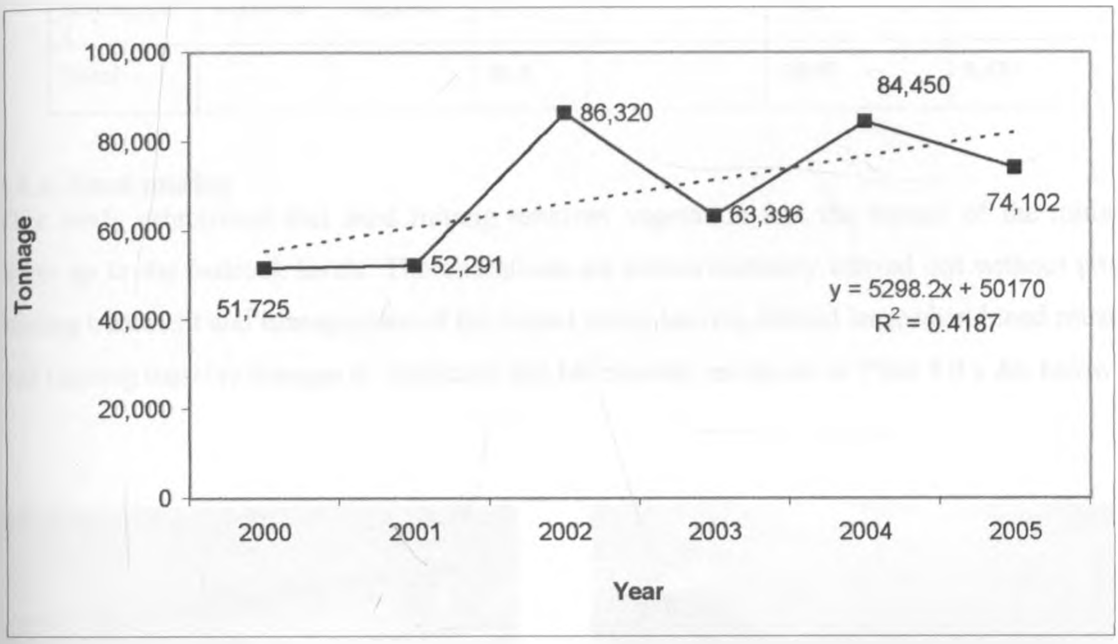


Figure 8: Map of the sand mines

The mining activities are steadily increasing with time. Figure 9 below depicts the amounts of sand mined from the area from the year 2000 to 2005. A total of 51,725 tones were mined in the year 2000, increasing to 74,102 in year 2005. The years 2002 and 2004 showed the highest sales due to better marketing strategies. The trends indicate that the quantities of sand mined are bound to increase in the future leading to more areas being opened for sand mining to satisfy the high demand



**The dotted line depicts the general trend while the full line shows the changes in the actual extracted over the years*

Figure 9: Volume of mined sand between year 2000 and 2005
(Source: District Environment Office, Malindi).

4.3.1: Depths of sand mines.

All the mined out areas have the sand removed up to the bedrock levels. The mines are also of different depths. Mwangani mines have an average depth of 3 meters; Wayani mines 2.5 meters while Timboni mines have an average depth of 3 meters. These findings are presented in Table 6.

Table 6: Sand mine areas and depths

Mine Name	Sub-Location	Location	Area (HA)	Average Depth (Meters)	Abandoned Area (HA)	Active Area (HA)
Timboni	Ngomeni	Ngongoni	16.2	3	12.14	4.05
Wayani	Mambrui	Magarini	6.8	2.5	4.37	2.43
Mwangani	Mambrui	Magarini	7.4	3	4.45	2.95
Total			**30.4**		**20.97**	**9.43**

4.3.2. Sand mining

This study established that sand mining removes vegetation and the topsoil of the mined areas up to the bedrock levels. The operations are indiscriminately carried out without post mining treatment and management of the mined areas, leaving behind large abandoned mines and causing massive damage to landscape and biodiversity as shown in Plate 4.0 a &b below

(a)

(b)

Plate 4: (a) Sand being loaded into lorries for transportation and (b) a newly opened sand mine

In addition to the vegetation cleared to pave way for sand mining, the mining leave behind open voids with steep slopes that encourage soil and vegetation loss. Vegetation falls off and is lost due to edge effects as shown in plate 5 below.

Plate 5: Loss of vegetation through edge effect in the mined areas

Most of the sand is mined for commercial purposes and to a smaller extent for local consumption. The mode of transportation of the sand is by lorries. In some instances the heavy trucks get stuck in the mined areas and vegetation from surrounding area is cut and laid on the wheel tracks for their easier movement (Plate 6 a & b). With time the laid vegetation is smothered by the heavy trucks and no longer serves the functions it was intended to. More vegetation has to be cut and laid on the same paths. This contributes to the degradation of vegetation around the sand mines

(a)

(b)

Plate 6: (a) Fresh and (b) old vegetation laid on the lorries tracks to avoid getting stuck

There is also a lot of off-road movement of trucks and other vehicles that cause further damage to vegetation and in general destruction of the area. These two processes have augmented loss of vegetation around the areas.

This study identified some plant species that are rare and endemic in the area. These include:

- *Aloe species (Kitonzi- Giriama)*
- *Carissa edulis (Mtandamboo-Giriama)*
- *Zanthoxylum chalybeum (Mdhungu, Mjafari-Giriama)*
- *Ximenia americana* (Mtundukula –Giriama) and
- Encephalartos hildebrandtii (Kitsapu –Giriama)

Plate 7 shows *Encephalartos hildebrandtii,* one of the rare and endemic species to the area. The indiscriminate sand mining activities pose threats to these plant species.

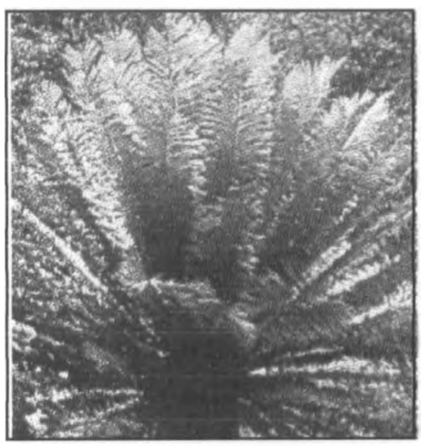


Plate 7: *Encephalartos hildebrandtii.* A rare and endemic species in Mjanaheri-Ngomeni areas.

4.3.3 Floristic Composition and Distribution in mined and un-mined areas

This study looked at the composition and distribution of plant species in varying distances in the mined and un-mined areas. The two areas showed varied composition in plant species.

Species composition and distribution in mined areas

Comparisons were made of plant species in regions of varying distances in the sand mined areas. Differences were noted in plant species numbers and composition in areas, which were 1 km and 2 km respectively away from the mined areas. A total of 451 herbs, 2,012 shrubs, 1,408 trees, 73 grasses, were recorded in transect one which was located 1 kilometer away from the sand mines. In transect two which was located another one kilometer from the first transect a total of 1,286 herbs 2,740 shrubs, 1,771 trees and 553 grasses were recorded (Figure 10.0).

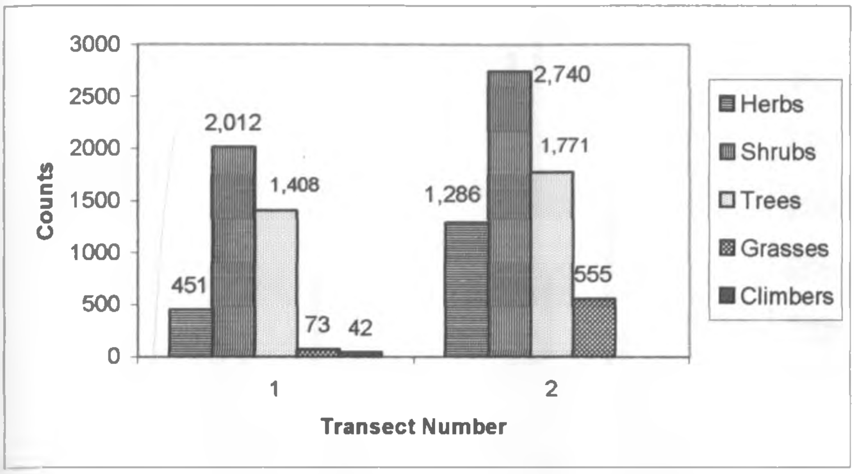


Figure 10: Plant types composition and distribution in mined areas.

(The number 1and 2 represents species found in regions that were 1and 2 Kilometers respectively from the sand mines)

The study also analyzed variations in plant families in different regions of the mined areas and noted differences in regions that were 1 and 2 kilometers from the sand mines. A total of 48 different tree families were observed in the mined areas. Out of these 37 families were observed in both the I and 2 kilometers regions from the sand mines. However, 10 more plant families were observed only in the region that were 2 kilometers from the sand mines. These were:

- Boraginaceae
- Vitaceae
- Cycadaceae
- Loranthaceae
- Opiliaceae
- Hypericaceae
- Convulvulaceae
- Compositaceae
- Pedaliaceae
- Celastraceae
- Incancinaceae.

One family species, incancinaceae was only recorded in regions of one kilometer from the sand mines.

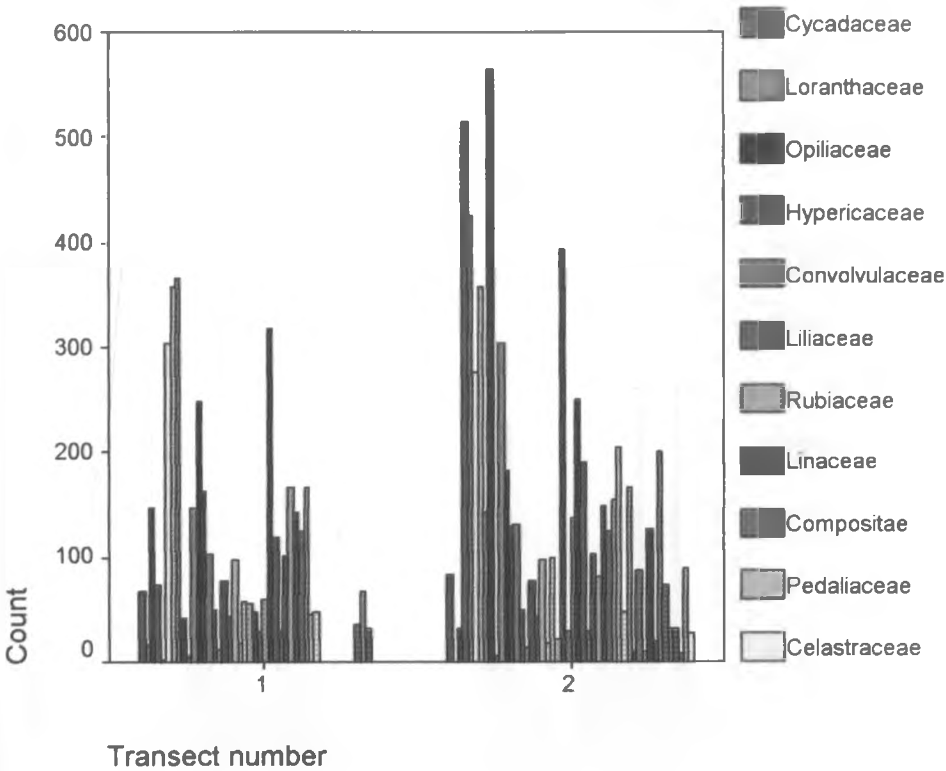


Figure 11: Plant families' distribution in regions of 1 and 2 kilometers respectively from the sand mines

4.3.4 Plant Species distribution and Composition in the mined and un-mined areas

A comparison of the composition and distribution of plant species in the mined and un-mined areas was carried out. Distinct differences in plant composition were noted. Higher numbers of all the species were noted in the un-mined areas other than for the climbers that are found in the mined areas only. A total of 1,736 herbs, 4,752 shrubs, 3,179 trees, 628 grasses and 42 climbers were recorded in the mined areas. In the un-mined area a total of 6,094 herbs, 12,643 shrubs, 8,466 trees, and 1,263 grasses were recorded (Table 7).

Table 7: Composition and distribution of plant types in mined and unmined areas

	Mined Area	Un-mined Area
Trees	3,179	8,466
Shrubs	4,752	12,643
Herbs	1,736	6,094
Grasses	628	1,263
Climbers	42	*
Total	10,337	28,466

* Not observed

The study also noted differences in plant species composition in the mined and un-mined areas (Figure 12)

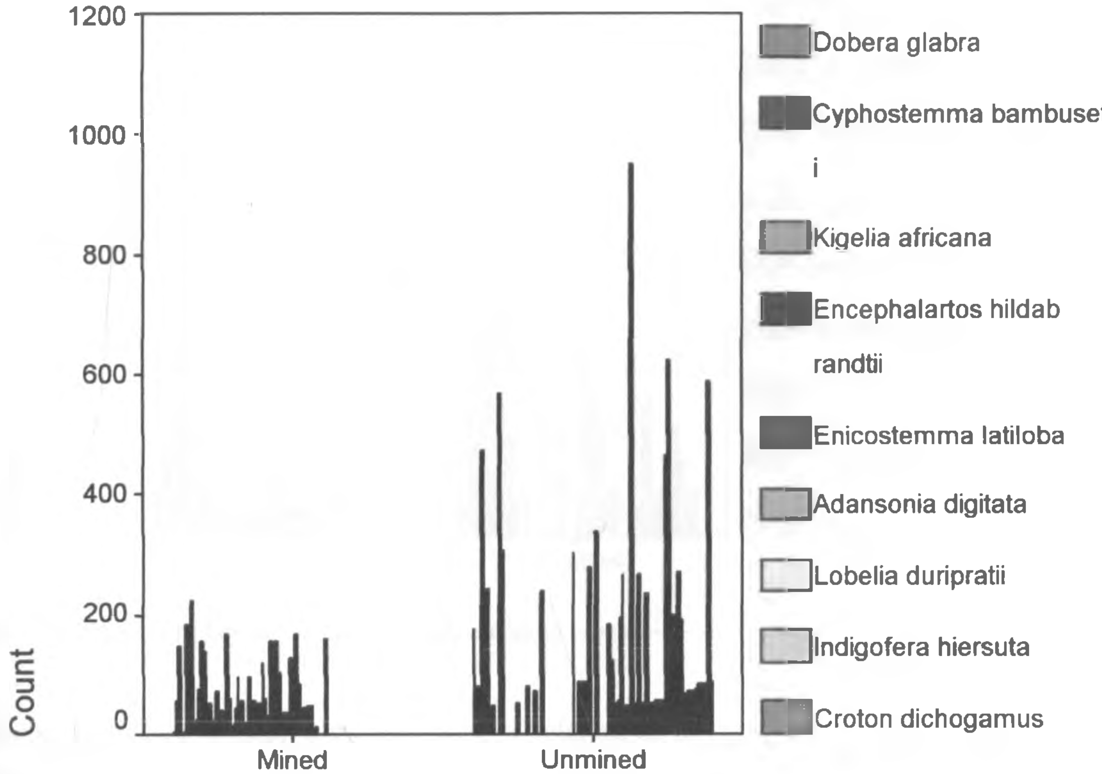


Figure 12: Differences in plant species distribution in the mined and un-mined areas

Differences were also evaluated in plant families' composition in the mined and un-mined areas. Figure 13 shows an evaluation of the plant families in the mined and un-mined areas. The un-mined areas showed a relatively higher family density than the mined areas. Occurrence of more families were noted in the un-mined areas than the mined areas.

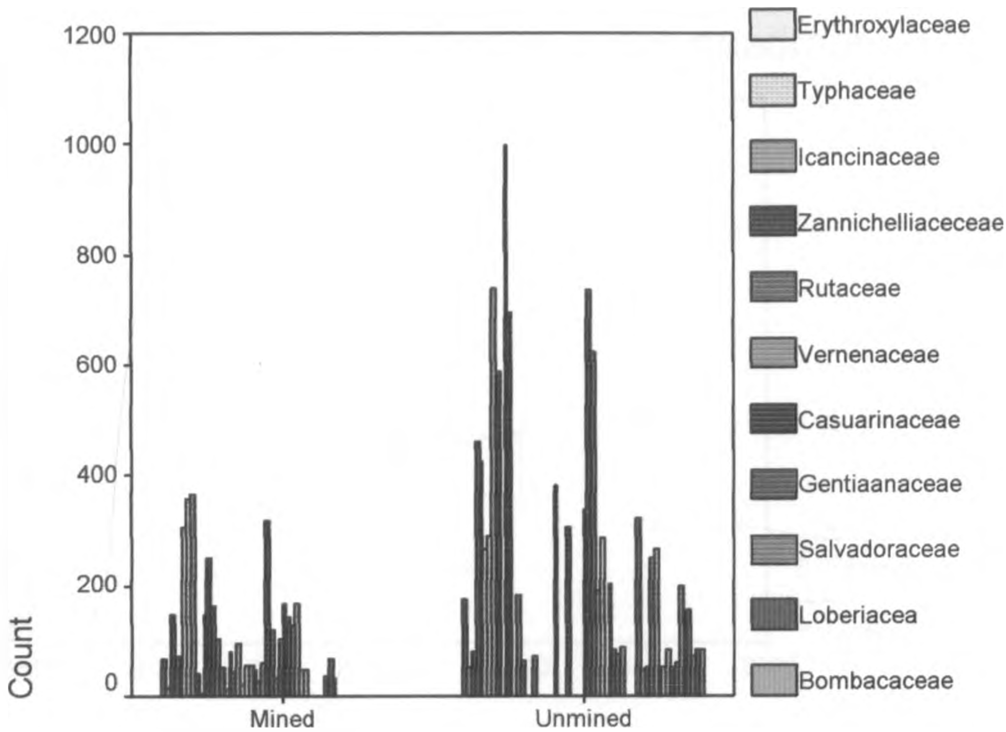


Figure 13: Difference in families in the unmined and mined areas

Differences in plant species were evaluated in relation to the horizontal distance from the mined areas. As the distance increased from the mined to un-mined areas, there was a noticeable increase in plant species abundance in the quadrates (Figure 14). Quadrates which were close to the mined area had less species abundance compared to those that were far off.. This indicates that sand mining had reduced the number of plant species in areas close to the sand mines.

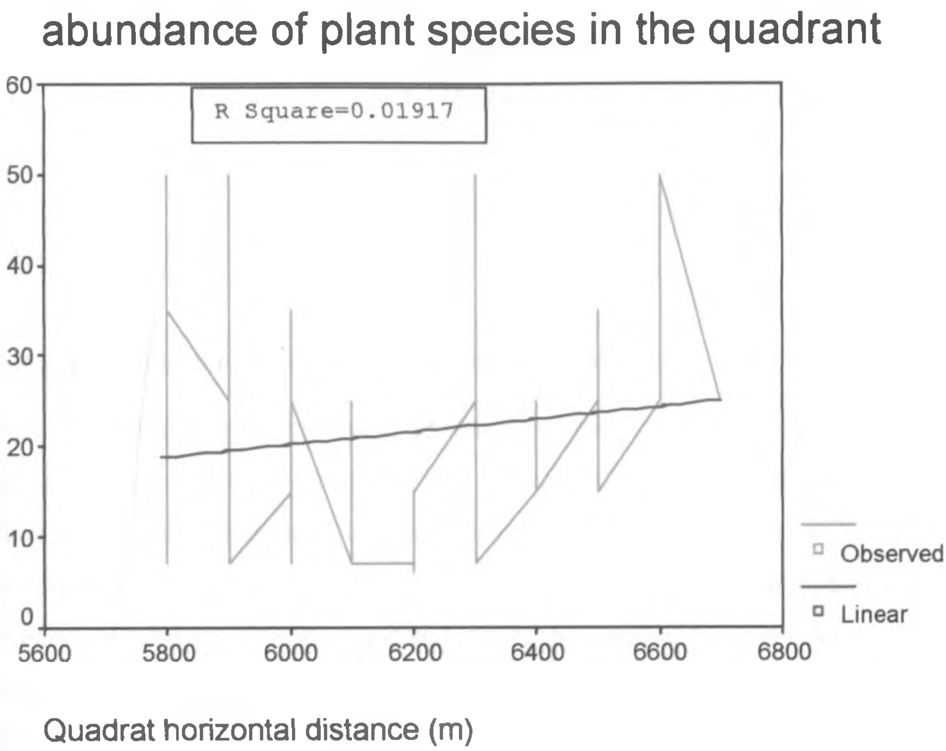


Figure 14: Increase in plant species abundance with horizontal distance increase from mined areas

4.4 Statistical Test

Differences in plant species composition in the mined and unmined areas were used to test the hypothesis that sand mining practices does not influence species composition and distribution. A non-parametric test Chi-square, was used to analyse the differences in vegetation in the mined and un-mined areas using SPSS software, at ∝=0.05 /95%. Table 8 below show the result of the Chi-Square test.

Table 8: Chi-Square Test Results

	Calculated value	Critical value	Degrees of Freedom (df)	Asymp. Sig. (2-sided)
Pearson Chi-Square	9904.052	1.980	105	.000
N of Valid Cases	14281			
9 cells (4.2%) have expected count less than 5. The minimum expected count is 84.				

Decision

The statistical test indicates that the $\chi 2$ Calculated is > than $\chi 2$ Critical. The null hypothesis is therefore rejected at a confidence level of 95%, and the alternative hypothesis is accepted. This means that on the basis of the data available there is sufficient evidence that the differences in vegetation composition and distribution are not due to chance but by sand mining.

4.5 Perception of local communities to sand mining

A total of 187 questionnaires were administered and analysed to assess the impacts of sand mining activities on the environment and livelihoods of the local communities. One hundred and thirty of the respondents were males (69.5%) and fifty-seven were females (30.5 %). The respondents were categorised into 3 main age classes, which included young adults (18 - 35 years), middle age (36-60 years) and elders (60 years and above). Most of the respondents were between 36 and 60 years (Figure 13.0) below shows responses on the impacts of sand mining activities on the environment in respect to gender and age.

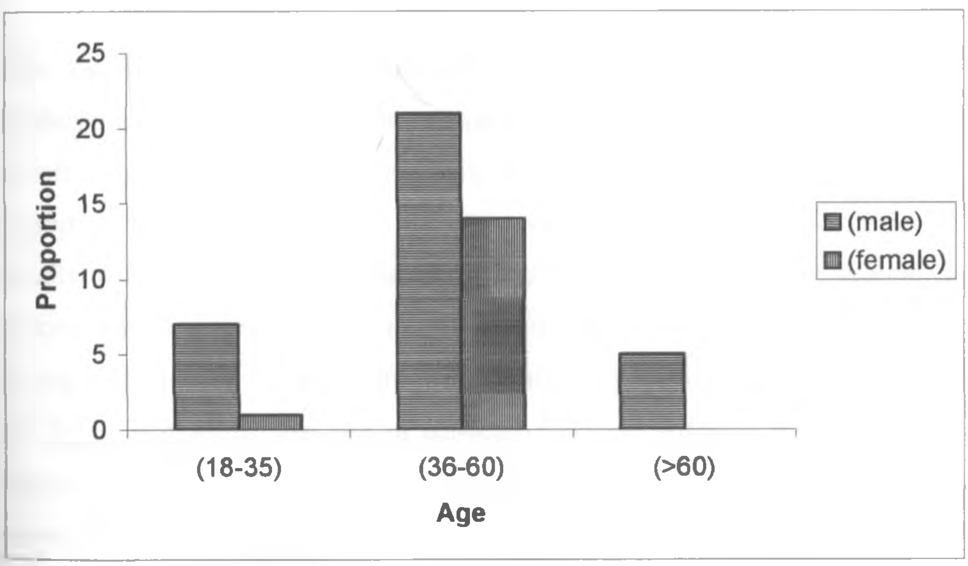


Figure 15: Respondents age and gender

The young and old expressed different perceptions and interests on sand mining activities. Respondents in the age groups of 18-35 years and those aged over 60 years showed less concerns when compared to those in the 36-60-age bracket. Gender of the respondents also showed varied feelings on environmental degradation caused by the sand mining activities. Sand mining activities are considered a men affair, as they are mostly the owners of land. The men noted that there were no guidelines in existence to guide mining activities. Most of the women interviewed were reluctant to give their opinions freely in presence of men but they were more concerned that the mining activities had increased the distances covered in search of fuel wood, medicinal plants and grazing. There is a need therefore for policy makers, natural resource managers and planners to develop policies on sand mining and rehabilitation that are guided by gender-sensitivity.

The research findings established that sand mining activities have been increasing over time. After an area has been mined, the local communities have no ready use of these areas. They abandon the area and move to new sites where vegetation and the topsoil are removed causing enormous damage to vegetation. The findings support studies by Fox (1996) who found that sand mining has historically resulted in long-term changes to biodiversity in Australia. The study area is located near Malindi and Mombasa towns where there is increasing demand for sand for construction and other industrial development. The sand mining activities are bound to continue destroying vegetation and the social life of the local communities.

This study established that other mining-related infrastructure developments like roads establishment also contribute to mechanical destruction of vegetation in the area. These kinds of infrastructure developments can have significant negative consequences for vegetation for example, creating opportunities for invasive weeds. Most of the lorries that carry sand usually will have brought livestock for sale. As the lorries drive around the sand mines looking for cheaper sand, cattle dung that has usually *prosopis juliflora* seeds from their area of origin, drop off introducing the weed in the area. This is in line with studies by (Noble *et al.*, 1996) that found that use of off-road vehicles; enhance spread of weeds and related vegetation diseases. The combined extent of these impacts can be far greater than those occurring within the mining areas

The sand mines are located near natural waterways and the permeability of the material in the floors and walls increases their water retention capabilities causing filling of the mines with water. The presence of water in the mines attracts concentrations of livestock in search of water around the mines. The populations of livestock overgraze the sand mining areas, a process that leads to plant species depletion (Plate 8 (a&b)). This is in agreement with studies by De Leeuw *et al.*, (2001) and Stoddart *et al.*, (1975) who observe that livestock species require drinking water either every day or every other day degrade areas surrounding the water sources. This is usually through losses in vegetation cover and hence contributes to soil erosion through wind and water

(a)

(b)

Plate 8: Livestock taking water in abandoned sand mine and (b) an overgrazed area around the sand mines

During the rainy seasons, the abandoned mines become small lakes and are a threat to people, livestock, wildlife and rehabilitation efforts (Plate 9 (a &b))

(a)

(b)

Plate 9: (a) Flooding of a newly mined area and (b) a fully flooded sand mine

The flooded sand mines also serve as breeding areas for harmful insects such as mosquitoes and other microorganisms.

4.6 Recent initiatives to rehabilitate the mines.

There has been an effort to rehabilitate the sand mines by the local communities, NGOs, Government Departments and other stakeholders. Plant species that have been planted include: *Casuarina ecquisetiofolia, Azadiracta indica.* and *Sienna siamea.* The Planted species and their numbers are shown in Table 9 below.

Table 9: Rehabilitated sand mines

Mine	Area (Acres)	Rehabilitated area (Acres)	Species planted	Quantity of trees
Timboni	40	17	*Casuarina ecquisetiofolia,*	4,500
			Azadiracta indica	8,000
			Sienna siamea	1,600
Wayani	16	2	*Casuarina ecquisetiofolia*	1,840
Mwangani	18	2	*Casuarina ecquisetiofolia*	1,000
			Azadiracta indica	
Total	74			16,940

Source: Magarini sand mines records office (2006)

Timboni mine is the largest mine covering approximately 40 acres, of which seventeen acres have been rehabilitated with a total of 14,100 seedlings. Of these there are 4,500 are *Casuarina acquisetiofolia,* 8,000 are Azadiracta *species* and 1,600 *Sienna siamea* seedlings. Survival rates are at 65 percent. However, the study found many seedling dying. This was attributed to flooding, diseases and the rocky nature of the mines. The local communities attribute the death of the seedlings along the Timboni–Ngomeni road, to the seepage of waste salt water from Mombasa salt work that is opposite the road. In Wayani mines, a total of 1,800 seedlings of *Casuarina acquisetiofolia* have been planted. Most of the seedlings have died due to flooding. Survival rate was approximated at 45 %. The hardest hit are Mwangani mines where in the year 2006, local communities, lead agencies and other stakeholders organized sand mines rehabilitation exercise. A total of 1000-tree seedling of *Casuarina acquisetiofolia* and *Azadiracta* species were planted. However exceptionally high rainfall was experienced and the mines were flooded and all the seedlings were destroyed.

Wayani sand mines have some parts that are relatively raised and were therefore not flooded There are about two acres planted with approximately one thousand eight hundred and forty (1,840) seedlings. The survival rate is at sixty percent.

4.5.1 Colonization of sand mines

The stony nature of the sand mines is nutrient deficient and makes the natural revegetation process slow. However some invasive species (*Prosopis juliflora* and *Cantharathus roseus*) tolerate the harsh conditions and have encroached into these areas. (Plate 10)

Plate 10: Colonization of the sand mines by *Prosopis juliflora* and *Catharanthus roseus*

This study established that *Prosopis juliflora* is widely spread in the mined out areas either by intentional introduction by the local communities as a rehabilitation measure or spread by livestock that come to drink water in the ponds. Other introductions are through Lorries that transport livestock for meat from *Prosopis juliflora* invested districts like Garrissa, Wajir, Mandera and Tana River. These vehicles are usually hired to carry sand to various destinations after accomplished missions with the livestock owners. The dung from these livestock contains *Prosopis juliflora* seeds that either fall off or are swept out of the lorries. The seeds then germinate in and around the sand mines. The *Prosopis juliflora* plants grow aggressively, invade vast areas and produce millions of seeds. These seeds give rise to *prosipis* plant species that pose risks to local livestock after there are feed on as illustrated below (Plate 11). Goats prefer eating the ponds that spoil their teeth due to high concentrations of sugars. The cattle eat leaves that have thorn that cause injuries to their stomachs that lead to deaths. The thorns are also poisonous in nature and inflict dangerous wounds to humans (Maundu and Tengnas, 2005).

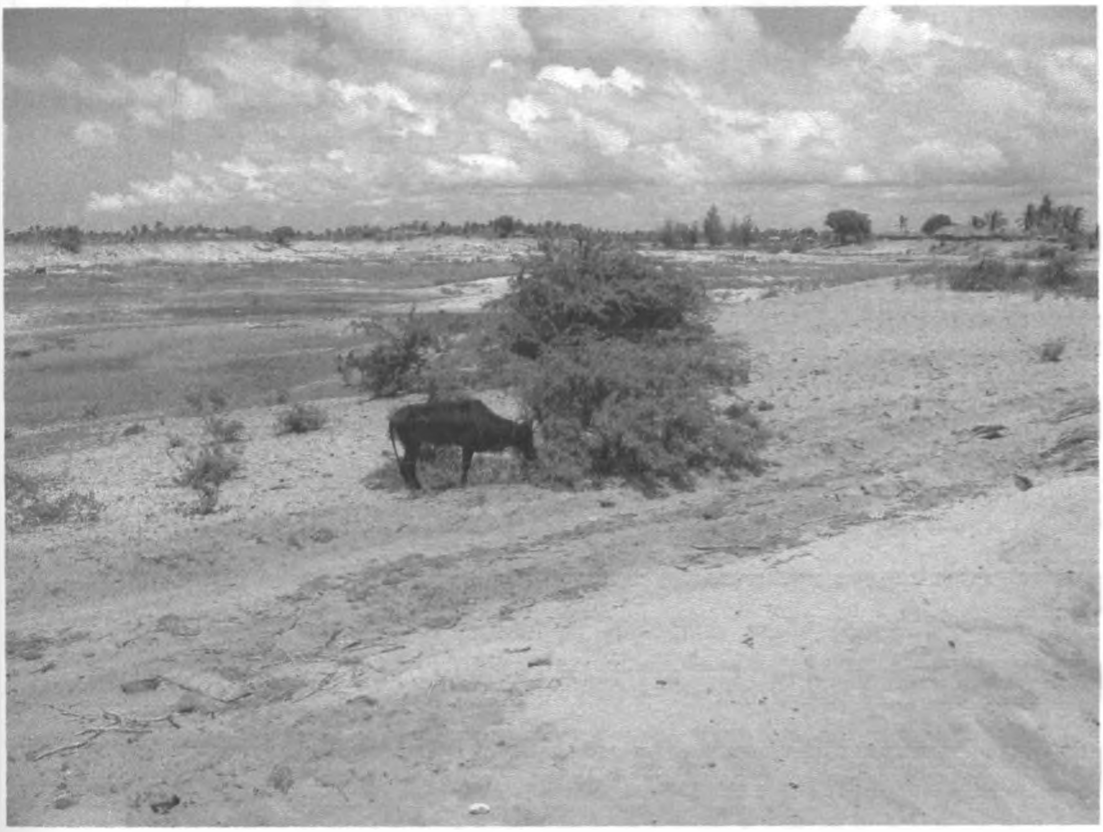


Plate 11: Livestock feeding on *Prosopis juliflora* plant species.

4.7 Sale of Sand

Out of the total 187 questionnaires administered in the study area, 54 respondents who were directly involved in the sale of sand. Of these, 20 sold their sand individually, 14 sold through cooperative and another 14 through both means every month (Figure 16). This represented 88.9% of all the sand mined. However there were other 6 cases representing the remaining 11.1 % who were reluctant to disclose how they sold their sand. The prices of sand are relatively low (Kshs.300 per tone of sand) and encourage continuous mining by the local communities to meet their needs.

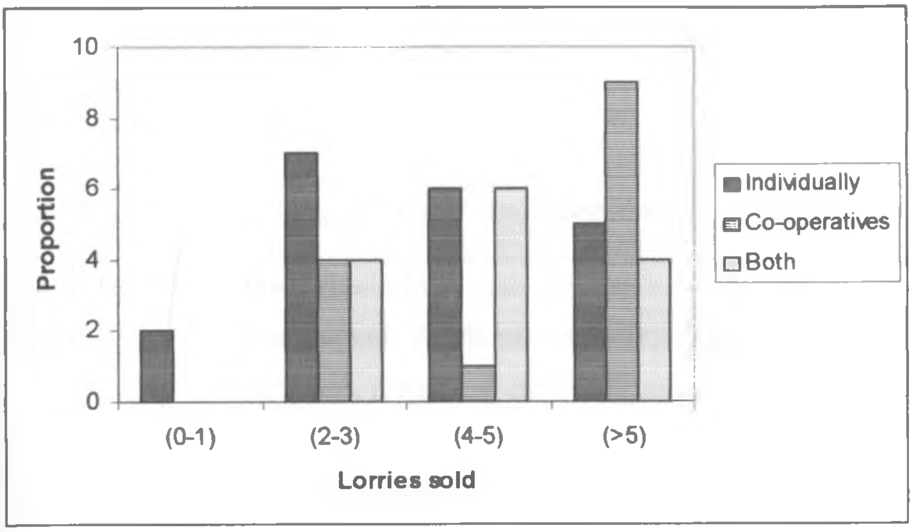


Figure 16: Mode of sale for sand in the study area

4.8 Utilization of plant species by the local communities

The local communities in Magarini division like any other African community have broad use of plant species. Plants provide fruits, leaves, roots or other parts that are fit for human consumption. Other plants provide fodder for the livestock; others contain drugs, which are widely applied in human and /or veterinary medicines while others are used for the construction of houses and other items of cultural values. Most plants have clearly defined place in the life of the local communities either through their material, economic and cultural values.

The plant uses were grouped into four uses groups namely: fodder, food, medicines and cultural material. The plant groups and their specific uses are shown in Table 10 below.

Table 10: Local Communities plant uses

Use group	Species use
FODDER (FO)	Dry and wet seasons grazing
FOOD (FD)	Fruits, vegetables, roots and tubers, soup, beverage and gum-resins
MEDICINE (MD)	**Human:** Headache & colds, eyes, ears mouth, sore throat, chest, coughs, asthma stomach, diarrhoea, dysentery, intestinal worms, venereal, menstruation, pregnancy, child birth, malaria, aphrodisiac, rheumatism, wounds and burns. **Livestock:** East coast fever, diarrhoea, worms, delayed placenta, liver flukes, trypanosomiasis, red water and mad dog.
CULTURE MATERIAL (CM)	Building houses, posts, carvings, building boats and dhows, firewood, fire drill, live and dead fencing, walking sticks, clubs, bows, arrows, bee hives, bee foliage, cattle troughs, stools, tool handles, dyes, preservatives, beddings, tooth brushes, traditional ceremonies, grave marks and coastal erosion control

Ranking was done of all the plant species that the local communities attach some use. The highest rank (1) was given to all plant species that the local communities attached four uses. Rank (2) was given to the species that the local communities attached three uses. Ranks 3 and 4 were given to those species with two and one uses respectively. *Carissa edulis, Cordia sinesis, Flacourtia indica, Grewia tenax, Lannea schweinfurthii, Prosopis julliflora, Thespesia danis* and *Ximenia americana* were found to be some of the most used species by the local communities. Table 11 below shows the plant species and their ranked uses.

Table 11: Ranked major plant use

Plant species	Family Name	Total number and types of local uses	Ranking
Acacia brevispica	Fabaceae (Mimosaceae)	CM, FD, MD	2
Adenium obesum	Apocynaceae	CM, FO, MD	2
Anacardium occidantale	Anacordiaceae	FD	4
Avicenna marina	Verbenaceae	CM, FD, MD	2
Azadirachta indica	Meliaceae	CM, MD	3
Cantharanthus roseus	Apocynaceae	MD	4
Capparis tomentosa	Capparidaceae	CM, MD	3
Carissa edulis	Apocynaceae	CM, FD, MD, FO	1
Cocos nucifera	Arecaceae (Palmae)	CM, FD	3
Commiphora linduesis	Burseraceae	CM, FO	3
Cordia sinesis	Boraginaceae	CM, FD, MD, FO	1
Cynodon dactylon	Cycadaceae	CM	4
Dichrostachyus cinerea	Mimosaceae	CM, FO	3
Flacourtia indica	Flacourtiaceae	CM, FD, MD, FO	1
Euphorbia tirucalli	Euphorbiaceae	CM, MD, FO	2
Garcinia livingstonei	Guttiferae	CM, FD, MD	2
Grewia plagiophylla	Tiliaceae	CM, FD, MD	2
Grewia similis	Tiliaceae	CM, FD, MD	2
Grewia tenax	Tiliaceae	CM, FD, MD, FO	1
Grewia villosa	Tiliaceae	CM, FD, MD, FO	1
Hibiscus greenwayi	Malvaceae	CM	4
Lannea schweinfurthii	Anacardiaceae	CM, FD, MD, FO	1
Landolphia kirkii	Apocynaceae	FD, MD	3
Manilkara sansibarensis	Sapotaceae	CM, FD, MD	2
Manilkara sulcata	Sapotaceae	CM, FD, MD	2
Prosopis julliflora	Fabaceae (Mimosaceae)	CM, FD, MD, FO	1
Sateria sagittifolia	Gramineae	CM	4
Solanum incanum	Solanaceae	MD	4
Terminalia spinosa	Combretaceae	CM, FD, FO	2
Thespesia danis	Malvaceae	CM, FD, MD, FO	1
Themeda triadra	Gramineae	CM	4
Thylachium thomasii	Capparidaceae	CM, FD, MD	2
Ximenia americana	Olacaceae	CM, FD, MD, FO	1

Key: (*MD-medicine, FD –food, FO –fodder, CM –culture material)*

1= Four uses, 2=Three uses, 3=Two uses and 1=One use

4.9 Infrastructure destruction

In Wayani area, sand mining was found to have caused threats to roads, water pipes and telephone and electricity lines (Plate 12). This is caused by lack of operational guidelines for sand mining.

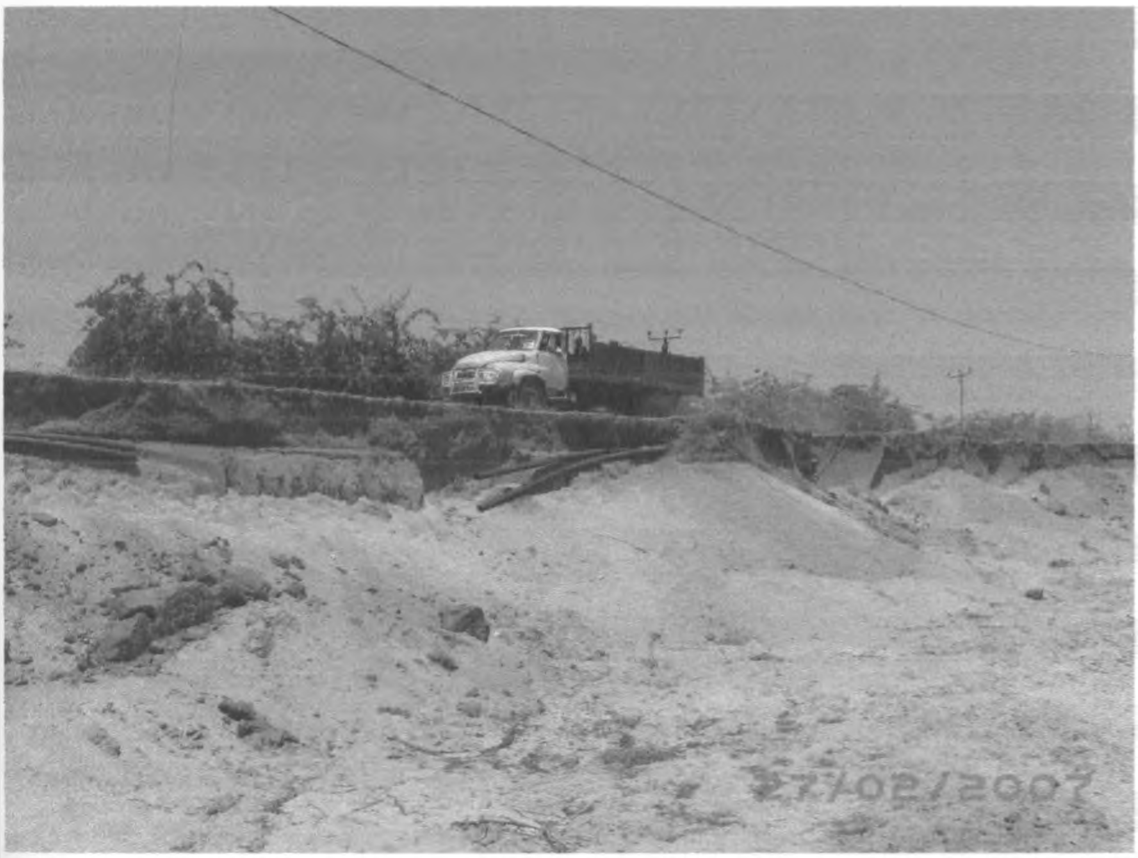


Plate 12: Destruction of roads, water pipes, telephone and electricity lines

CHAPTER FIVE

5.0 Discussion

The study area has been most extensively exploited for sand that is unscientific extracted. This has been going on for long and the area affected is increasing day by day. Mining of sand has caused massive damage to the landscape and biological communities. Remote sensing and GIS techniques offered a rapid detection of the changes that had occurred in the area.

5.1 Changes in Vegetation cover

The study area has undergone considerable modifications in vegetation cover types as a result of sand mining. This is in conformity with studies by Lambin (1997), Shrestha (1996), Horn (1992), Agatsiva and Mwendwa (1992) whose studies note that anthropogenic activities contribute significantly to modification and changes in natural land cover. A new cover type Shrub land, covering 15.117 Hectares had evolved near the sand mines during the period from 1992 to 2006. This study associated the emergence of this vegetation cover type to conversions of the Woody shrub land and Shrubby grassland vegetation cover types caused by mining practices.

The high percentage land cover change (6.36 %) under sand mines 1992 and 2006 and the dominant vegetation found under different land covers is in agreement with the new non equilibrium paradigm by (Fox 1996), who attribute evolution of ecosystems to adaptive complex non stationery environmental patterns that include fluctuations in weather, climate, disturbance regimes and biotic invasions as in the case of *Prospis juliflora* in the study area. The changes in cover types that have occurred in the area further agree with Serneels *et al.*, (2001) who found that species combinations may never appear in a limited finite sample as the case of woody shrub land, shrubby grassland, grassland, mangrove forest and sand mines. Limited dispersal of propagules, patterns of vegetative growth and reproduction or preference of individuals to certain patches of a heterogeneous habitat may have caused the varied species combinations especially in the natural land covers. The increase in mangrove cover (Plate 3) during the study period is attributed to the reforestation programme around Ngomeni town through collaborative efforts of NGOs, local communities and other stakeholders.

The more and varied vegetation found as you move from mined areas to un-mined areas, with 10 more families observed 2 km from sand mines is normal trend following habitat

destruction. Bartha *et al.*, 2004 explain the importance of external processes in an ecosystem. The variability of succession trajectories and the individualistic nature of plant community dynamics are influenced by initial condition of ecosystems and the accumulating effects of processes such as sand mining. The edge effects render vegetation threat of being uprooted by upcoming wind, livestock and instability of the rooting of the vegetation. Anchorage, supply of water and nutrients is tampered with and succession rate does not keep up with destruction rate. Ideally, disturbance caused changes in an ecosystem are expected to spontaneously return to the pre-disturbance equilibrium state but mostly this is not the case.
The natural plant communities are disturbed by the mining activity because the mining environment alters the climatic and edaphic complexes of the plant communities leading to a drastic reduction in the plant growth in the mined areas. The physical factors that may have limited plant establishment and survival in the mined areas are high temperatures, moisture stress, soil particle sizes and compaction. Soil fertility is also a major factor that limits plant growth in the mined areas. Other factors could arguably be shortage of organic matter attributed to the absence of litter, other soil physical chemical characteristics like PH, electrical conductivity and soluble Ca, Mg, Na cations exchange capacity (Semeels *et al.*, 2001). Bradshaw 1997), working on mine spoils reported that the number of species colonizing on the mined areas was influenced by its PH. Water holding capacity and infiltration rates are important variables, which might have been limiting in the mined areas. Low nutrient habitats are usually colonized by species with low relative growth rates. These adaptations enable colonizing species to maximize the nutrient uptake and ensure high nutrient use efficiency in low nutrient environments. Other studies by Siddharth Singh, (2000) and Sarma's, (2002) works lend support to these findings of Mjanaheri-Ngomeni areas.

However, human activities such as mining, overgrazing, machinery trampling (Lorries that carry sand) often destroy ecosystems and render them incapable of natural regeneration hence the sharp distribution in the floristic composition and distribution in the mined and un-mined areas. The old mines often have attracted some invasive species (*Prosopis juliflora* and *Cantharathus roseus*) that are able to withstand harsh conditions. The space vegetation of trees and shrubs that is associated in clearance of vegetation for sand mining practices, has supported growth of climbers as indicated in their numbers in the mined areas. The climbers are completely lacking in the un-mined areas.

5.2 Extents of Sand Mining

The volumes of mined sand in five years, from 2000-2005 is indicative of increasing sand mining over time (Figure 8). This study associated the increases to increases in population, poverty levels and lack of adequate alternative livelihoods. This has lead to over reliance on sand mining that has decreased environmental quality in the area.

This study area has mining-related infrastructure developments that include corridors for roads, pipelines and establishment of human settlements. Large increases in local human populations that are concentrated in small areas place pressure on the local environment through mechanical clearance for space, fuel wood, and building materials demands. Off-road vehicles also contribute to destruction of vegetation and spread of weeds and plant disease. This concurs with studies by Noble *et al.*, (1996), who argue that infrastructure developments in fragile ecosystems have significant negative consequences for biodiversity for example, creating opportunities for weeds and pests, modifying natural water flows, and acting as barriers to the movement of native organisms. However, sand mining also poses a threat to the same infrastructure it helped create by destroying them as shown in plate 12.

The areas under sand mining have increased since the year 1992. A change of 6.36 % of the total area was recorded under sand mining. All the mining practices do not include any rehabilitation efforts and neither is there any regulations guiding them. On opening up of the sand mines, sand is extracted up to the bedrock level and on exhaustion miners move to other areas. Vegetation regeneration is difficult as the topsoil is removed and the mines retain water discouraging vegetation growth. Sand mining activities therefore greatly contribute to the degradation of vegetation and other natural resources in the area.

The damage to soil and vegetation caused by mining unless prevented by careful planning is usually extreme, because the original ecosystem has been grossly disturbed or buried by the mining process (Bradshaw 2000, Drechsler 2001). This means that to achieve a successful restoration the soil has to be restored and the vegetation re-established.
Sand mining has impacts on other natural resources in the study area. The activities alter the relationship of organisms and their habitat in time and space. Destruction of the vegetation cover during mining operation is invariably accompanied by an extensive damage and loss to the system. Many parts of the area have been converted from lush green landscape into open mines. Large-scale denudation of vegetation cover (Figure12), are some of the conspicuous environmental implications of sand mining. A detailed understanding of the status of sand

mining practices, their impacts on soils, lowering of water levels in the boreholes, aesthetic degradation, vegetation and plant diversity on time and space, social lives of the local people and ways of making sand mining practices sustainable is pre-requisite for the area.

The findings of this study has established that there is differences in plant densities recorded in the mined and un mined areas (Figure 12). Since the mined and un-mined areas have similar climatic, edaphic and physiographic features the differences in species densities could be attributed to the mining activities. This is in agreement with the findings of Buckney and Morrison (1992), Fox *et al.*, (1996), Lloyd *et al.*, (2002) who compared the floristic composition of mined and un-mined sand dunes in Myall Lakes National Park, Australia. Sreebha and Padmalal (2006) also carried out similar studies in Southwest India. They found that the mined areas were different from both adjacent un-mined dunes in species richness. The vegetation also showed a decreasing similarity over time to the vegetation previously on the sites.

This research noted that plants are essential for the existence of the local communities in the study area as is noted in table 11. The communities attached at least four different uses to some plant species. Some of the species are a source of food. Other species provide products or services that the local communities depend on directly or indirectly, for example by fixing nitrogen in the soil, conserving soil and water, providing shade, fodder for livestock, fibre and materials for construction among others. Other plants are important sources of herbal medicine for both humans and livestock. Local knowledge on precise methods of preparation and dosage is needed and the guidance of an authentic herbal practitioner should always be sought before using these plants medicinally. Some of the plant species that the local communities attached most use include *Carissa edulis, Cordia sinesis, Flacourtia indica, Grewia tenax, Lannea schweinfurthii, Prosopis julliflora, Thespesia danis,* and *Ximenia Americana.* The usage of these plants is however under a threat from sand mining coupled with population increase.

5.3 Measures for sustainable sand mining

Sand mining is a widespread and complex activity in Mjanaheri-Ngomeni areas. Small-scale sand mining encompasses social, environment and economic issues and any strategy to improve the livelihood of those engaged in it must be cross-sectoral. The sustainable livelihood approach is one such strategy. It is an approach to poverty reduction, which focuses on a community's assets and strengths and their ability to access and manage productive resources. The unregulated nature of sand mining coupled with the high poverty levels has resulted to neglect of environmental concerns in the industry. The relationship between poverty and sand mining in the study area could be described as poverty trap mainly driven by the economic crisis, growing poverty and unemployment levels. The major concern is how to make an extra shilling from the mining that makes the phenomenon of the 'tragedy of the common' to become very prevalent. The first sand miners were generally able to achieve a reasonable livelihood, but subsequent increases in the number of people joining the mining practices lower productivity and income per head. This low income coupled with a lack of investment opportunities in sand mining technology and skills result in inadequate and inappropriate techniques being used. This in turn causes extensive damage to the environment including water contamination, siltation and destruction of the landscape. Inefficient sand mining technology and methods coupled with destructive use of land results in low productivity for miners and the cycle begins again.

Issues of abandoned mines, presently operating mines and future mines, presents serious environmental challenging to the sand mining industry in the study area. Commitment to sustainable development requires integration of environmental policies and development strategies so as to satisfy current and future human needs, improve the quality of life and protect resources. This was not taken into consideration when mining processes were initiated in Mjanaheri-Ngomeni areas. Although, EMCA (1999) requires that mined land be restored to approximately its original status, nothing much has been done in the study area, due to compliance problems of the industry. However, Bell (2001) observes that restoration of mining disturbance is essentially impossible no matter how much money is spent in the reclamation. Reclamation of Mjanaheri-Ngomeni mines, therefore should aim at the establishment of stable and self sustaining ecosystem that will in time lead to a productive and suitable ecosystem that will replace the pre-mine ecosystem and achieve the desired post mining land use. This calls for cooperative planning by the sand mining operators, Government land use planners, local communities and NGOs dealing with natural resources management in the area.

CHAPTER SIX

6.0 Conclusions and Recommendations

Sand mining has adversely affected the vegetation in Mjanaheri-Ngomeni sand mining areas. Existing land use / cover types have undergone conversions and or modifications within the period 1992 to 2006.

Areas under sand mining have been on the increase and have caused massive damage to the landscape and biological communities. The unfavorable habitat conditions prevailing in the sand mined areas have reduced the chances of regeneration of many a species, thereby reducing the number of tree and shrub species in the mined areas. Although the numbers of trees and shrubs have decreased, the numbers of some species colonizing the mined areas were found to be higher than in the unmined areas.

Recommendations

6.1 Policy Recommendations

Guidelines on sand mining

Sand mining as a sector needs to be regulated in order to balance economic development and environmental management in the quest to achieve sustainable development There is therefore a need for the Government in consultation with relevant stakeholders to develop and enforce guidelines on sand mining.

Land Tenure (land adjudication programme)

Land in the study area is communally owned and its utilization is governed by the communities' customary practices. There is need to hasten the ongoing land adjudication programme by the Government, that could encourage the local communities to own and take care of the land resource.

Economic Instruments and Incentive measures

The Government in consultation with the relevant stakeholders should design and apply appropriate economic instruments such as fees, charges, incentive measures and tax rebates so as to increase rural, local government and national government incomes targeted for poverty alleviation strategies. These should then be ploughed back for management of the sand resource.

6.2 Administrative Recommendations

Tools for Environmental Management

The initial sand mining operations should be subjected to Environmental Impact Assessment (EIA). For the abandoned mines, the proponent should carry out rehabilitation or decommissioning of the used mines. The existing sand mines should carry out an Environmental Audit (EA) as per section 68 of EMCA 1999.

In addition the sand mining operators should pay deposit bonds to NEMA in accordance to laid guidelines as a form of risk management for their mining activities. The money would be used for rehabilitating the mines in case the sand miners failed to do so after the operations.

Identification of Environmentally Significant Areas

Parts of the sand mining areas are important sources of fresh water that are at risk from environmental degradation. These areas should be identified and gazette as environmentally Significant Areas as stipulated by EMCA 1999 section 54.

Flood Management

Flooding has been noted to greatly affect the rehabilitation efforts of the abandoned mines. Further rehabilitation efforts by stakeholders and local communities should only be attempted after addressing the problem of flooding. The DEM produced by this study will guide in developing strategies for deflecting surface runoff to designated areas. The mined areas also need landscaping to control the flooding.

Establishment of cooperative societies

The sand miners guided by the District Social Development Office should establish cooperative societies within the correct legal framework that provides for determination of sand market prices and restoration/rehabilitation funds

Ecotourism Development

Rehabilitated mined areas could be converted to ecotourism ventures where indigenous species are grown. This will encourage biodiversity development and earn foreign exchange for the country through tourism. Funds to finance these activities could be sourced from both the Community Development Fund (CDF) and the Local Authority Trust Fund (LTF) allocations for the constituency.

6.3 Further Research

There is need to undertake further research in the following areas:

Valuation of the sand resource

Sand mining contributes significantly to the economic development of the local people in the study area. Valuation of the sand resource needs to be undertaken so that it maybe reflected in national accounting systems. This would help in attracting support from the Government and other relevant agencies for environment planning and management in the area.

Medicinal plants

Limited research has been carried out pertaining to the documentation and conservation of medicinal plants. There is need for continuous research to update data on the status of the indigenous medicinal plants and their utilization.

Faunal species water and air

There is need to research on the impacts of sand mining on the faunal species, water and air in the study area.

Salt farms waste water

There is a need to undertake further research to establish whether the neighbouring Salt Farms wastewater deposited nearby affects the rehabilitation of Timboni mines.

Child labour and gender

Further research needs to be carried out on matters pertaining to child labour and gender parity to further understand the impacts of sand mining

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Annex: 1

Questionnaire for Sand mining areas in Mjanaheri-Ngomeni Areas, Malindi

Preliminaries

Questionnaire No.: ___________

Date: ____________________

Interviewer: _____________________

Introductory Remarks

A research team is currently conducting research in this area with the aim of inventorying sand mining areas and identifying activities towards rehabilitation in Magarini in Malindi District.

Objectives of the fieldwork

1 To collect baseline information on Sand mining areas:

2 To assess extent of vegetation degradation by sand mining;

3 To provide recommendations on rehabilitation measures;

4 The information collected will be used for research, and will contribute to conservation policies in respect to community participation in Sand Mining.

Respondent's Bio Data

Name of respondent (optional) ____________________

Sex:

Female	Male

Location: ____________________

Sub-location: ______________________

Estimated distance from Sand Mines __________________

Categorize Age of respondent in (youth/Adult/Elder: ___________

(* Youth = 18-35 Adult 36-60 Over 60 =elder)

1. How many people live in your household?

Category	**Male**	**Female**	**Total**
> 60 years			
51 – 60 years			
41-50 years			
31-40 years			
18-30 years			
<18 years			
Total			

2 What is the respondent's main occupation?

Pastoralism	Agriculture	Government employment	Private sector employment
Own business	Artisan (e.g. wood carving)	Sand mining	Other (specify)

*Own business refers to people who are pure trader

Artisan refers to people who are dealing with production and selling of goods

3 What are the major economic activities in the farm (Sand Mining, cash crop, Subsistence crop) ……………………………………………………………….

4. What are types of livestock kept on the farm

(a) Exotic and crossbreeds………………………………………………………….

(b) Local breeds……………………………………………………………………

(c) How many beef breeds?………………………………………………………..

(d) Shoats/number…………………………………………………………………

(e) Poultry (I) for eggs……………………………………………………

(ii) for meat……………………………………………………

(f) Any other (specify)……………………………………………………………

5. When did you start sand mining in your farm?……………………………………

6. How many operational mines do you have? ---------------------------------------

7 How many are exhausted and abandoned? --

8 What is the area covered by the mines (Ha) Active………. Exhausted……….

9. What are the amounts of sand mined in a month (Approx.) (Lorries and tonnage)? . ---------

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10. How do you market your sand?

(a) Individually……………….

(b) Co-operatives……………….

11. How is sand transported to the market?

a) Lorry
b) Pickup
c) Oxen or donkey drawn cart
d) Others

12 (a). What are the benefits derived from sand mining?

……………………………………………………………………………………

(b) Has your economic situation improved over years?

i) No / Slightly / Greatly.

Explain………………………………………………………………………………………

…………………………………………………………………………………………………

13 (a) How do you use the Forest and Range resources in your area?

……………………………………………………………………………………………

……………………………………………………………………………………………

(b) What plant species are used to meet the above needs (13a)?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(c) What are the impacts of sand mining on Forest and Range Resources?

i). Water

ii). Land

iii). Vegetation

iv) Others?

Specify………………………………………………………………………………………

……………………………………………………………………………………

13. What are the main social problems you experience in sand mining?

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

15.a). Suggest rehabilitation measures in existing sand harvesting mines

……

……

……

b) Are you willing to participate in rehabilitation activities of the sand mines?

c.) State how you will participate

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

16. Would you like to change from sand mining as an economic activity to the other identified alternative livelihoods? Yes / No

If yes what would be the limitations?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

If No.

Explain…………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

17. Is there other information not covered by this questionnaire that you feel is important?………………………………………………………………………………………

……………………………………………………………………………………………………

Annex 2:

Data sheet for recording plant species and their frequencies during vegetation sampling

Date----------------- Quadrant size----------------------

Transect No……………………………..

Mined / Un-mined Area

Quadrat / Plot	Species	Local Name	Observed Frequency

Annex 3

Plant species found in the study area

Plant species
Azadirachta indica
Avicenna marina
Indigofera colutea
Solonum incanum
Cynodon dactylon
Ceriops *tagal*
Catharanthus roseus
Grewia Plagiophylla
Carissa edulis
Prosopis julliflora
Acacia brevispica
Asparagus humilis
Thespesia danis
Dichrostachyus cinerea
Anacardium occidantale
Croton talaesporos
Grewia villosa
Thylacium thomasii
Clerodendrum hildebrandtii
Allophyllus parvillei
Themeda triandra
Lantana camara
Adenium obesum
Ximenia americana
Justicia flava
Hoslundia opposita
Euphorbiaa tirucalli

Grewia tenax
Diospyros consolatae
Commiphora linduesis
Hibiscus greenwayi
Commelina benghalensis
Aloe kilifiensis
Ovaria lucinda
Haplocoelum inoploeum
Hugonia castaneifolia
Hibiscus Micranthus
Salacia Madagasceriensis
Lannea schweinfurthii
Garcinia Livingstone
Manilkara sansibarensis
Julbernardia magnistipulata
Ochna mossambicensis
Psychotria amboniana
Grewia similis
Heinsia crinita
Capparis tomentosa
Cussonia zimmermanii
Cyperus difformis
Ovaria acuminata
Fuirena ciliasis
Cyperus frerei
Mariscus assimilis
Strychnos madagascensis
Manhot esculenta
Cocos nucifera
Ozoroa obovata
Cynometra webberi

Mangifera indica
Landolphia kirkii
Terminalia spinosa
Flacourtia indica
Cissus rotundifolia
Phyllanthus reticulatus
Basilicum polystachion
Dactyloctenium scindicum
Cassia occidentalis
Hunteria zevlanica
Croton pseudopulchellus
Mariscus diurensis
Cistanche Lutea
Sida cordifolia
Quisaualis littorea
Memecylon verruculosum
Tristellateria africana
Nectaropetalium Kaesssneri
Typha latifolia
Deinbollia borbonica
Bulbostylis boeckeleriana
Indigofera spinosa
Thalassodendron ciliatum
Samanea saman
Lepturus repens
Securinega virosa
Eleusine jageri
Cassia abbreviata
Phyllanthus beillei
Strychnos henningsii
Vitex ferruginea

Zanthozylum chalybeum
Clerodendsum hildebrand
Lasiodiscus ferrugineus
Pedallium murex
Sateria sagittifolia
Casuarina equisetifolia
Euphorbia nyikae
Dialium orientale
Gloriosa superba
Dobera glabra
Cyphostemma bambuseti
Kigelia africana
Encephalartos hildabrandtii
Enicostemma latiloba
Adonsonia digitata
Lobelia duripratii
Indigofera hiersuta
Croton dichogamus
Rhizophora *mucronata*