ASSESSMENT OF LAND COVER CHANGE AND SOCIO-ECONOMIC IMPACTS OF STONE QUARRYING ACTIVITIES IN NAROK TOWN WARD

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A RESEARCH PROJECT SUBMITTED TO THE SCHOOL OF NATURAL RESOURCES, TOURISM AND HOSPITALITY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF ENVIRONMENTAL PLANNING AND MANAGEMENT OF MAASAI MARA UNIVERSITY

MAASAI MARA UNIVERSITY

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DECLARATION

This research project is my original work and has not been presented for any degree in any other University.

Signature________________   Date________________

Barchok Festus Kiprop
TM03/JP/MN/13629/2021

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DEDICATION

I dedicate this research work to my parents and siblings, my aunts and my grandmother. God bless you abundantly.

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I thank The Almighty God for giving me energy, good health and endurance throughout the course work and research project.

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LIST OF ABBREVIATIONS

CIDP	County Integrated Development Plan
EIA	Environmental Impact Assessment
ETM	Enhance thematic mapper
GIS	Geographical Information system
GOK	Government of Kenya
ITTCZ	Intertropical Convergence Zone
KPHC	Kenya Population and Housing Census
MASL	Meters Above the Sea Level
NEMA	National Environment Management Authority
PPEs	Personal Protective Equipment
TM	Thematic Mapper
USGS	United States Geographical Survey
UTM	Universal transverse Mercator
WGS 84	World Geodetic System 1984

ABSTRACT

Quarrying is an excavation process involving extracting materials, which are neither fuel nor minerals in nature from rocks. The increased quarrying activities have led to detrimental environmental and social economic impacts which are usually ignored at the expense of economic pursuit by developers. The main goal that guided the study was to assess land cover change and socio-economic impacts of stone quarrying in Narok Town Ward. The specific objectives were; assessment of land cover changes, identification of socio-economic impacts of stone quarrying and assessment of the existing measures taken to mitigate the impacts. The study employed mixed method research design. Stratified sampling and random sampling techniques were used in the study. Collection of secondary data involved desktop review of both published and unpublished literature relevant to the study. Spatial analysis of land cover changes was conducted by processing and analysis of remote sensed images from Landsat and Sentinel 2 satellite data. Supervised classification was performed on the images into vegetation and non-vegetation cover classes using environmental visualization software, version 5.3. Findings were presented descriptively in tables, charts, graphs and textual forms. The study found that non-vegetation cover class had increased by 18.70% between the year 1985 and 1995.There was an increase in vegetation cover class between the year 1995and 2010 by 37.81 %. Between the year 2010 and 2022 vegetation cover reduced by 18.24 %. More than half (57.65%) of house hold heads noted that the previously vegetated landscape was now scarred and exposed. Moderate correlation was found between landscape degradation and vegetation loss(R^2=0.384). Land use changes were reported with crop farming 41.18%, grazing 48.24% had been replaced by quarrying activities in the study area. Most of the quarry workers (56.7%) were not using PPEs during their daily quarry operation. Social issues reported include change of social behaviors, conflicts, influx of new people into the area, relocation among the residents, destruction of cultural sites and health issues. The respondent (51.2%) indicated absence of mitigation measures put in place to alleviate negative impacts of quarrying activities. The study concluded that quarrying activities has led to landcover changes, negative social impacts and inadequate mitigation measures taken to alleviate negative impacts of quarrying activities in the study area. The study recommended that County government, National government and other stakeholders to put in place plans to rehabilitate and restore already degraded landscape. Strict authorization and effective regulations of quarrying activities by agencies, in order to minimize negative environmental and social impacts of quarrying activities.

CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

Quarrying is defined as the process of removing sand, dimensional stones, gravel or any minerals from the ground to be used as raw materials for constructions or other uses. It is also described as the process materials which are neither fuel nor minerals in nature from rocks (Ukpong, 2012). The majority of stone mining firms utilize open pit techniques, which entail activities such as taking away the top layer of soil, drilling and cutting stones, and occasionally, blasting and crushing rocks (Punmia et al., 2013). This process of extracting materials entails the utilization of heavy machinery that shifts the ground and other colossal machines that extract the end product, leading to harmful impacts on the environment around it, such as noise, dust, and vibrations.

The escalating development projects in major cities across the globe have made it imperative for quarries to furnish building materials (Bewiadzi et al., 2018). Increased development in major urban centers globally is perhaps due to population growth, advancement in technology, urbanization and infrastructural development (Opondo et al.,2022). According to Bhattacharjee et al. (2018), the unorganized extraction and crushing of stones have harmful effects on both the natural and human environment, which are frequently disregarded at the expense of economic growth. These effects are usually associated with a failure to implement sustainable resource management policies and strategies

Quarrying operations and quarry pits left after the operations leaves scars on the landscape which degrades the aesthetic value of the environment and impact the social wellbeing of the people living around quarried lands negatively (Bamgbose et al., 2014; Chatterjee, 2010; Lad & Samant, 2014). There are numerous reported negative impacts of quarrying on the environment which include loss of biodiversity (Darwish et al., 2010) air pollution, water pollution and landscape disruption as reported by Dentoni et al. (2006). Additionally, quarrying activities may cause underground water pollution, lowering water table, increase soil erosion and landslides, destruction of habitats and air pollution from fumes, smoke and noxious gases (Chatterjee, 2010; Dong-dong et al., 2009; Kaliampakos & Mavrikos, 2006).

Milgrom (2008) argued that quarrying causes extensive changes to ecosystems and ecological interconnections that may be irreversible in nature. Furthermore, quarrying negatively affects the appearance and visual appeal of landscapes by creating unappealing quarry scars that ought to be restored but often are left unrehabilitated (Dong-dong et al., 2009; Menegaki & Kaliampakos, 2006; Misthos et al., 2018)

Nonetheless, according to Flavenot et al. (2014), abandoned quarries may have some positive impacts on the environment for instance acting as a water reservoir when well maintained and provides habitat refuge for valuable flora and fauna.

In Kenya, similar impacts have been witnessed for instance in study done by Waweru et al. (2018) in Ndarugu, Kiambu County showed that there is increasing development of quarries with little concern to the environment. Anunda (2014) attributed the increased quarrying activities to the rising real estate business and road expansion in most of urban centers in Kenya. Mbandi (2018) in her study on environmental effect of quarries in Kitengela indicated that there are more than thirty thousand stone mining quarries in Kenya and most of them are located near major towns. The study also indicated that in Kitengela, Juja and Tala were most prominent mining sites causing damage to environment and affecting the social wellbeing of the residents. It is also reported by NEMA (2011) that Embakasi alone has nineteen (19) quarries, some of which are active and some have been left without rehabilitation. Eshiwani (2014) and Mbandi (2018) noted that the increased quarrying activities in Embakasi and Kitengela respectively has caused detrimental effects to the environment and the residents. They both reported that there was increased dust emission, destruction of vegetation and cracking of residential houses due to heavy blasting causing unrest of the people. This is an indication that environmental degradation caused by quarries is continually increasing in the country.

A cross the country the rate of urban development is increasing daily and some towns are being upgraded to cities, other small centers are becoming municipalities for instance, recently Nakuru town was upgraded to be a city. These developments indicate high demand for construction materials across the nation resulting to increased quarrying activities in the country.

Narok town is also growing at a fast rate, being a tourist, agricultural, administrative and business center, its population has nearly doubled in the past few years causing shortage of housing (KNBS 2019). This provides a business gap to investors to develop more housing infrastructure to meet the demand. The increased housing development has led to increased demand for construction stones leading to increased quarrying activities in some parts of Narok Town Ward. The consequences of increased quarries and quarrying activities cause various forms of environmental degradation including air pollution, loss of biodiversity, changes in landscape, land use and social-economic impacts (Dentoni et al., 2006). Concerns on environmental and socio- economic impacts due to increased quarrying activities in Narok Town Ward has prompted the study in this area in order to identify these impacts and recommend the way for Ward to curb and reduce the intensity of these impacts.

1.2 Statement of the problem

Quarrying activities in Kenya have increased recently due to increased demand for quarrying material for urban development. Population pressure has resulted to shortages of housing in major towns in the country, this has prompted developers to increase construction activities in order to meet the demand. The increasing urban development for instance in Narok town has led to increased number of quarries in Narok Town Ward. Abundance and accessibility of building stones in some areas in the ward have attracted many developers in rapid growing Narok Town and ever-expanding estates in its outskirts (NCG, 2018). This is due to increased economic income and population influx resulting from tourism and hospitality, education institutions and business communities. Additionally, introduction of devolved government, necessitated construction of County government headquarters which has also led to increased development in major towns. The repercussions of the increased quarrying activities to meet such demand may lead to environmental degradation (Bhattacharjee et al., 2018). Additionally, uncovered pits pose high risk to humans, livestock and wildlife. Environmental problems caused by stone mining are further aggravated by inadequate mitigation measures by the respective quarry operators. This causes direct damage to ecological sustainability which is a threat to overall economic sustainability (Orimba, 2020). Despite the greater magnitude of impacts caused by quarrying and post quarrying activities in Kenya, there is insufficient information on environmental and socio-economic consequences due to quarrying activities in the study area. Therefore, this study will focus on assessing land cover change and socio-economic impacts of stone quarrying and post quarrying activities in Narok Town Ward.

1.1 Study Objectives

1.2.1 Broad Objective

The main goal of the study is to assess the land cover change and socio-economic impacts of stone mining in Narok Town Ward, Narok County.

1.2.2 Specific Objectives

I. To assess land cover changes due to stone quarrying in Narok Town Ward.

II. To identify socio- economic impacts of stone quarrying in Narok Town Ward.

III. To identify the existing measures taken to mitigate the impact caused by stone quarrying in Narok Town Ward.

1.3 Research Questions

I. What is the land cover change due to stone mining on landscape in Narok Town Ward?

II. How does stone quarrying impact on the socio- economic development in Narok Town Ward?

III. What measures have been put in place to mitigate impacts caused by stone mining in Narok Town Ward?

1.4 Research Hypotheses

H0: There is no significant relationship between land degradation caused by quarrying activities and vegetation loss in the study area.

H0: There is no significant relationship between severity of dust and respiratory ailments reported in the study area.

1.5 Justification of the study

This study is in line to the current issues for instance sustainable development goals. Sustainable development goals in particular goal 12 aims to ensure sustainable consumption and production patterns. The goal seeks to promote resource efficiency, reduce waste, and minimize the environmental impact of economic activities, including industrial production and extraction of natural resources such as stone. Target 12.2 particularly aims to achieve sustainable management and efficient use of natural resources and thus this target is directly linked to the impacts of stone quarrying on the environment. To achieve this target, quarrying activities need to be managed in a sustainable manner that ensures the efficient use of resources and minimizes waste. Quarrying operations if not regulated well, violates the states obligation of ensuring sustainable exploitation, utilization, management and conservation of the environment.

1.6 Significance of the Study

Narok County being a tourist center, there is need to ensure sound environmental conditions and beautiful landscape to ensure high level of aesthetic value in the region. According to Narok County integrated development plan (2018-2022) report, there inadequate information related to environmental degradation caused by mining and quarrying activities which also prompted this study in Narok Town Ward. Therefore, this study has pin pointed the various environmental issue related to stone mining, socio-economic impacts of quarrying activities in Narok Town Ward and recommends various strategies to mitigate such impacts. The findings of this study will also guide the relevant authorities in environmental policy formulation and implementation. This finding will be useful in academics by providing literature on stone quarrying activities.

1.7 Scope of the Study

The study involved assessment of land cover change and socio-economic impacts associated with stone mining quarries in Narok Town Ward. The study area covers Olpopong quarries which has three quarry sites numbered one to three, Morijo quarries in Polong'a area and Kipangas quarries. Olpopong' and Morijo quarries are mainly the source of dimensional construction stones while in Kipangas quarries have both dimensional stones and ballast extraction on a small scale especially towards the river where granitic rocks are available. Respondents who were involved in the study were quarry workers, residents and official from NEMA and county department of environment.

1.8 Limitations of the Study

The limitation experienced during the study include issues of gender disparity among quarry workers. Uncooperative respondents also came up during the study. The issues were handled carefully by assuring the respondent of confidentiality of information provided. Consistency of intervals in years between which the images for landcover change analysis were acquired was a challenge due to image quality available at a particular interval, this was solved by providing allowance of two to three years at a particular interval.

1.7 Operational definitions of terms

Stone Quarrying- Stone excavation process involving abstracting materials which are neither fuel nor minerals in nature from rocks for construction and other uses

Landscape degradation – Damage caused by quarrying activities such as opencast, vegetation clearing, heaps of quarry waste on the landscape affecting its aesthetic value

House hold head-Male or Female who assumes the roles of the family head at time of survey.

Quarry workers-includes all those working in the quarry sites; stone breakers, loaders, plan operators.

Quarry manager- male or female who assumes supervisory roles in a quarry site.

CHAPTER TWO
LITERATURE REVIEW

2.0 Overview of Environmental Impacts of Quarrying Activities

Quarrying and other small-scale mining have been reported to be among the leading human activities that have greatly resulted in the alteration of the landscape (Dentoni et al.,2006 and Flavenot et al.,2014). Worldwide, quarrying activities have been noted to cause more harm to the environment than its positive impacts. Stanton and Roma (2015) noted massive environmental degradation in Canada caused by quarrying operations near the Bay of Fundy. The two scholars noted lower quality of life caused by air and water pollution in the area. The waves generated by the activity were reported to disturb the breeding fish in the bay by damaging the bladder and eggs of fish.

In Lebanon, Darwish et al. (2010) indicated the area of land consumed by quarries in 2005 increased more than three times over former arable lands, one third for forest lands and doubled for pasture lands. Quarries additionally destroyed 676 ha, 137 ha, and 737 ha of productive lands, forested land and pasture land respectively. The comparison of quarry distribution with the land capability map revealed that quarries were found mainly on productive soils, consuming one thousand, three hundred and fourteen (1314) ha in 1989 and two thousand one hundred and ninety-two (2192) ha in 2005 of prime lands (Darwish et al.,2010).

There is increasing quarrying activities due to high demand for building materials especially in the expanding cities and towns across the world which has been escalated by increasing urban population (Olesegun et al.,2009; Samant,2014 & Dong-dong et al.,2009). Quarrying processes, small scale or large scale causes environmental distortions due to the large amount of waste generated during the process and open pits left after the process. David (2007) described the aftermath problems of quarrying in Hungary and United Kingdom as a scar on the landscape, Ukpong (2012) also added that excavation sceneries are visually dramatic and lowers the aesthetic value of the landscape.

Quarrying processes have detrimental impacts on land cover due to the magnitude of the waste generated during quarrying. Small and scattered quarries have been reported to have greater level of impact on health of the ecosystem (Nawaz et al.,2004). Across the world, stone mining and other excavations activities especially those that use open cast methods cause alteration to vegetation and wildlife habitat as reported in Appalachian Mountains and Germany (Tischew et al., 2014; Townsend et al., 2008)

Similar cases of loss of biodiversity and landscape destruction have been reported in Africa (Ata-Ezra, 2016; Akanwa et al., 2016). In Nigeria, Akanwa (2016) indicated that the open cast method used in quarries around the Ebonyi states caused massive damage to the land and vegetation cover which has become an emerging issue within the study area especially in the local areas of Ebony state where it is reported to be the center of active quarries. In Tanzania limestone mining has led to extensive loss of vegetation and soil degradation (Haule et al., 2016). Quarrying processes occupy large pieces of land and thus clearing of vegetation to get working space have been reported and has been attributed to loss of biodiversity across the world (Lameed & Ayodele, 2010). Additionally, the uncontrolled quarrying operations were reported to disturb hydro geological and hydrological regimes, modify the substratum, disrupt the natural succession and cause reduction in genetic resources (Lad & Samant, 2014). Altered hydro geological and hydrological regime results in reduced ground water due to disturbed aquifers (Lad & Samant, 2014). This led to water scarcity in the quarried lands and their surroundings.

Kenya too has a pinch of environmental and socio- economic impacts caused by stone quarrying. Mukindu and Waweru (2016) found unpleasant social and economic impacts of stone mining in Kiambu County such as loss of agricultural lands, loss of cultural site and cases of diseases. Orimba (2020) noted imbalance between environmental sustainability and economic benefits of stone mining. Similarly, Mbandi (2018) and Eshiwani (2014) indicated detrimental environmental and social impacts of stone quarrying in Kitengela and Embakasi Sub-Counties.

2.1 Land cover changes due quarrying activities over time

Land cover change is described as dynamic change in terrestrial surface of the earth induced by human activities (Brown et al., 2017; Nairuku et al., 2020; Alverez Martinez et al., 2011). Changes in land cover include urbanization, agricultural activities, increased mining activities/quarrying activities which result in alteration of initial land surface status. Quarrying operations have been reported to cause alteration in vegetation cover and landscape, open cast methods used in stone mining leads to destruction of land resources including denudation of vegetation cover, loss of soil fertility and soil erosion (Musah, 2009). Remote sensing and geographical information system approaches are potentially important aspects that have been utilized for detecting and analyzing land cover change (LULC) overtime (Chowdhury et al., 2020). According to IUCN (2004), Land clearing primarily for quarrying activities is the most significant cause of environmental degradation, loss of species and depletion of ecological communities worldwide. Thus, temporal assessment of land cover change caused by stone quarrying is crucial. Clearing for both quarrying sites and access roads has led to increased loss of vegetation cover (Groom et al., 2006). Quarrying activities represents major disturbances to the natural landscape, creating significant impacts on the soil, vegetation, fauna and habitat loss. Townsend et al. (2008) noted massive vegetation loss in Appalachian Mountains caused by quarrying activities. The resultant impacts noted were decreased vegetation cover leading to increased soil erosion and destruction of habitat.

Quarries left after the exhaustion leaves uncovered pits and heaps of quarry waste on the landscape affecting the aesthetic value of the area (David, 2007). According to Walker and del Moral (2003) quarrying activities cause significant disturbances to the landscape, resulting in the removal of original ecosystems, alteration of topography, disruption of basic ecological relationships, and reduction of biodiversity. Across Africa landscape changes due to vegetation loss have been noted in several regions. For instance in Western Ethiopia, Endalew (2019) noted that quarrying activities had caused massive vegetation loss , alteration of water course and changes in land use having the previously cultivated land occupied by quarries. Similarly, Melody (2017) reported cases of vegetation losses and landscape degradation in Ogun state, Nigeria with 75% of respondents reporting that quarrying activities are responsible for reduction on vegetation cover in the study area. Regionally and nationally perspectives, studies on temporal analysis of landcover change specifically due to stone quarrying is limited and thus this study comes in to fill this gap particularly in Narok Town Ward.

2.2 Air Quality with Respect to Stone Mining

The quality of air is important for the wellbeing of the people, plants and animals. The use of explosive and heavy machineries in Ogun state in Nigeria were reported to cause air pollutions by releasing toxic gases into the atmosphere (Melody, 2017). UNDP and UNEP (2018) reported that quarrying industry account for about thirty percent (30%) of the total greenhouse gases which are the main drivers of global warming. Bhattacharjee et al. (2018) indicated that extraction, crashing of stones and associated transportations affect the ambient air quality due to ejection of huge amount of dust with greater than 10 micrometers and particulate matter in the air. The size of dust particle decreases with increase in distance. Tribhuwan and Patili (2009) also noted the various quarrying stages that generate dust such as extraction, crashing and transportation of the quarrying materials. This depicts that the level of impact experienced near the site is greater than that felt at a greater distance from the extraction site. Polluted air is harmful to health of the resident in the neighbouring community and workers in the quarry site. Air pollution has been reported to be a major cause of allergic reactions, lung infection and other long term respiratory diseases (Nwibo et al., 2012).

Dust particles that settle on the leave surfaces retards plant development (Prasad et al., 2013). Photo respiration of plants is altered when dust blocks the stomatal opening hence affecting the process of photosynthesis, this was witnessed in most mining sites in Nigeria (Nanos et al., 2015). Similar cases of air pollution caused by stone mining have been reported in Kenya, Mbandi (2018) indicating that blasting of rocks, crashing and transportation produces large volume of dust which affect both people and vegetation. It was also found that most quarry companies do not take action to suppress the dust especially during dry seasons when the dust emission is high (Mbandi, 2018). Ministry of environment and mining also notes that despite the increasing number of quarries in the country, a larger percentage of quarrying companies have no rehabilitation plans and this was attributed to laxity in the enforcement authorities (GoK, 2010).

2.3 Health Impacts of Stone Mining Quarrying

According to Wanjiku et al. (2014), different communities hold varying views on the impacts of quarrying activities. The lives of people living and working in the quarry areas are positively or negatively impacted by quarrying activities (Nartey et al., 2012). Scholars such as Olusegun et al. (2009); Nartey et al. (2012); Saliu et al. (2014) and Wanjiku et al. (2014) have reported negative impacts on the socio-economic status, and increased health complications like pneumonia, ear and eye infections, and respiratory illnesses linked to the dust, smoke, fumes, and noise emitted during quarrying operations. Potential health impacts are directly associated with the presence of airborne dust, which is the primary cause of respiratory ailments and cardiovascular diseases, as articulated by Banez et al. (2010). Inhaling micro particles such as dust cause respiratory complications which are among the medical issues related to dust exposed laborers in quarry and residents living near the quarrying zones (Nwibo et al., 2012). Dust infiltrate into the breathing system causing obstructions of the air ways causing serious respiratory ailments (Kim et al., 2015). Crystalline silica which is a compound reported to be found in extracted materials from the earth in some areas cause silicosis disease that significantly affects the respiratory system (Horwel et al., 2012). Borm et al. (2011) reported that silicon oxide is major causative agent of cancer which was reported by the International Agency for Research on Cancer.

In Kenya, a study by Mbandi (2018) in Kitengela showed various incidences of respiratory infections with allergic reaction such as sneezing, eye irritation having the highest percentage. Other reported cases in the study include pneumonia and coughing, malaria was reported also which was associated with increased breeding grounds of mosquitoes in the pools of water in the open pits left after quarrying. This was also reported by Kibii (2020) in a study in Tuluongoi, Baringo county. Eshiwani (2014) articulated that quarry workers were mostly affected due to their long-term exposure. According to her findings, quarry workers were found with ailments such as 22.9% respiratory infection, 20.8% hearing problem, 19.8% chest problems, 18.8% common cold, 10.4% coughing and 7.3% eye infection. The increased infections among quarry workers were further attributed to lack of proper working gear (Kibii, 2020).

2.4 Social Impacts of Stone Quarrying

Social impacts of stone quarrying identified by Waweru et al. (2018), in a study on management status and perception of post quarrying in Ndarugu, Kiambu included influx of new people, change in social ethics and cultural beliefs among locals. The study also noted quarrying resulted in significant destruction of productive agricultural land leading to food insecurity, mismanagement of funds, health and safety hazards, domestic violence, and insecurity. In addition, cultural sites such as caves along the river used for traditional activities and prayers were also lost as a result of quarrying activities. Abate (2016) and UNEP (2O20) asserted that unstable quarrying activities affects sustainable livelihood of the surrounding communities through environmental pollution and depletion of natural resources which has been related to be significant cause of stress among communities.

According to Termiski (2012) displacement of local community caused by stone mining and other developments leads to community depression, insecurity and conflicts. Displacement caused by mining activities are global social problem occurring in all regions of the world, as a human rights issue, and as a source of challenges to public international law and institutions providing humanitarian assistance. Increasing mining activities and the sudden population influx in rapidly growing mining towns can give rise to school drop-outs, child labor, insecurity, alcohol-fueled violence, mental health problems and prostitution (George & John, 2018).

2.5 Economic Impacts

Stone quarrying and crushing have generated an alternative source of employment and earning. Poverty or insufficient income, lack of agricultural development, poor agricultural productivity, absence of substitute economic activities, low level of education and unemployment are some of the instrumental factors that have pushed the local people to be engaged in this manual sector as low-paid daily laborers. The acute and prolonged jobless condition of more than six months of the rural people has easily been compensated for by the employment opportunities offered by the quarrying and crasher sector (Bhattacharjee et al., 2018). Quarrying industry in Kenya has been noted to have significant role in enhancement of local construction industry, (NEMA, 2011). It has created a wide range of jobs and is significant contributor to the country's national economy as it contributes to the overall gross domestic product (GDP) of the country.

On the contrary to economic gain due to stone mining, there is an economic cost incurred by the affected community. According to Melody (2017) communities around the quarry sites are forced to spend a lot of money in treatment of ailments associated with stone mining due to pollution. Furthermore, due to pollution of water, communities incur cost in purchasing alternative clean water (Melody, 2017). Land degradation caused by quarrying is also a major cause of low and declining agricultural production and thus resulting in food insecurity and continued rural poverty (Temesgen et al., 2014).

2.6 Theoretical Framework

Several theories have been developed to relate the various aspects of human activities and the environment. For instance, the Malthusian theory which was developed by political economist Robert Malthus in 1718. The theory accords that the population grows exponentially while food supply increases arithmetically as described by Mayhew (2014). Over years the proponents of this theory have reshaped the theory leading to the Neo Malthusian theory which focuses on the population and environmental degradation. According to Simon (2010), the neo-Malthusian theory argues that "rapid population growth, combined with resource consumption patterns, will eventually lead to resource depletion, environmental degradation, and social unrest. In the context of stone quarrying, this theory predicts that the continued extraction of stone will eventually lead to the depletion of this resource and damage to the surrounding environment. This is because stone quarrying often involves the removal of large quantities of rock and soil, which may lead to soil erosion, landslides, and habitat destruction for wildlife (Ghose, 2012). The use of heavy machinery and explosives in stone quarrying can cause air and noise pollution, further damaging the environment.

System theory is also another theory that guides this study. The theory was developed by Bertalanffy (1951). The theory accords that a natural system is made up of interconnected subsystems and changes made to one subsystem will impact the whole system. It also highlights that real systems are open and interact with their surroundings, and may acquire new properties through the emergence of new characteristics, leading to ongoing evolution. Environment in totality of nature consist both living and nonliving things, thus alteration of part of the environment will affect the other subsystem. This theory thus conceptualizes quarrying activity altering the physical environment leading to both environmental and socio-economic impacts.

2.7 Conceptual Framework for the Assessment Landcover Change and Socio-economic Impacts of Stone Quarrying

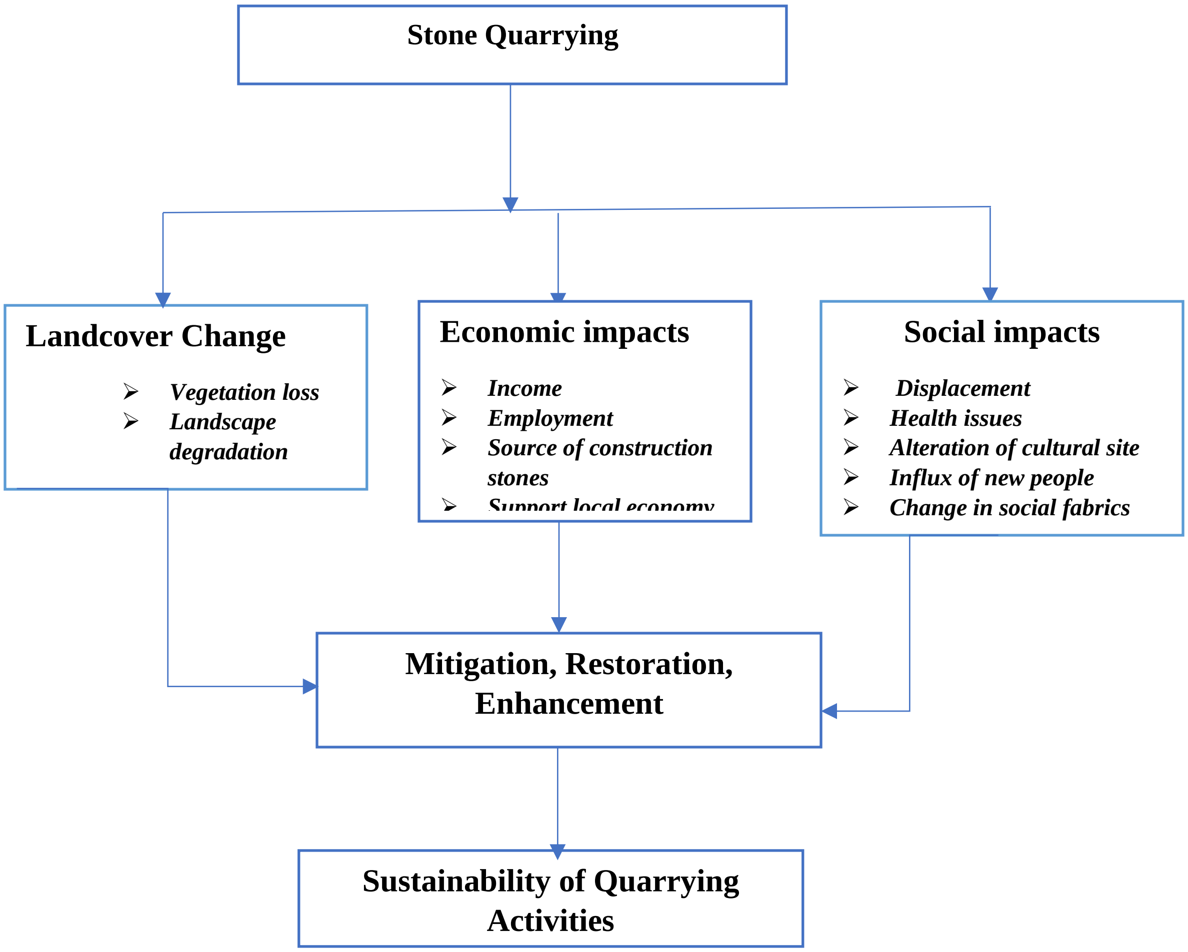


Figure 2.1: Conceptual framework

Stone quarrying is the major factor affecting the entire environmental system. The impacts can lead to changes in the other component of the environment for instance vegetation, landscape, air and water quality. Communities can also benefit from the activity through employment and increased economic development. Consequently, health, moral and other social issues arose due to existence of quarrying operations.

Considering the above framework, quarrying operations are the independent variables while environmental component, social and economic aspects are dependent variable. Mitigation measures, restoration measures and enhancement of positive impacts of stone quarrying will eventually lead to sustainability, these measures form the intervening variables.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Study Area

The study was conducted in quarries within Narok Town Ward.

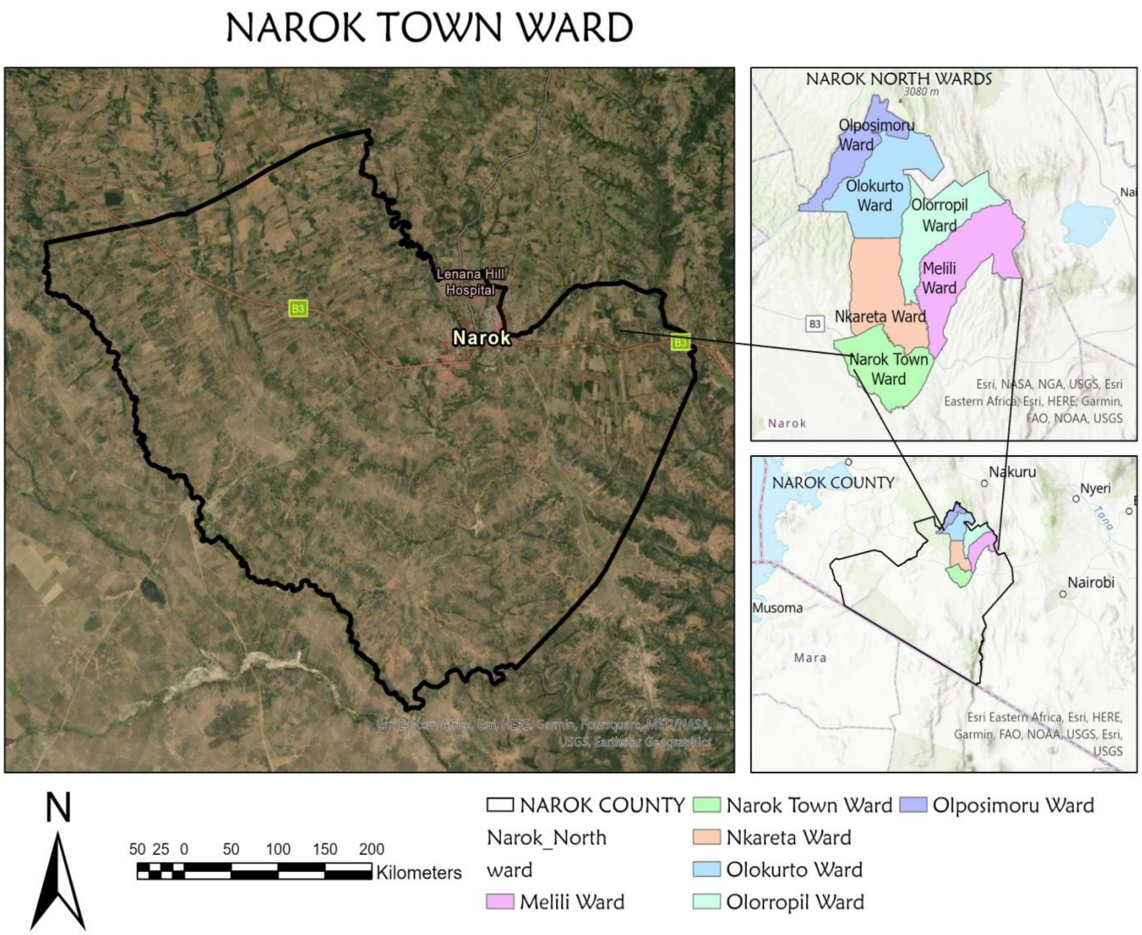


Figure 3.1 Map of Narok Town Ward,

Source, Google earth, Narok Town Ward shapefiles

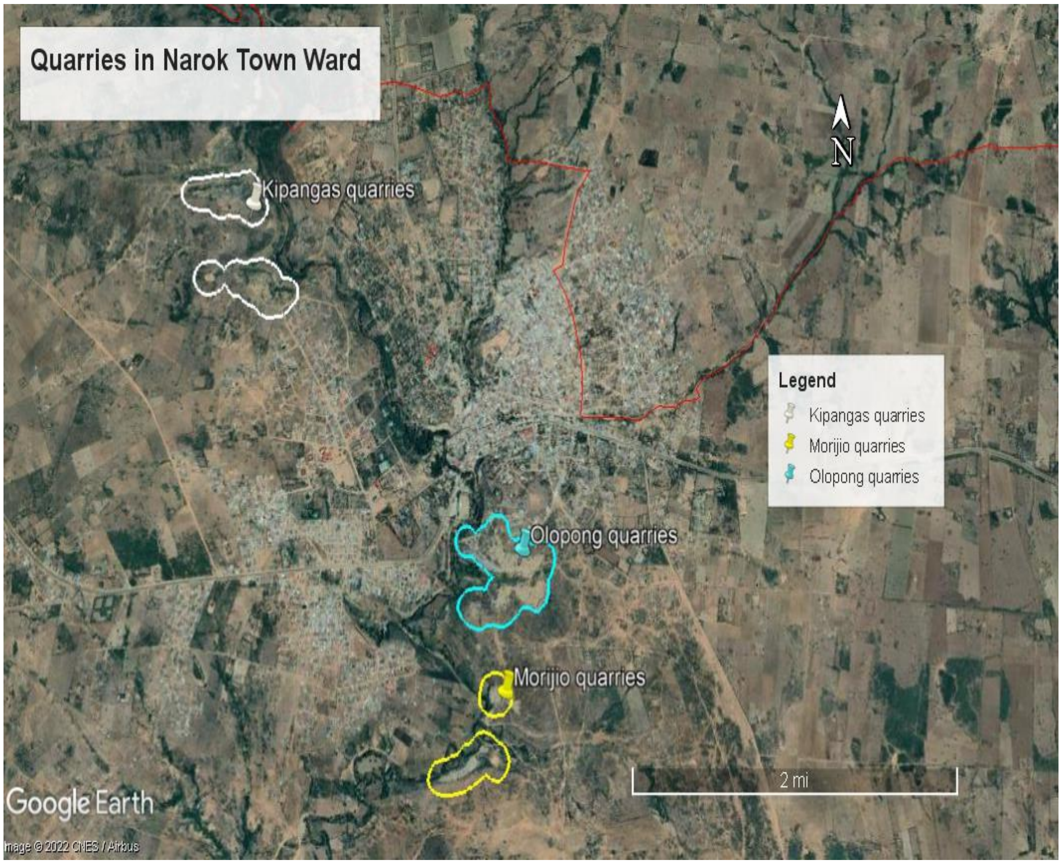


Figure 3.1b locations of quarries

Source google earth maps

3.1.1 Geographical Location

Narok Town Ward is one of the Wards in Narok North Sub-County that covers the Narok Town Municipality. The Ward lies between latitudes 0° 50´ and 1° 50´ South and longitude 35^{o} 28´ and 36^{o} 25´ East in Narok County which borders the Republic of Tanzania to the South, Kisii, Migori, Nyamira and Bomet counties to the West, Nakuru County to the North and Kajiado County to the East. Narok Town Ward host the County headquarters. The Ward is divided into two locations namely Oleleshwa location and Narok township location. The Ward also has the highest urban population among other Wards in the County of about 68000 (KPHC, 2019).

3.1.2 Climate and Physical Features

T The Narok town Ward in Narok Sub-County has a diverse topography, ranging from a plateau with altitudes between 1000m to 2350 meters above sea level in the Southern parts to mountainous terrain reaching up to about 3098 meters above sea level at the highest peak of Mau escarpment in the North. The Sub-County has five agro-climatic zones: humid, sub-humid, semi-humid to arid and semi-arid, of which two-thirds are classified as semi-arid (NGC, 2018). The agro-ecological zones found in the Sub-County include Tropical Alpine, Upper Highland zones, Lower Highland zones, and upper-midland zones. The County experiences bi-modal rainfall patterns with long rains (mid-March to June) and short rains (September to November). Rainfall distribution is uneven with high potential areas receiving the highest amount of rainfall ranging from 1200mm to 1800mm p.a., while the lower and drier areas classified as semi-arid receive 500mm or less per annum. The County experiences a wide variation of temperatures throughout the year, with mean annual temperatures varying from 10°C in Mau escarpment to about 20°C in the lower drier areas (NGC, 2018).

3.2. Research Design

The study employed mixed method research design incorporating both quantitative and qualitative techniques of data collection. The design is suitable for describing the existing situation, narrating facts and investigating phenomena using both quantitative and qualitative data (Creswell, 2012; Opondo et al., 2022). It enables the researcher to understand past state and the current state of the phenomena under investigation.

3.2.1 Target Population

The study focused on those people working in the stone mining quarries and the residents living near the quarries. Additional to these were special groups such local government officials and agencies representatives on matters relating to the environment.

3.2.2 Sample Size

The total population of Narok Town Ward is about **67,683** with a population density of 95 persons per sq. with 17420 households. (KPHC,2019).

To obtain the sample size for the residents, Taro Yamane's formula (2016) was applied

$$\mathbf{n} = \frac{\boldsymbol{N}}{\mathbf{1} + \boldsymbol{N}\ (\boldsymbol{e})^{\mathbf{2}}}$$

Where n= sample size required

N =Total population

e=allowable error (%)

$$\frac{\mathbf{67683}}{\mathbf{1} + \mathbf{67683}\ (\mathbf{0.1})^{\mathbf{2}}} = \mathbf{99.85}$$

Therefore, a total of 100 residents living near the quarry site were sampled during the study.

Reconnaissance was conducted to find the current number of quarry workers in the study area. Total of nine hundred and ninety-five (995) workers were found to be working in different quarry sites in the study area. Quarry owners noted that the numbers keep fluctuating as some workers join and others leave for better jobs. According to Mugenda and Mugenda (2013) when the population less than ten thousand (10,000), a sample size of between 10%- 30 % of the population can be used for generalization therefore, for this study, 15% of the workers in the quarry were sampled to participate in the study. The percentage used is within the range and the is the average of the upper value in the range.

$$\mathbf{n} = \frac{15}{100} \times \mathbf{995} = \mathbf{149.25}$$

Thus, hundred and fifty (150) quarry workers were sampled randomly to participate in the study based on the convenience and availability of at the time of visit to quarry site. The proportional distribution of quarry workers in different quarry areas is shown in Table 3.1a below.

Table 3.1a Proportional Distribution of Quarry Worker

Strata	**Pop**	**Calculations**	**Sample size**
Morijo quarries	310	$\frac{310}{995} \times 150 = 47$	47
Olpopong quarries	350	$\frac{350}{995} \times 150 = 54$	53
Kipangas quarries	335	$\frac{335}{995} \times 150 = 50$	50

Additionally, two village elders for villages covering study area and three NEMA officials who were in the office at time of field visit were included in the sample size. Summary of the respondents is shown in Table 3.1b

Table 3.1b Summary of the respondent

Group	Population	Sample size
House hold heads	**67683**	**100**
Quarry workers	**995**	**150**
NEMA officials	**5**	**3**
Village elders	**2**	**2**
Total	**6865**	**255**

3.2.3 Sampling Techniques

During the study, a combination of stratified and simple random sampling was employed in sampling quarry workers and resident's household heads. Due to different locations of quarry sites in the Ward, each site formed a stratum. Three strata were formed which include olpopong' quarries also known as Narok Town Council Quarry with three quarry sites numbered one to three, Morijo quarries in Polong'a area and Kipangas quarries site. A total of 100 household heads of residents living near the quarries within the three strata were randomly selected to participate in the study. One hundred and fifty (150) quarry workers were also randomly selected and were issued with questionnaires to fill. Census was utilized in quarry pits with less than ten workers. Stratified and random sampling has been noted to be effective in achieving representation (Mugenda & Mugenda, 2003). Additionally, purposeful sampling was used specifically to select officials from government ministries, NEMA officials and Quarry officials(management).

3.3.0 Data Collection tools

3.3.1 Primary data

The various tools that were used to collect primary data include; questionnaires and interviews. Questionnaires (Appendix I and II) were issued to the residents' house hold heads and the quarry workers distributed in different quarry sites in the study area to collect information required for the study. The two sets of questionnaires contained both open and closed ended questions and were divided into subsections as per variables of each objective. Quarry managers, officials from Narok County department of environment and NEMA officials were purposefully interviewed using Interview guides. The guiding questions in the guide were arranged based on the study objectives. (Appendix III and IV)

3.3.2 Secondary Data

This involved review of existing studies. Desktop review which focused mainly on both published and unpublished literature relevant to the study. The documents reviewed include journals textbooks, newspapers and relevant documentations. The documented information assisted in the realizing the objectives of the study.

3.3.3 Spatial Data Acquisition and Data sources

Remote sensing and Geographical Information System (GIS) techniques were used to assess land use land cover changes (LULC) due to stone mining in the study area. Satellite images covering study area were downloaded from United States Geographical (USGS) earth explorer (https://earthexplorer.usgs.gov) for four epochs1985, 1995, 2010 and 2022 for analysis. Average interval of between ten to twelve years in which the images were acquired was used to facilitate change detection analysis of landcover. The year 1985 was the base year in which the preceding year were compared to. The USGS provides users with remotely sensed data which have been collected for over forty years using Landsat satellite with different sensors on board thus provide a wide range of remotely sensed data for deferent purposes (Hassan, 2009). The satellite images were acquired from Landsat 4 and 5 satellites which carries the thematic mapper sensors for the years1985, 1995 and 2010 epoch. For the current year 2022, an image was acquired from Sentinel 2 satellite which carries multi spectral instrument. Landsat 5 has 7 bands, comprising of optical bands 1-5 and 7 with a spatial resolution of 30m, and a panchromatic band (band 8) with a spatial resolution of 15m. On the other hand, Sentinel 2B has 13 bands with a spatial resolution of 10m, except for band 8 which has a higher spatial resolution of 5m that enhances the image quality. The satellite images were initially in the WGS 84 coordinate system and later transformed to the UTM coordinate system zone 36 S, WGS 1984 datum. The utilized bands had a spatial resolution of 30m pixels, while for Landsat 5 (TM), band 6 was obtained at a 60m resolution, which was later resampled to 30m pixels. For consistency in the imagery resolution, the Sentinel 2B MSI bands were also resampled to 30m, despite being acquired at 10m resolution.

Table 3.2 shows a summary of all the satellites images acquired for the study.

GPS points that were used for ground truthing during the accuracy assessment were collected in the field during the study.

Table 3.2 summary of images used in the study

Satellite data	Number of bands	Date acquired	Spatial resolution (meters)	Source	Function
Landsat 4-5 MSS/TM C2 L1 (Path 169 row 061)	8 bands	09-01-1985	30 M bands 1,2,3,4,5and7 15M band 8 panchromatic	(USGS)	Facilitated the change detection process
Landsat 4-5 MSS/TM C2 L1 (Path 169 row 061)	8 bands	21-01-1995	30m for all band expect band 8 with 15m panchromatic	(USGS)	Facilitated the change detection process
Landsat 4-5 MSS/TM C2 L1 (Path 169 row 061)	8 bands	30-01-2010	30m for all band expect band 8 with 15m panchromatic	(USGS)	Facilitated the change detection process
Sentinel 2B MSI (T36MZD)	13bands	26-01-2022	10m for all band expect band 8 with 5m panchromatic	(USGS)	Facilitated the change detection process

3.4 Satellite Image Processing and analysis

3.4.1 Resampling

Resampling is the method of pre-processing digital image and transforming it into a different resolution for the purpose of changing orientation and required resolution (Lillesand,2015). This is because the images captured have limitations as a result of imaging geometry or sensor orientation difference (Lu & Weng, 2007).

According to Onačillová et al. (2022) Landsat 4-5 images are readily resampled and accessed at a resolution of 30M while Sentinel Images are acquired at 10m resolution a higher resolution than the Landsat Images. For this analysis, all the images were required to be in the same standard resolution, therefore, Sentinel images with resolution of 10m were resampled to 30m. This was done in ENVI software using layer staking tools by adjusting the X-pixel size and the Y-pixel size and used the bilinear resampling algorithm to resample the Sentinel Image from 10m resolution to 30m resolution.

3.4.2 Image sub-setting using Narok Ward shape files

The coverage provided by both Sentinel and Landsat images is wider than what is actually needed. The Landsat satellite has a swath width of 185km, while the Sentinel covers an even larger area of 290km, which exceeds the required extent of the region of interest (Roy et al., 2019). Sub setting involves extraction of the area of interest in the image. Narok Town Ward Quarry Boundaries and its environs shape file drawn from Google Earth pro were used for the purpose of clipping. The Narok Town Ward Quarry Boundaries and its environs was clipped from the full mosaic images of both the Landsat images and the 2022 Sentinel mosaic image.

3.4.2 Image classification

Image classification involves automatically categorizing all pixels in an image into a divined number of individual classes. During the study, a supervised classification approach was employed, utilizing 50 training datasets for each of the two cover classes that were established: Vegetation and Non-Vegetation. The Vegetation class was defined as regions that contain vegetation, using Google Earth Pro's ground-truthing vectors. This class primarily consisted of areas with trees, cultivated crops, and shrub lands, with a minor contribution from the spectral signature of chlorophyll to determine the class values. Training data for the Non-Vegetation class were generated from areas devoid of vegetation such as cleared farmlands, human settlements, and bare-lands. The classification process utilized the Maximum Likelihood algorithm. The known land cover regions were digitized, and spectral reflectance of the land cover types was computed using ENVI 5.3 software during image processing. The study area was examined using Google Earth, and personal knowledge was used to develop training sites for the two land-use/land-cover classes. To generate normalized vegetation index (NDVI) values, the NDVI generation functionality in the ENVI toolbox was utilized. The software automatically selected the near infra-red band and the red band as input variables to calculate NDVI and generated values ranging from -1 to 1. In Landsat 4-5 TM, band 4 was used as the near infra-red band, while for the Sentinel 2B image package, band 8 was used. The red band was band 3 for Landsat 5 and 7, and band 4 for the Sentinel image package. The NDVI was computed for each year, and the resulting grayscale representation displayed values ranging from +1 to -1Appendix I.

The density slices were generated from the already generated NDVI of the Narok Town Ward Quarry Boundaries and its environs of each epoch. In ENVI software, this was done using the raster color slices tool in the classification toolbox. In this case color slices of the NDVI based on the spectral wavelength emission class range of the Near Infra-red of 0.25 to 0.50, 0.50 to 0.75 and 0.75-1.00. The analysis relied on fluctuations in plant health determined by the level of chlorophyll present in the plants. Greater concentrations of chlorophyll correspond to increased green vegetation in the pixel. A standard algorithm was employed for calculations, generating reliable outcomes ranging between -1 and +1, which were subsequently utilized to create density slices from raster colour slices of the NDVI. For this particular study, values ranging from 0.25 to 1.00 density slices were chosen as this corresponds to the range where vegetation exists.

Density maps were not displayed in greyscale as the NDVI but changed the table color output to a reverse GREEN – LINEAR WHITE color gradient to display the density slice map as shown in Appendix I.

3.6. Reliability and Validity of Research Instrument

Reliability refers to the consistency of the research instruments in its output. Therefore, to establish reliability of the questionnaires, pilot study was conducted by administering the questionnaire among ten respondents and feedback was used to check evenness of question in the questionnaires. The data obtained was then tested using Cronbach's alpha. The value obtained for each variable based on the objectives were above the acceptable level (0.70) of internal consistency (Mugenda & Mugenda, 2003). The result for the test is shown Table 3.2 below

Table 3.3 Reliability test

Reliability Statistics

Variable	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
Impacts on landscape	0.707	.717	5
Socio-economic impacts	0.742	0.752	7
Mitigation measures	0.763	0.768	4

Validity shows how well the results of a research conforms to the reality, to enhance validity of the research instruments, supervisors were consulted for their opinions and modification was done before the actual study.

3.7 Data Analysis

Data were analyzed using descriptive statistics; frequencies, averages and percentages. Qualitative data in textual form acquired from open-ended questions were analyzed through content analysis which involve coding of data into desired themes then analyzed using percentages and averages.

Image analysis and classification for different epochs was done using Environment visualization software version 5.3. Spearman's correlation statistic formular was used to test hypotheses. Coded data was first tranformed to fit the the the correlation model

$$\boldsymbol{r} = 1 - \frac{\mathbf{6}\sum d^2}{\mathbf{n}(\boldsymbol{n}^{\mathbf{2}} - \mathbf{1})}$$

Where r =correllation coeficient,

$\sum d^2$= sum of squares of defferences between ranks,

n= number of items.

3.8 Data Presentation

Data was presented using both quantitative and qualitative forms, which include tables, pie charts, bar graphs, averages, percentages and inform of text. Spatial data has been presented using maps and tables.

3.9 Ethical Consideration

Before data collection, authorization was sought from Maasai Mara University and the National Commission of Science Technology and Innovation (NACOSTI). The study assured confidentiality to the respondent on information they provided and ensured informed consent from respondents that were not forced in any to provide information.

Summary of the methods used to achieve the objectives is given in Table 3.3 below

Table 3.4 Summary of different methods for achieving the objectives

Objectives	**Data variable**	**Data sources**	**Data collection methods**	**Data analysis**	**Data presentation**
To assess land cover changes due to stone mining in Narok Town Ward.	Temporal changes in area under quarries Land uses Vegetation cover	Satellite images Google earth maps Field survey	Satellite images Observations Questionnaires	Spatial data analysis: land use land classification and analysis Descriptive statistics	Land use land cover maps Tables Frequencies, Reports/ Text
To identify socio- economic impacts of stone quarrying in Narok Town Ward	Social and health issues, economic impacts	Field survey	Questionnaires, interviews Observation	Descriptive statistics (SPSS, MS Excel	Reports Charts Tables Frequencies and percentages
To identify the existing measures taken to mitigate the impact caused by stone quarrying in Narok Town Ward.	Mitigation measures;	Field survey, key informants,	Interviews, questionnaires Observation schedules	Descriptive statistics (SPSS, MS Excel)	Charts Tables Reports

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Spatial Analysis of Land use land cover Change due to Stone Mining in Narok Town Ward

Spatial data were utilized in analysis of Land Cover Changes in Narok Town Ward Quarries and its environs. Classified images of years 1985, 1995, 2010 and 2022 were utilized. The results are discussed under the post classification which includes the area comparison, spatial patterns identified in the changes and the rates of change from one epoch to another and the normalized deference vegetation index NDVI results.

4.1.1 Classification Results

The data used for the classification methods was from USGS Landsat and Sentinel imageries. Landsat 4-5 Multi-Spectral Scanner/ Thematic Mapper images for year 1985, 1995 and 2010 Sentinel 2B images for year 2022. The difference between the Sentinel images and Landsat 4-5 images is that Sentinel has band 8 for Near Infra-red hence 8,4,3 combinations while Landsat 7 and 5 has band 4 as Near Infra-red hence the band combination is 8,4,3. Both of them have a panchromatic band 8 that has got a higher spatial resolution of 15 M this band was used for pan sharpening. The analysis of the various land cover types was conducted based on the number of pixels representing that particular land cover type relative to the total number of pixels in the image. The three sites shown in the thematic maps are the quarry site in the ward as shown in the study area map Figure 3.1b.

4.2 Post Classification Analysis and Discussions

Post Classification analysis was performed on the supervised classification images for the years 1985, 1995, 2010 and 2022 Imageries. From the 1985, the vegetation cover class is assumed to be intact with most of the area of study being vegetated and a small portion under non-vegetation cover class. Non-vegetated areas included built up areas, bare land and even newly prepared farms. Classified image of 1985, the initial year was used as a starting point in the change detection analysis.

4.2.1 Classification image for the year 1985

In this year the vegetation cover class occupied area percentage of 61.00% which was a huge portion of the classified 1985 imagery. This was the initial image used as a start point for the change detection analysis of the Narok Town Ward Quarries and its environs. The vegetation cover class was almost fully intact with a high percentage of the area coverage being vegetated while the non-vegetation cover class covers only a small portion of 39.00 %as shown in Figure 4.1a. The non-vegetated area contains mainly bare land and exposed rocks, an indication that either the Stone Quarrying activity could have started this early or the area had exposed rocks on the surface.

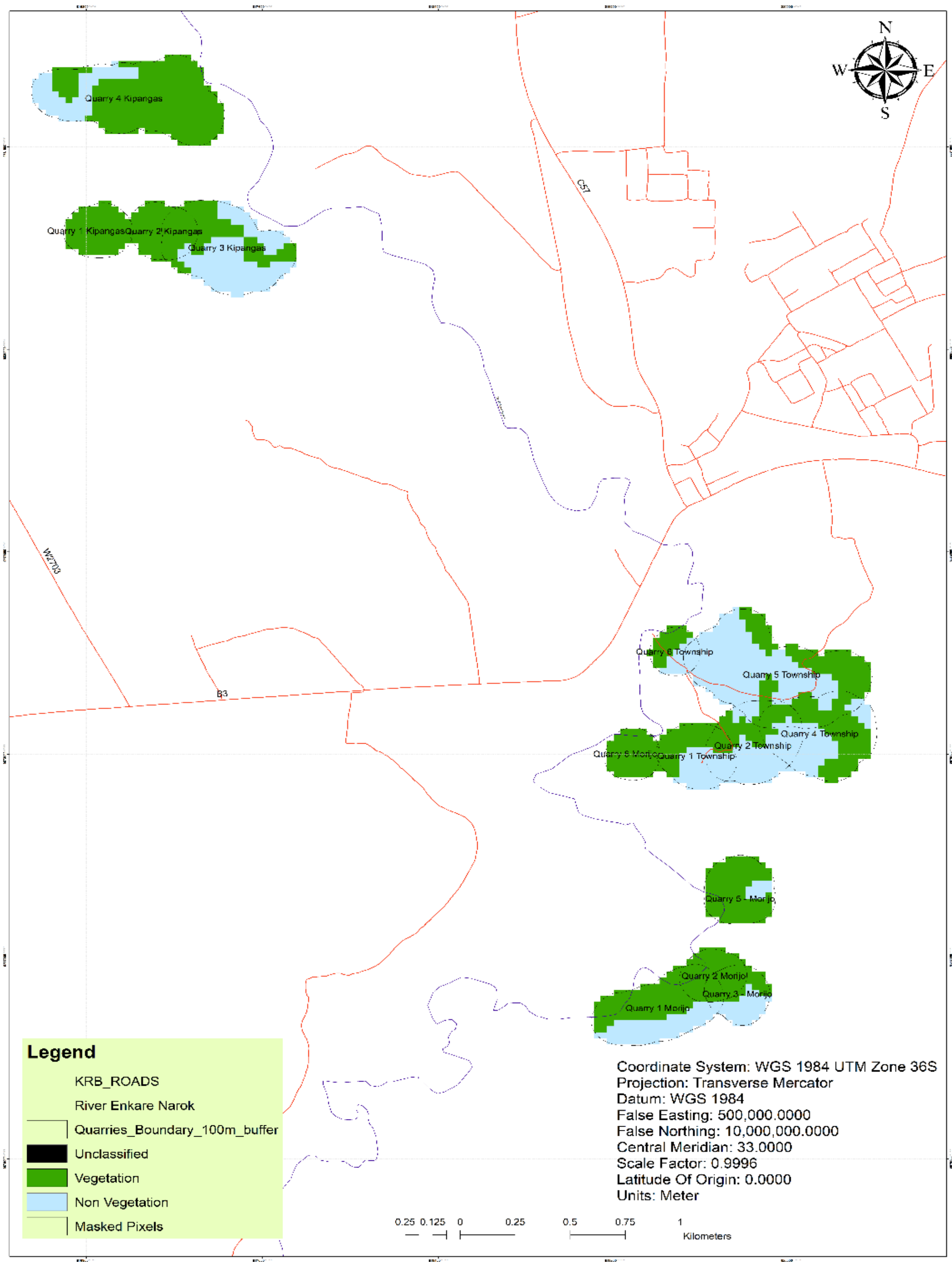


Figure 4.1a: Land cover map of the Narok Town Ward Quarries and its environs in 1985

4.2.2 Classified image for the year 1995

In the year 1995 the vegetation cover class occupied area percentage of 42.30% while the Non–vegetated regions are covered by an area percentage of 57.70%. The dense forested land cover area reduced from the classified image for the year 1985.The land cover map shows a decrease in coverage of the areas under vegetation cover class while area under non-vegetation cover class increased as shown in the Figure 4.1b. The areas under non-vegetation cover class increased from 39.00% in 1985 to 57.70% in 1995 and a reduction in vegetation cover class. This is to indicate either a lack of rain in the previous year or the community indulged in the stone mining activities to verify the increase in non-vegetation areas and the reduction of the vegetation cover class.

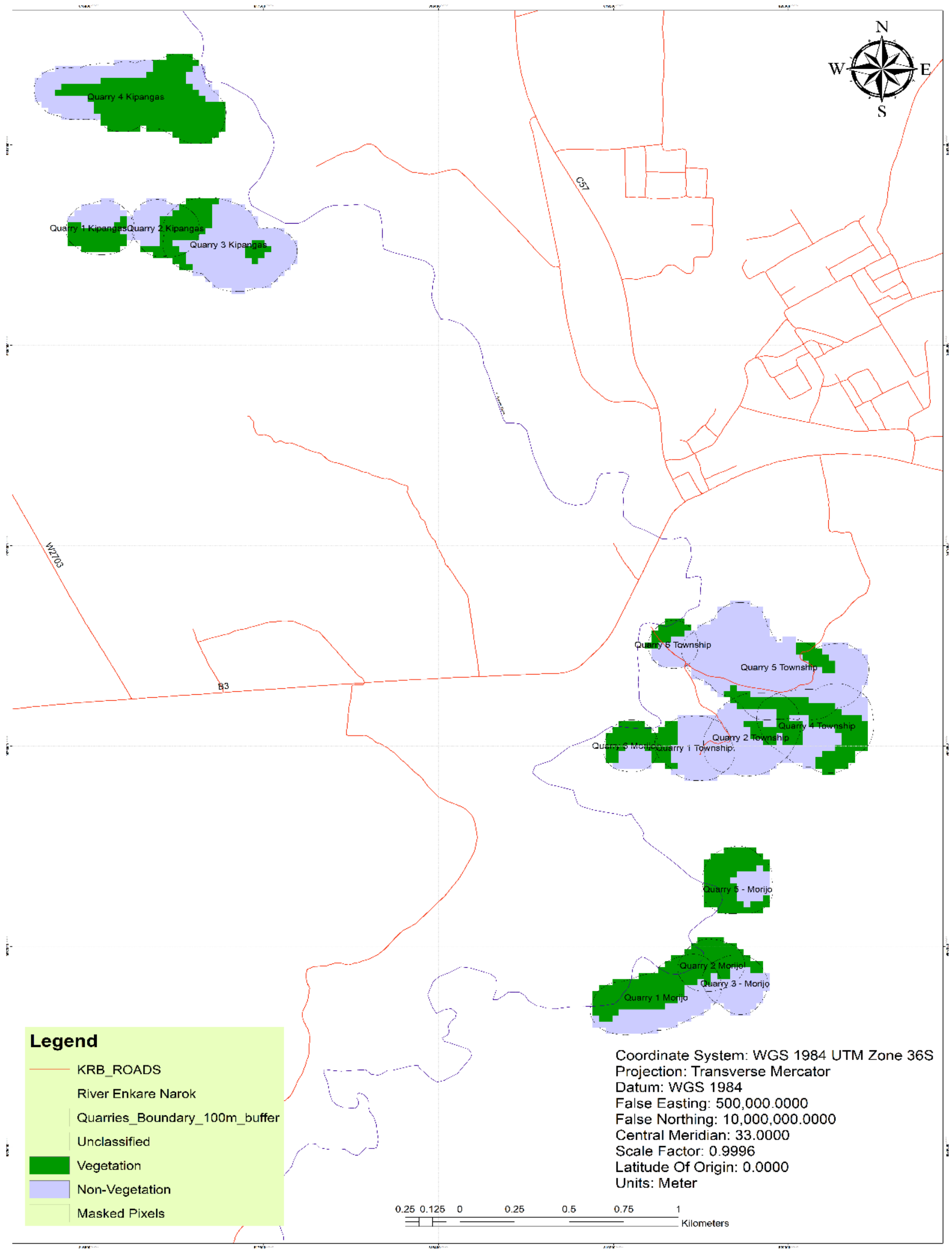


Figure 4.1 b: Land Cover map of the Narok Town Ward Quarries and its environs in 1995

4.2.3 Classified image for the year 2010

The vegetation cover class for the year 2010 occupied an area percentage of 80.10% while the Non–vegetated area land cover class covered an area percentage of 19.90%. The vegetated land cover area increased by a huge percentage of about 37.80% from 42.30% vegetation class cover in the year 1995. A decrease of about 37.80% was experienced on the non-vegetation cover class same amount increase experienced in the vegetation cover class from 42.30% cover in 1995 to 80.10% in the year 2010 (Figure 4.1c). This is an indication of rains experienced at the ending months of the previous year 2009 to explain the increase in the vegetation cover class in the year 2010 and a reduction of the non-vegetated areas.

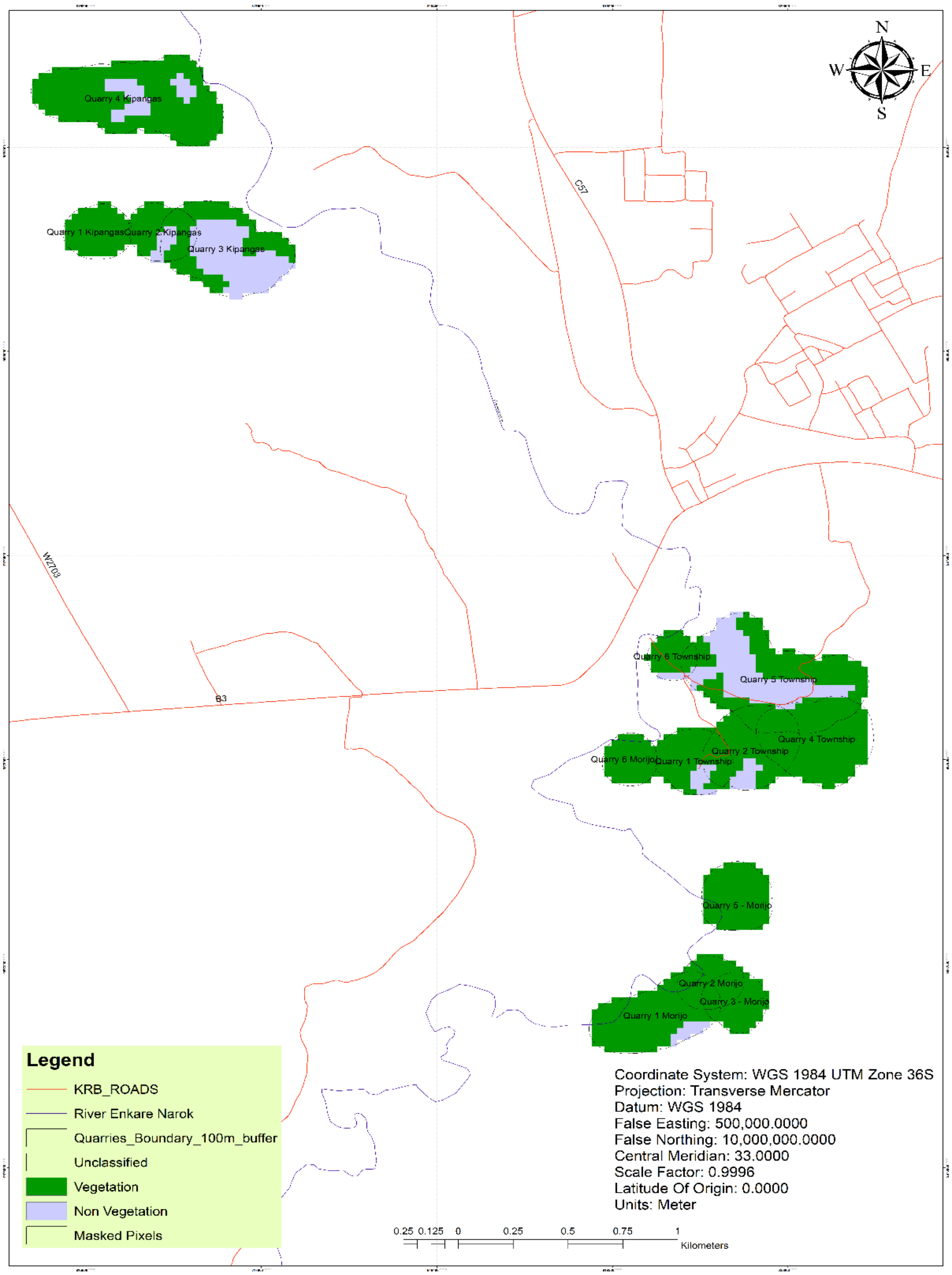


Figure 4.1c: Land Cover map of the Narok Town Ward Quarries and its environs in the year 2010

4.2.4 Classified image for the year 2022

In the last year of study 2022, the vegetation area land cover class occupied area percentage of 61.87% a huge reduction from 80.10% in the previous year of study, 2010 cover class while the non-vegetation cover class occupied an area percentage of 38.13% a huge increase of 18.23% from the previous values of 19.90% the year 2010 (Table 4.1) The vegetation cover class area decreased by 18.23% compared to the previously classified 2010 imagery. This is an indication of increased stone mining activities during the period of 2010 and 2022 (Figure4.1d). This finding suggest that a lot of stone house construction was experienced during that period. It could also indicate that the stone mining sites environs could be occupied by people to explain the slight reduce in vegetation cover and increase in non-vegetation class cover in the last year of study. These findings could also indicate reduced in rainfall received in the area of study in the last months of the previous year, 2021.

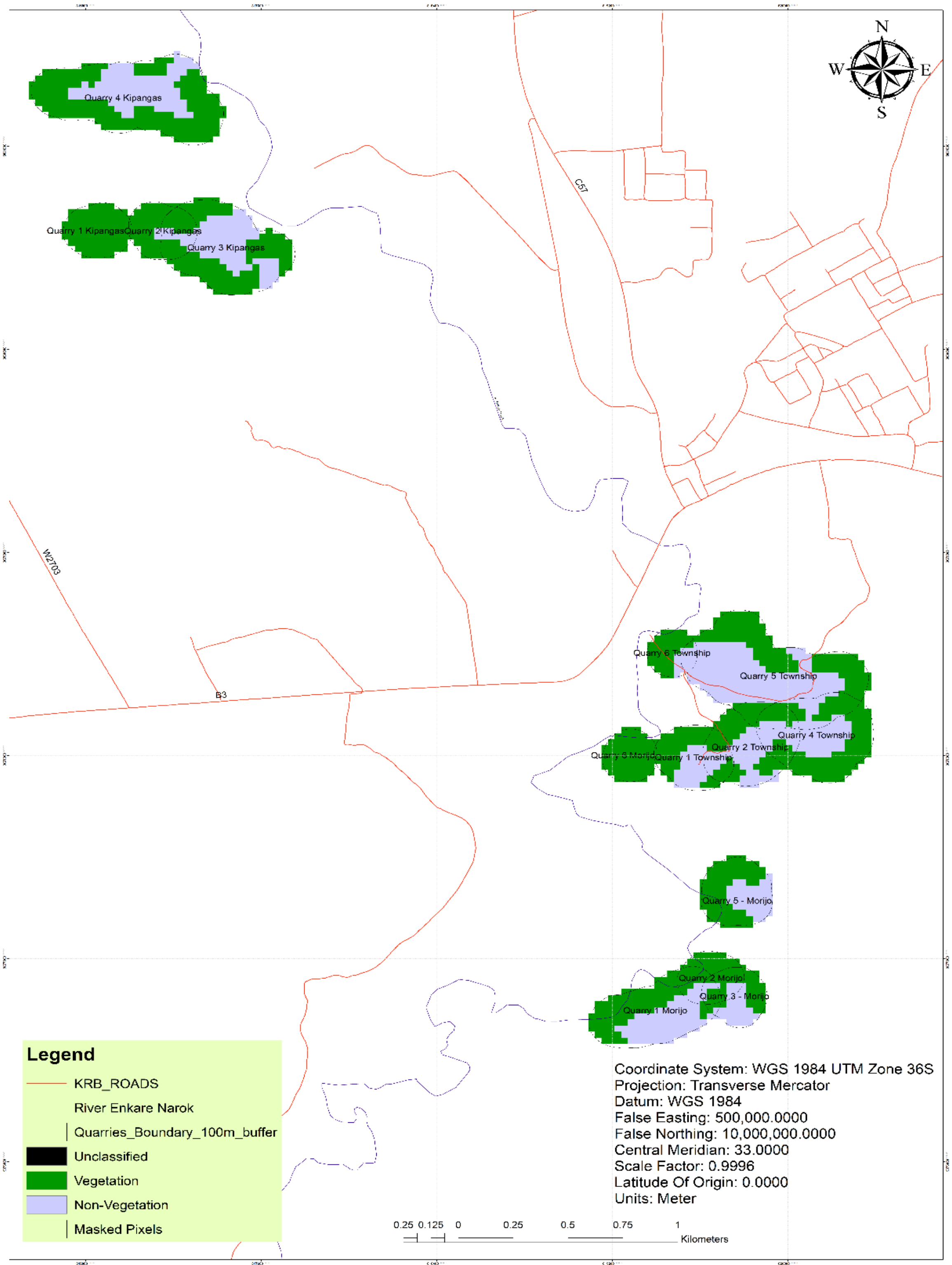


Figure 4.1d: Land Cover map of the Narok Town Ward Quarries and its environs in 2022

Table 4.1: Narok Town Ward Quarries and its Environs Land Cover Class Areas for 1985, 1995, 2010 and 2022 Classified Imageries

Class Category	Area in M^2 and their Percentages							
Cover Type (Class)	Area 1985		Area 1995		Area 2010		Area 2022	
	Area (M^2)	Percent	Area (M^2)	Percent	Area (M^2)	Percent	Area (M^2)	Percent
Non-Vegetation	617400.	39%	913500	57.7%	315000	19.9%	603000	38.1%
Vegetation Cover Class	965700	61%	669600	42.3%	1268100	80.1%	978300	61.9%

The vegetation cover class reduced from 61% in 1985 to 42.3% in 1995. Human activities also had an impact due to the increase of non-vegetation cover class (exposed ground & rock) During the 1995 to 2010 the vegetation cover class increased from 42.3% to 80.1% while the non-vegetation cover class reduced to 19.90% down from 57.7%. The non-vegetation cover class experienced an increment from 19.9% to 38.13% during the period 2010 – 2022 while a drop was deduced from the area under vegetation cover class from 80.10% in 2010 to 61.9% (about 18.24% reduction) in 2022 (Table 4.1, Figure 4.2). This increase in the area under other non-vegetation cover class was mainly an indicator of human activity interference with the vegetation cover class.

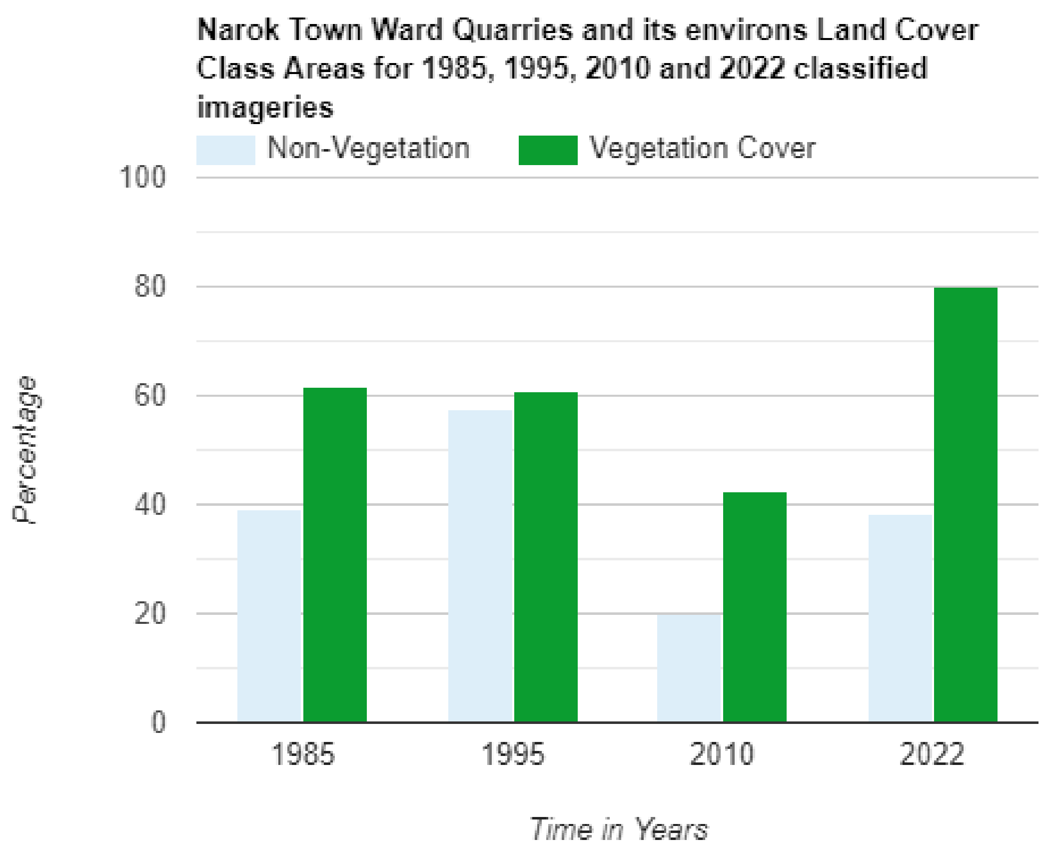


Figure 4.2 Cover class areas in each of the years considered in the spatial change analysis

4.2.5 Area Comparison, Spatial Patterns and The Rates of Land Cover Change

Between 1985 and 1995, vegetated land cover class had reduced by 296,100 m^2 (-18.70%) while non-vegetated cover class representing quarried areas increased by 296,100m^2 (18.70%). The non-vegetated land cover class was reduced by 598.500 m^2 (-38.15%) between the year 1995 and 2010, while an increase of vegetation cover class was experienced by 38.81% in 2010. Between 2010 and 2022, the vegetation cover class decreased by 288,000 m^2 (-18.24%), while area under non-vegetated cover class increased by 288,000 m^2 (18.24%).

The 1985 to 1995, the vegetation cover class had an annual rate of change of -29610 m2, while the area under other non-vegetation cover class had an annual rate of change of 0.0187%. Between 1995 and 2010, there was a positive annual rate of change in the area under vegetation cover class of 39900 m2, while the area under non-vegetation cover class increased by 0.025207% annually. From 2010 to 2022, the area under vegetation cover class experienced an annual rate of change of 24,150 m2, while the non-vegetation cover class had a rate of change of 24,000 per annum (0.0152%). (Table 4.2a)

Table 4.2a Land cover class changes magnitudes and trends

Class Category	Change of Area in M^2 & Changes in Percentage					
Cover Type (Class)	1985 -1995		1995 – 2010		2010 – 2022	
	Area (M^2)	Percentage	Area(M^2)	Percentage	Area (M^2)	Percentage
Non-Vegetation	296100	18.70%	-598500	-37.81%	288000	18.24%
Vegetation Cover Class	-296100	-18.70%	598500	37.81%	-289800	-18.24%

The changes recorded justified the fact that stone mining activities increased in the non-vegetated regions, as more land cover classes were converted from vegetation cover class to non-vegetation cover class indicating more construction activities. These processes catalyzed the increase bare lands and reduction in vegetation over time. Figure 4.3 below indicates changes in cover classes in meters squared (m^2) against time. The need to conserve the Narok Town Ward Quarries and its environs is dire for the purposes of controlling the Quarrying sites from the heavy stone mining as experienced from the period of the year 2010 to the year 2022.

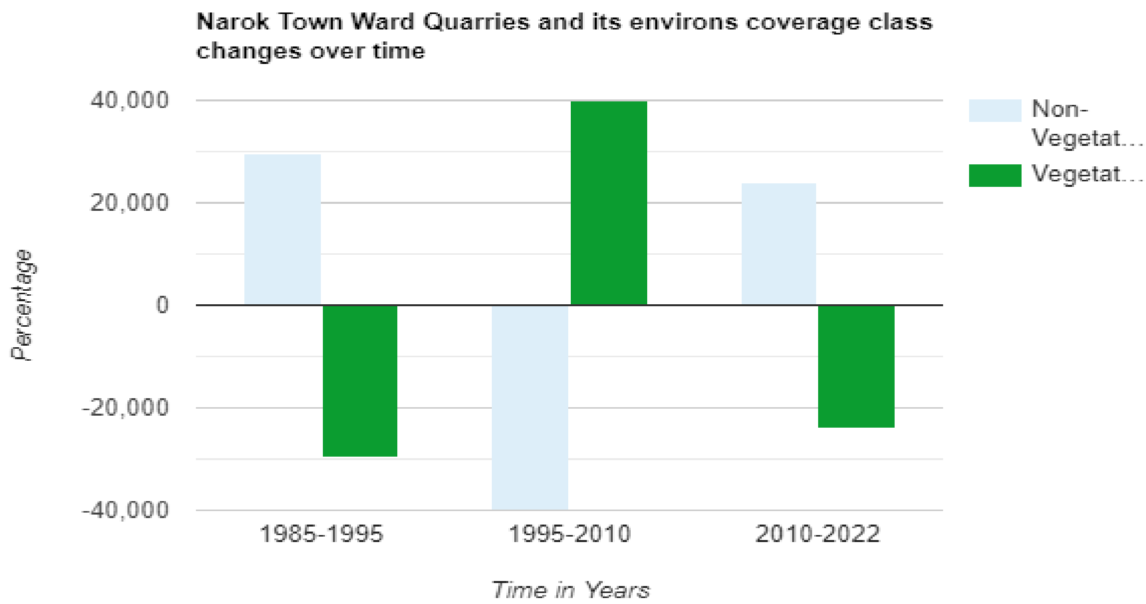


Figure 4.3: Cover classes changes over time

4.3 Thematic Cover Change Between the Different Epochs

4.3.1 Thematic Land Cover Change Between 1985 and 1995

These are changes that occurred between two different epochs and is generated by overlay of and initial image to a final image.

Table 4.3a shows figures representing the nature and area of change between the year 1985 and the year 1995.

Table 4.3 a: Changes in land use and land cover between 1985 and 1995

1985	**1995**	**AREA**	**PERCENT**
Vegetation	Vegetation	641700	40.53
Vegetation	Non-Vegetation	324000	20.46
Non-Vegetation	Vegetation	35100	2.22
Non-Vegetation	Non-Vegetation	582300	36.78

A slight increase on the vegetation cover class was experienced while a slight change from the non-vegetation cover class converted to vegetation cover class by 2.22%. There was increase non-vegetation cover class by 36.78% indicating possible stone mining activities during this period. The cover class change is shown in the overlay image of the year 1985 and 1995 Figure 4.4a

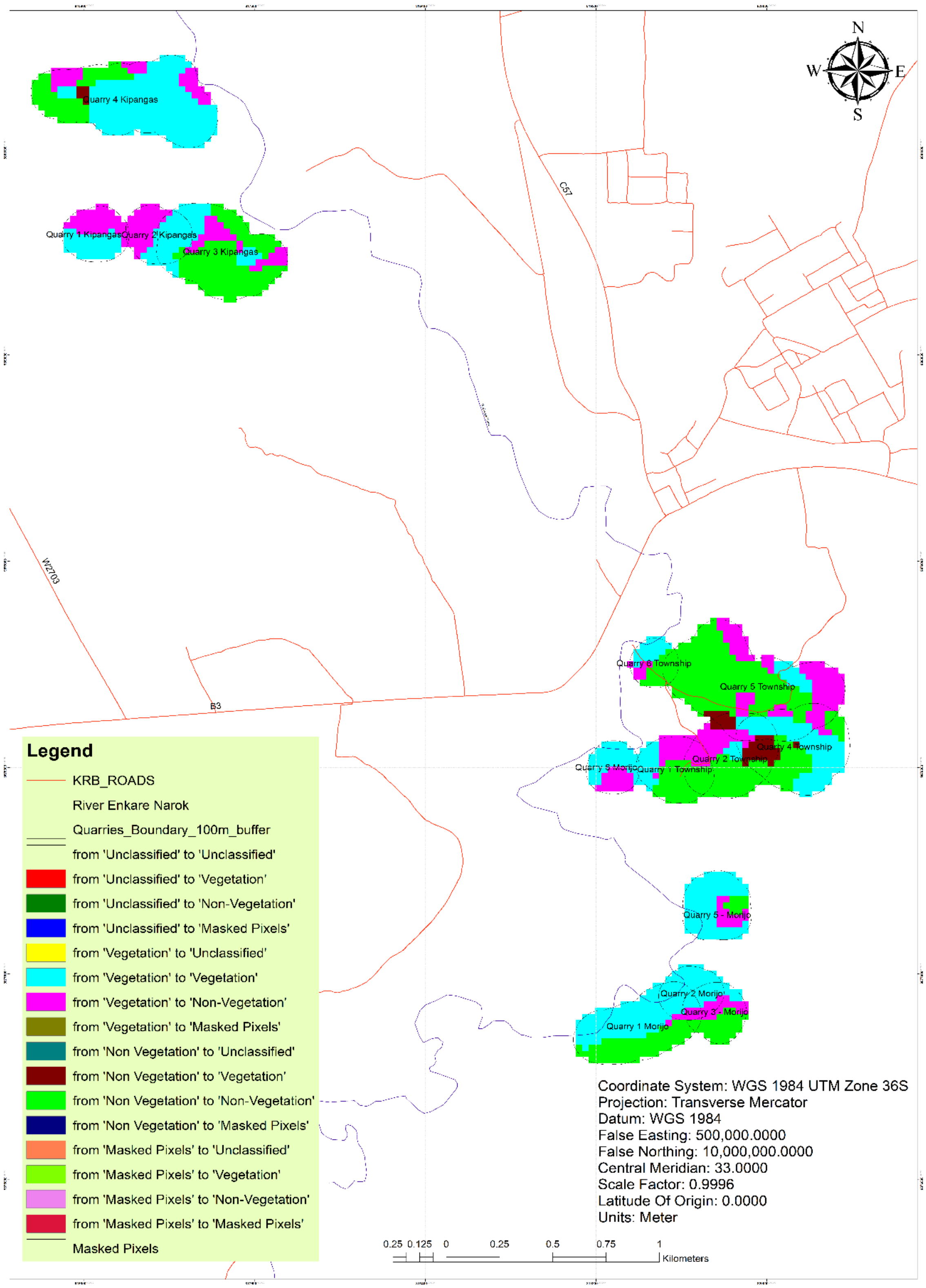


Figure 4.4a: An overlay of 1985 and 1995 images

4.3.2 Thematic Land Cover Change Between 1995 and 2010

During the period 1995 to 2010 a slight decrease on the vegetation cover class by 3.29% was experienced while a slight change from non-vegetation cover class converting to both non vegetated area and vegetation cover class by 16.20% and 41.67% respectively (Table 4.3b, Figure 4.4b).

Table 4.3b Land cover types change between years 1995-2010

1995	2010	AREA	PERCENT
Vegetation	Vegetation	614700	38.82
Vegetation	Non-Vegetation	52200	3.29
Non-Vegetation	Vegetation	659700	41.67
Non-Vegetation	Non-Vegetation	256500	16.20

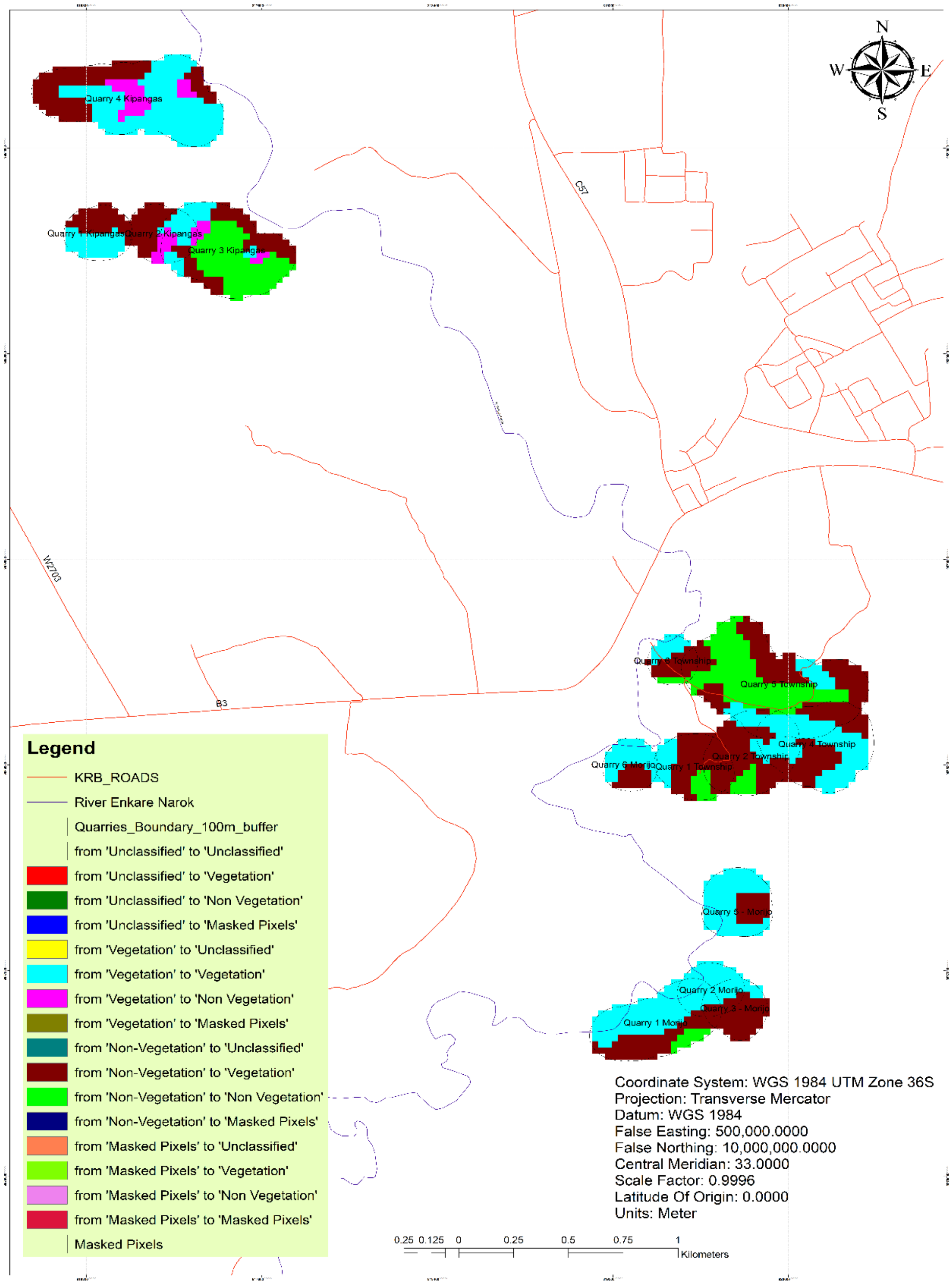


Figure 4.4b: An overlay of 1995 and 2010 images

4.3.4 Thematic Land Cover Change Between 2010 and 2022.

Table 4.3c Land cover types between years 2010-2022

2010	2022	AREA	PERCENT
Vegetation	Vegetation	872100	55.1
Vegetation	Non-Vegetation	355500	22.46
Non-Vegetation	Vegetation	90000	5.68
Non-Vegetation	Non-Vegetation	226800	14.32

Massive land cover changes were noted during this period between the years 2010 – 2022 (Figure 4.4c). A percentage of 22.46% drop-in vegetation cover class while an increase in non-vegetation cover class is an indication of tree cutting clearing of shrubs and bushes to provide more space stone mining and construction. (Table 4.4c). Stone Mining is a booming business in current times at Narok Town Ward Quarries and its environs but the aftermath of stone mining is open land pits as a result of decades of stone mining. The period 2010 to 2022 the vegetation cover class converted to non-vegetation cover class by the highest percentage compares to the other years of comparison (1985 – 1995 and 1995 – 2010).

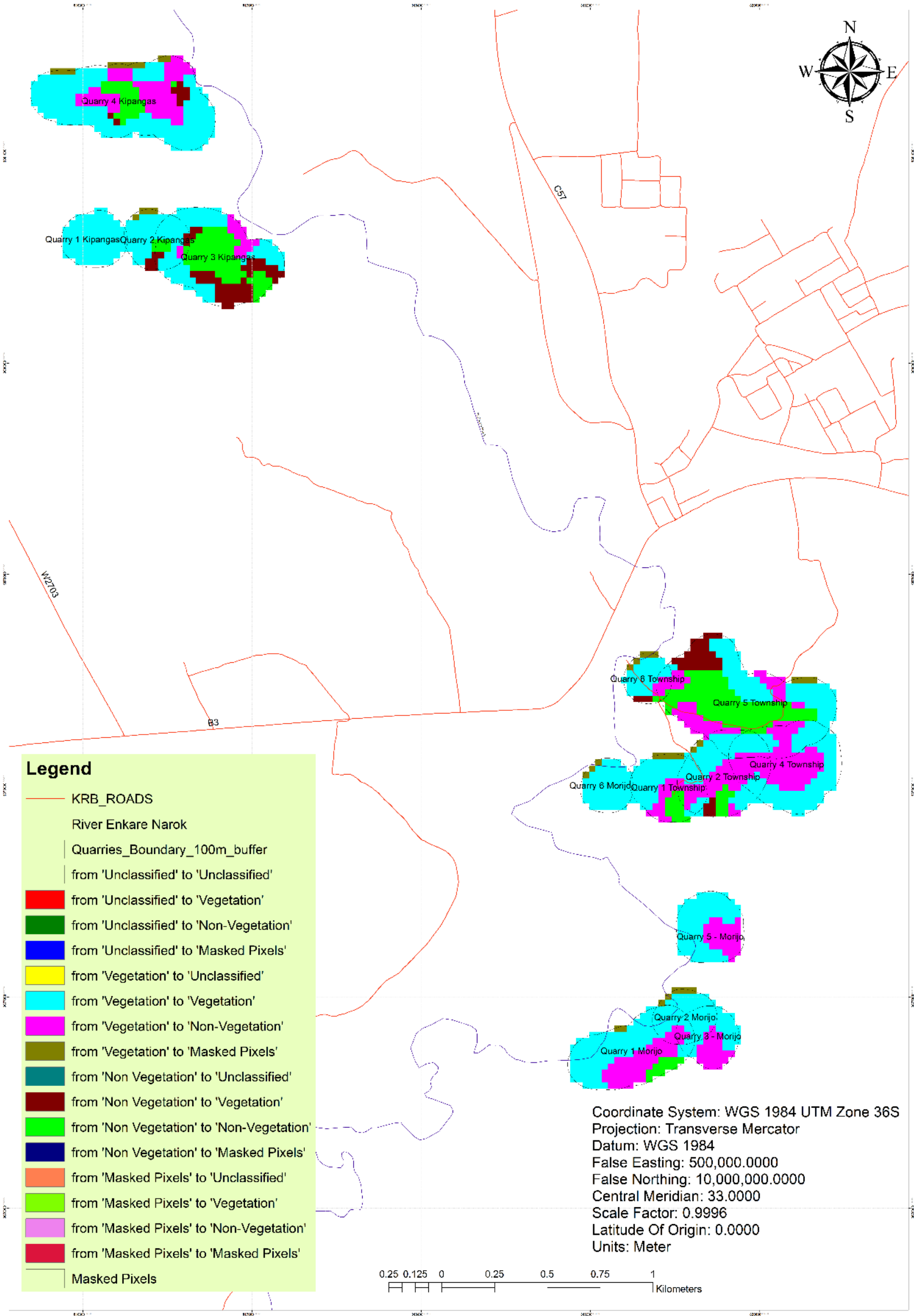


Figure 4.4c: Changes in land use and land cover between 2010 and 2022

4.3.5 Data Validation: Accuracy Assessment

A classification accuracy assessment was performed on the different land cover maps for the study area. An assessment report was obtained having the overall accuracy totals and the kappa coefficients. The accuracy assessment was conducted for each year epoch, 1985, 1995, 2010 and 2022. The results of the accuracy assessment are as follows: -

Table 4.3c Accuracy assessment

Image Year	Overall Accuracy	Kappa Co-efficient
1985	(1000512/1033978) 96.7634%	0.9431
1995	(996641/1016471) 98.0491%	0.9647
2010	(986539/1033978) 95.4120%	0.9205
2022	(8603326/9297288) 92.5359%	0.8778

4.4 Surveyed Impacts of Quarrying Activities on the Landscape

Quarrying activities in the study area has led to scarred appearance of landscape. In order to gather insights from the residents in the study area on the effects of land use/land cover changes, the satellite images were complemented with a household survey where the household heads who were residents in the study area were asked to contrast landscape appearance before quarrying activities and the current state of landscape. The respondents were asked to highlight whether the landscape was vegetated, bare or rocky in the past 15-20 years. Sixty three percent (63.53%) acknowledged that the land was vegetated, 20% indicated that it was rocky and 16. 47% approved that the land was bare. The response on the current state of landscape shows that quarrying activities in the study area have led to changes in the appearance of the landscape with 57.65%, scarred, bare31.76%, vegetated 3.55% and 7.06% for rocky. Figure 4.4

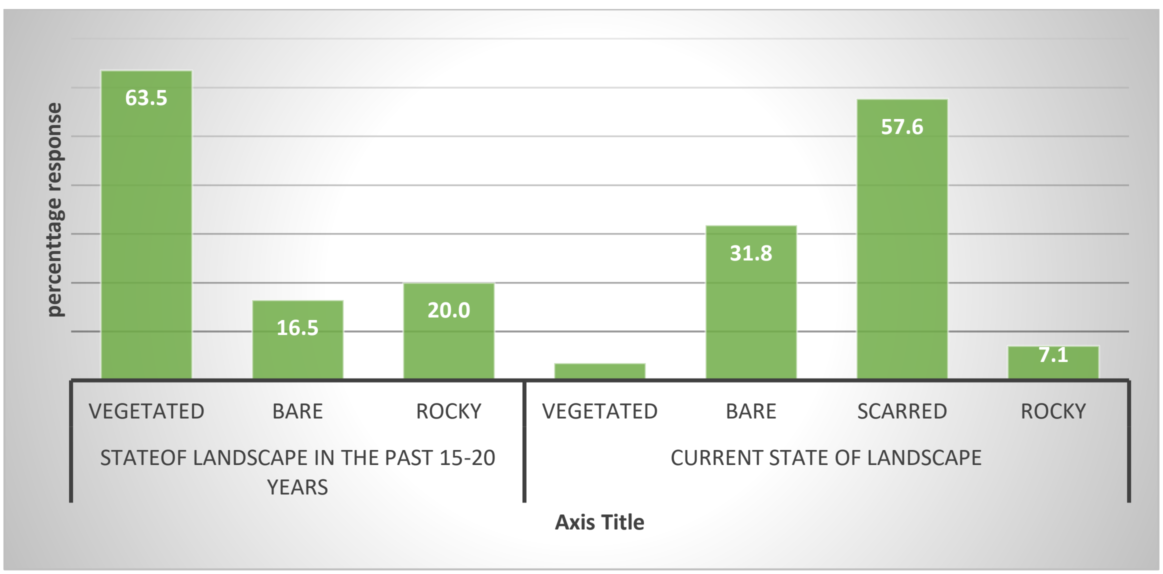


Figure 4.4 State of landscape before quarrying activities and the current state

The current state of landscape shows that the previously vegetated land has been converted to bare and scarred landscape with scattered shrubs making it visually unpleasing due to presents of uncovered pits and huge heaps of quarry waste. The findings corroborate with land use land cover change analysis performed using time series analysis of remotely sensed images for the four epochs;1985,1995, 2010 and 2022 which shows significant changes in land cover between the periods as shown in Table 4.2a. Additionally, during the interview, in Olpopong' area, it was noted that the land that was previous rocky was aesthetically pleasing and attractive to visit for picnics are no more attractive. This is an indication that quarrying activities have affected the aesthetic value of the area. The findings concur with the studies of David (2007) in Hungary and Flavenot et al. (2014) who noted massive alteration of landscape caused by opencast excavation used in stone quarry. Moreover, Ukpong (2012) explains that excavation sceneries cause visually unpleasant condition that lowers the aesthetic value of the landscape.

4.4.1 Vegetation loss caused by quarrying activities

The initial stages of quarrying activities involve clearing of vegetation to give space for excavation process and development of access roads to and from the quarry site. During the study quarry workers who are the primary subjects interacting with the activities in the site were asked to describe the severity of vegetation destruction caused by quarrying activities. The findings showed that the severity of vegetation destruction is between severe (48.33%) and very severe 40% indicating that the extent to which vegetation is lost was alarming. Only 11.67% had a different opinion indicating that vegetation loss was not severe

The situation was observed during the observation schedules in different quarry site in the study area, which confirms the respondents' views on the severity of vegetation destruction caused by quarrying activities as displayed in plate 4.3-Apendix II. The photos were taken during the field visit shows that vegetation is cleared to give room for excavation and some are uprooted during excavation process

H0: There is no significant relationship between land degradation caused by quarrying activities and vegetation loss in Narok Town Ward

A correlation between landscape degradation and vegetation loss was run to assess the relationship between the two variables in order to make a decision whether to reject null hypothesis and accept the alternative or vice versa results displayed in Table 4.4 below

Table 4.4 Correlation between land degradation and vegetation loss

Correlations			
Spearman's rho		Land degradation	Vegetation loss
Land degradation	Correlation Coefficient	1	.384**
	Sig. (2-tailed)		.000
	N	120	120
Vegetation loss	Correlation Coefficient	.384**	1
	Sig. (2-tailed)	.000	
	N	120	120

**. Correlation is significant at the 0.01 level (2-tailed).

From the table (r=0.384, at 0. 01sig. level, p>0.005) there is moderate positive correlation between land degradation caused by quarrying activities and vegetation loss. Therefore, the study rejected null hypothesis and accepted the alternative hypothesis. Despite that there is relationship between land degradation caused by quarrying and vegetation loss, the moderate correlation between the two variables perhaps indicates that there are other factors that contribute to loss of vegetation cover such as drought which has persisted recently in the entire county

4.4. 2 Land use changes due to stone quarrying

Abundance and easy access of building stones in the study area have led to increased quarrying activities, which has replaced the previous land uses activities in the area. To find out changes in land use activities in the study area, residential households heads who participated in the study were asked to indicate pre-quarrying land uses activities in past 15-20 years and the current land use. The finding indicates that before quarrying in the area, residents used the land for crop farming (41.18%), grazing of livestock (48.24%) and residing in the area. These activities were practiced despite the migratory nature of the native community. These activities have been greatly impacted by quarrying activities which is the current land use indicated by majority of the respondents (n-35,41.2%) as shown in Figure 4.6

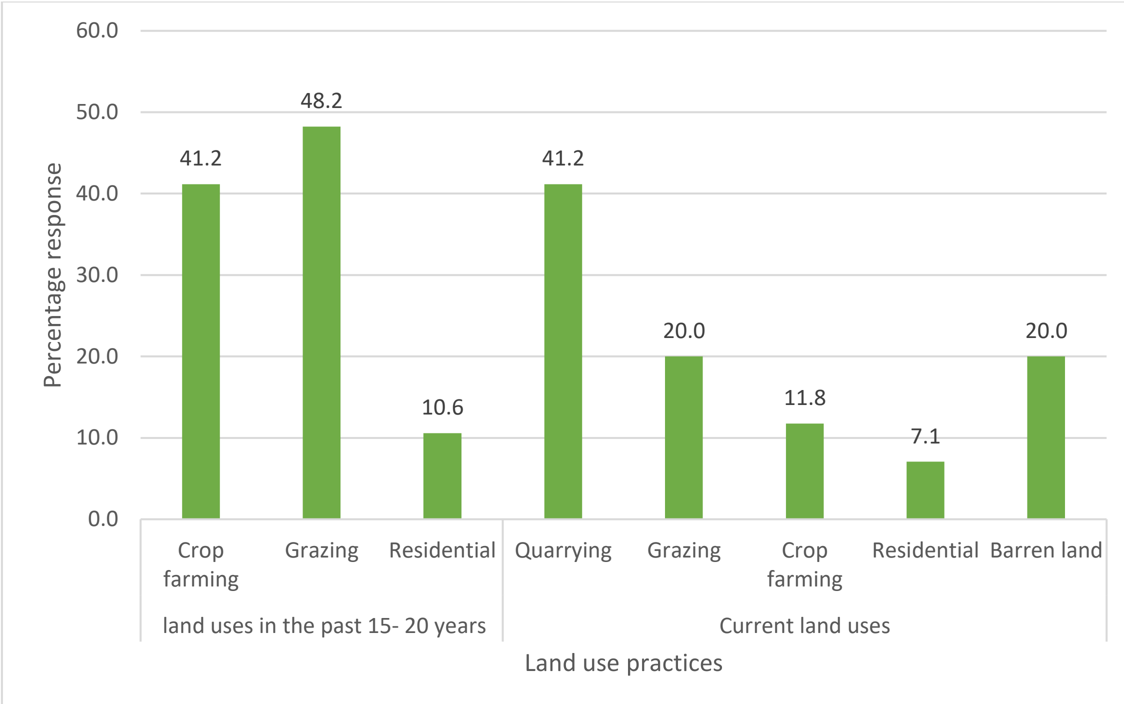


Figure 4.6 pre -quarrying land uses and current land uses

The current land use depicts reduction in grazing and crop farming in the study area due to increased quarrying activities. Vegetation lost due stone quarrying has led to reduction in available forage such grasses and other palatable vegetation for grazing animals thus reducing animal grazing in the study area. This agrees with result obtained in analysis of thematic cover classes indicating that the period 2010 to 2022 the vegetation cover class converted to non-vegetation cover class increased by the highest percentage 22.46% (Table4.4c) Despite the fact that some of the areas where not used for farming, some areas where residents practiced crop farming have been abandoned for quarrying activities. This is attributed to increased soil erosion which has lowered soil fertility in the area. The finding corresponds to the findings of Darwish et al. (2010) who found that quarrying activities in Lebanon had encroached into arable land and previously forested lands leading to reduced productivity in the area. Similarly, Kibii (2020) in her study noted reduction in agricultural activities due to encroachment of quarried lands. Reduction in agricultural activities can also be attributed to fact that quarry income can be realized within a short time as compared to agricultural activities whose returns take relatively longer time and this has pushed majority of the youth into quarrying activities. Over dependency on quarrying activities and increased conversion of agricultural land will to some extent contribute to food insecurity in the area which leading to unsustainable livelihood. Results also indicates presence of barren land has indicated by 20% of the respondents, this would mean that some of the quarried land is not usable due to its status after quarrying since the land has not been rehabilitated.

4.4 Socio-Economic Impacts of Stone Quarrying

The study assessed social and economic ramification of quarrying activities in the study area that is in the three strata, Kipangas, Olpopong' and Morijo through analysis of information gathered from both quarry workers and residents

4.5.1 Demographic Characteristics

4.5.2 Respondents' Gender

The study noted unevenness in gender among workers having the male gender dominating the industry with 83.33% and female gender having only 16.67%. The high number of men in the study area indicate that quarrying activities are undertaken by a majority of the male gender. The findings correspond to those of Balcha and Oyda (2021) in Southern Ethiopia and Mbandi (2018) in Kitengela who also found that majority of the respondents in the quarry were male. The women who were interviewed were actually found in the quarry site breaking the stones in contrary with the findings of Kibii (2020) and Wangela (2013) whose findings indicated that women were doing domestic work and running eateries near the quarry sites.

4.5.3 Age of the Respondents

Age wise, majority of the respondents especially for the quarry workers were youth aged between 21-30 years having the highest percentage of 60% followed by respondents aged between 30-40 with a percentage count of 21.67%. Respondents aged above 50 years were the least with 5%. Majority of the youths could be attributed by the fact that activities involved in the quarry for instance excavation of rocks and breaking of granitic rocks for ballast requires more energetic youths. Limited employment in the formal sector and difficult economic situations are some of the reasons that have pushed most of the youth to work in quarry for them to earn a living. The study established that those aged between 16-20 years comprising of 6.67% had worked in the quarry for less than five years (Figure 4.8) This would mean that this age group comprising of the young people who were being introduced to the industry, while those aged above 50 years mostly were the owners of the quarry pits and some performed administrative roles.

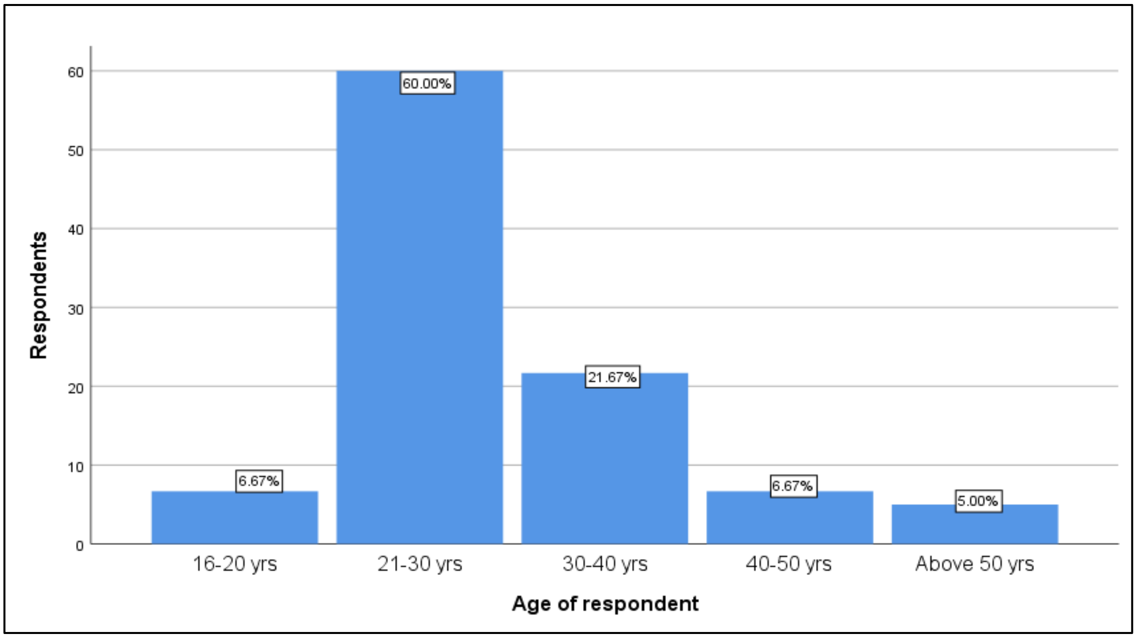


Figure 4.8: Age distribution of quarry workers

Majority of the housed hold heads were aged between 30 and 50 years were resident in the study area. This age bracket, above 50 years (36.5%) indicated to have stayed in the study area for over 15 years, this indicates that they have resided in the study area for reasonable time to experience the impacts of the quarry activities and had a better understanding of the previous and current status of landscape and land use changes

Table 4.5 Household heads age distribution

Age	**Frequency(n)**	**Percent**
21-30 years	1	1.2
30-40 years	19	22.4
40-50 years	31	40.0
Above 50 years	34	36.5
Total	**85**	**100.0**

4.5.4 Respondents Level of Education

To understand whether the education level is a factor contributing to the youth working in the quarry, the study sought the level of education of the quarry workers. The study findings indicated that majority (50.83%) had attained secondary level education, whereas 31.67% had received only primary school education and 10.83% had not received any formal education as shown in Figure 4.8 below

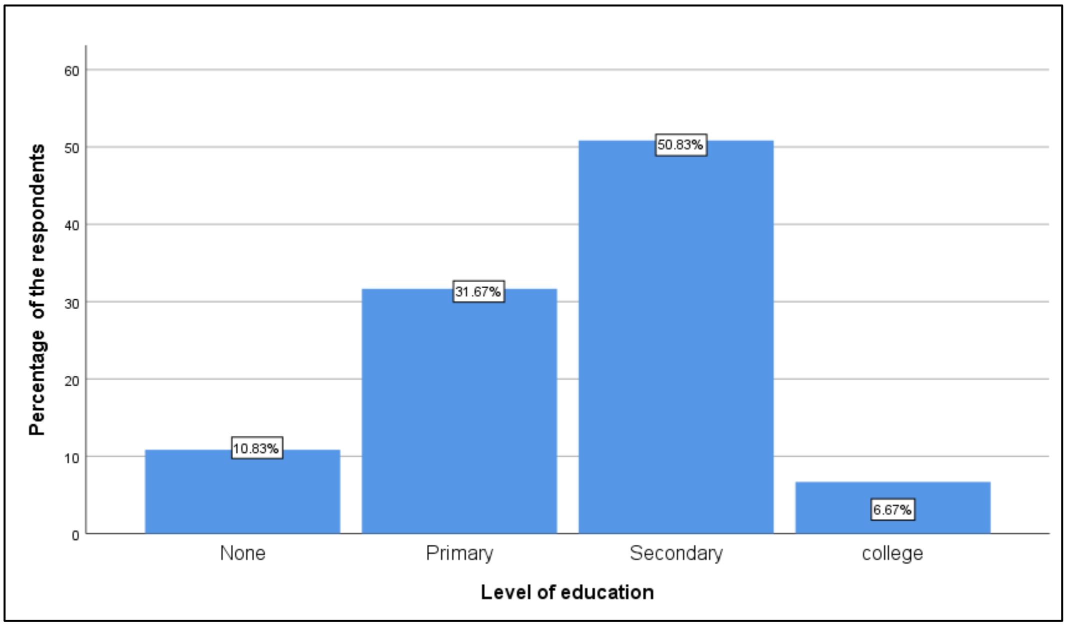


Figure 4.8 Respondents level of education

Even though the majority of the respondents had secondary level education, education level is not a requirement among the quarry workers due to the fact that quarrying activities do not require any qualification except for those who are drivers and machine operators. It was noted that none of the machine operators and drivers interviewed had attained education below the secondary school level. The few (6.67 %) respondents who had attained college level education were tasked with managerial roles.

4.5.5 Social impacts related to quarrying activities

The study aimed at investigating whether stone quarrying in the study region resulted in any social impacts. To assess the social impact in the area, participants were requested to provide their views on the perceived social implications of quarrying activities. The social concerns that emerged as a result of the introduction of stone quarrying in the study region are depicted in Figure 4.9.

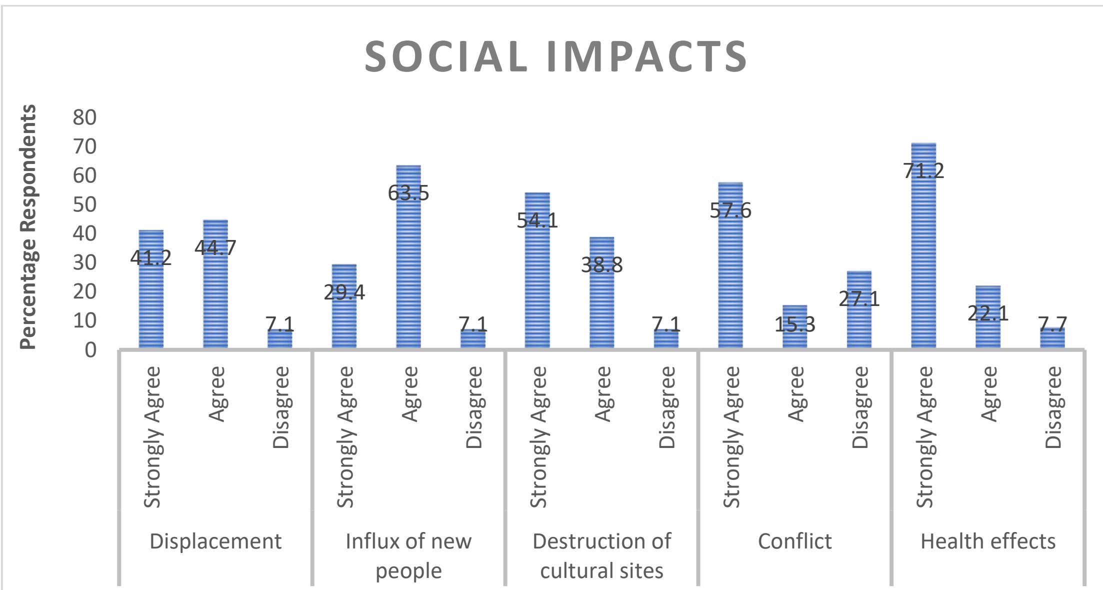


Figure 4.9 Social issues arising due to quarrying activities

Findings indicates the aspects of displacement were among social issues in the study area caused by quarrying activities in the area,44.7% of the household heads agreed while 41.2% strongly agreed that indeed quarrying had caused displacement of some residents in the area. Some residents who were owners of commercial rental houses in the area noted that there are many vacant houses since their tenants had to relocate after a short while due challenges related to quarrying activities such as noise and exposure to dust. They further explained that they have been forced to lower the price of their commercial rental houses in order to attract tenants. Population influx in the area was also an issue that stood out in the area with 63.5%of the respondent agreeing ,29.4% strongly agreeing that there are more people coming to work in the quarry. Further, respondents asserted that people came from other areas especially from informal settlement areas of Majengo to look for jobs in the quarry. The issues of conflicts also were indicated as 57% of the respondent strongly agreeing that indeed quarrying activities has led to conflicts in the area. (Figure 4.9)

Further probing indicated that conflict resulted due quarry owners, managers failing to mitigate dust generated especially during the transportation, furthermore, and business people along main access road to Kipangas quarry site were reported to have demonstrated several times due dust and blame the county government for not watering the road to reduce dust

4.5.6 Effects of Dust on respondents

Dust is a common phenomenon in quarry site produced directly during excavation process or during transportation of quarrying products. Quarrying is often accompanied by the production of dust, which is a highly noticeable and intrusive by product. This dust cause significant discomfort and irritation, particularly to the respiratory system, and is a leading cause of respiratory illnesses for both quarry workers and nearby residents. The study assessed respondents' opinions on nuisance caused by dust in the area, the results are presented in Table 4.6 Larger percentage 55% of the respondents strongly agree that quarrying activities are responsible for dust emission that cause nuisance in the area,55.3% agreed ,31.8% strongly agreed relating dust discomfort.

Table 4.6 effects of dust as perceived by the respondents

Statement	Agree		Strongly agree		Disagree		Strongly disagree	
	F	**%**	***F***	**%**	***F***	**%**	***F***	**%**
Quarrying is the main source of source of dust	26	30.6	47	55.3	22	14	0	0
Dust from quarrying activities cause discomfort	47	55.3	27	31.8	6	6.6	5	5.4
Water collected from the roof contain dust	36	42.4	41	48.2	8	9.4	0	0
Dust settles on clothes on the hanging line	50	58	30	35.3	5	5.9	0	0
Dust has led to respiratory illnesses in the area	48	56.5	40	47.1	7	8.2	0	0

Dust affecting the quality of water collected from the roof catchment was also indicated by the respondents (42.4%-agreeing,48.2%-strongly agreeing) this is an affecting most of the residents since majority harvest rain water for domestic use.

From the findings dust quarry dust has been attributed to cause health issues, nuisance and affect vegetation growth. Langer (2009) affirmed that quarry dust is generated from excavation processes, haul roads and even blasting. Dust in the study area was indicated to be caused majorly by tracks transporting the quarry product passing through residential areas

4.5.7 Noise and Vibration caused by quarrying activities

Noise and vibration are common phenomenon in quarry sites. The most common source of noise and vibration are Earth moving equipment and blasting. The study sought to find out the major source of noise in the study areas and respondents were asked to indicate which quarrying activity is perceived to be a source of noise.

The findings indicate that machines and tracks are main sources of noise as indicated by majority of the respondents (44.71%), blasting 28.24% and 27.06% affirmed noise is a result of both machines and blasting. Noise is responsible for hearing problems among the quarry workers and residents living near the quarry site. Lad and Samant (2014) noted significant effect of noise among the locals with 64% ,36% indicating main cause of noise as blasting and tracks transporting quarry products. Concurrent study by Opondo et al. (2022) in Nyando Sub-County showed that noise and vibration caused significant impacts to local community. Blasting in the study area is done almost daily without following regulations provided in noise and excessive vibrations act of 2009 as most of the quarries were not licensed. Inadequate enforcement measures in the study area are have contributed to reluctance of quarry owners in mitigation of noise and other impacts, in fact during an interview with county environmental officials it was noted that insufficient resource especially funds were the limiting factors to undertaking enforcement measures.

4.5.8 Safety measures

Safety measures and gears among the quarry workers are important aspects in preventing health issues related to stone quarrying activities. The study first sought to find out whether quarry workers were aware of safety measures, possess and use safety gears. From the study, it was noted that majority of the quarry workers (71.67%) were aware of available safety precautions. The findings further demonstrated that despite being aware of safety precautions majority of the quarry workers were not in possession of the protective gear (Figure 4.11).

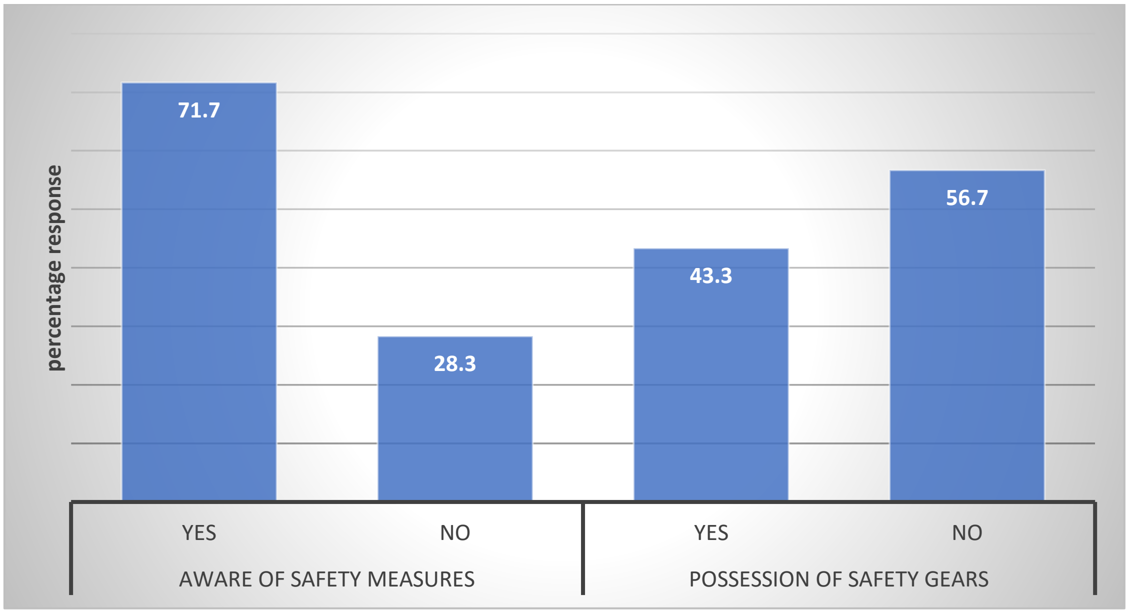


Figure 4.11 Awareness of safety measures and possession of safety gears.

Most of the respondents (56.7%) who were not using protective gear such as gloves, safety goggles and masks, explained that gears were expensive based on their income, thus were at high risk of physical injuries and health issues related to quarry dust. Similarly, those who used protective gear (43.3%) explained that they faced minimal injuries and the masks they put on protected them from inhaling dust.

4.5.9 Health impacts of stone quarrying

This study found various health problems related to quarry activities ranging from physical injuries to respiratory illnesses. Dust generated by quarrying activities both during transportation, excavation and during breaking of stones exposed the respondent to dust related ailments. Respondent were asked to describe their health status before expose to quarry dust and their current health status after the exposure to dust. The findings showed that respondents' health had change after the exposure to quarry dust (Figure 4.12). Quarry workers further explained that their health status had changed a while after working in the quarry indicating that they had regularly suffered respiratory ailments, which they had not suffered before engaging quarry jobs.

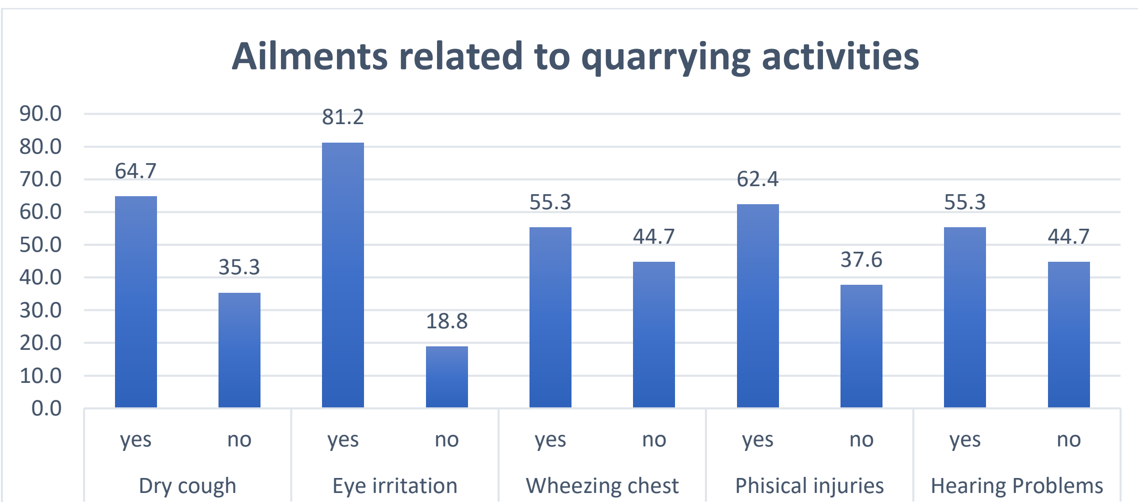


Figure 4.12 ailment indicated by respondents

Exposure to dust among quarry workers and residents has led to increased cases of respiratory infection among them. Findings (Figure 4.12) indicates that 64.7%,55.3% had suffered from coughing and wheezing chest respectively which are symptoms of respiratory infections that result due to exposure to dust. Similarly, 81.2% of the respondents indicated to have suffered from eye irritation which is also attributed to dust exposure. Some of the quarry workers indicated they had suffered from hearing problems which are attributed to high levels of noise caused by quarrying operations such as blasting and movement of the machines. The findings indicated further that 62.4% of quarry worker had suffered from physical injuries due to the fact that majority were not using safety gear. The findings are supported by those of Mbandi (2018) in her study which noted various respiratory ailments among the respondents. The findings also correspond to the findings of Nwibo et al. (2012) and those of Banez et al. (2010).

H0: There is no significant relationship between dust and respiratory ailments reported in the study area

The study sought to find out whether exposure of dust has led to respiratory ailments in the area base on the issues raised by respondents. Correlation was run to determine the relationship.

Table 4.7 Correlation between dust severity and respiratory illnesses

Correlations

			Severity of dust	Respiratory ailments
Spearman's rho	Severity of dust	Correlation Coefficient	1.000	.705**
		Sig. (2-tailed)	.	.000
		N	120	120
	Respiratory ailments	Correlation Coefficient	.705**	1.000
		Sig. (2-tailed)	.000	.
		N	120	120

**. Correlation is significant at the 0.01 level (2-tailed).

The correlation indicated strong relationship between severity of dust as indicated by respondent in this case quarry workers and respiratory ailments. Correlation coefficient ($r=0.705$, $P<0.001$) Shows that dust and respiratory illnesses are highly positively correlated. From this finding null hypothesis is rejected and alternative hypothesis is upheld.

4.5.10 Economic Benefits of Stone Quarrying

Despite negative impacts associated with quarrying activities, quarrying activities also bring about economic improvement in the area. The study sought to find out whether perceived economic benefits of quarrying activities exist in the study area and respondents were asked to give their opinions on perceived economic benefits as shown in the Table 4.8 below.

Table 4.8 Economic benefits attributed to quarrying activities in the study area

Statement	**Agree**	**Strongly agree**	**Disagree**
Quarry has created employment opportunities	**55.3%**	**27.1%**	**17.6%**
Quarrying supports local economy	**49.4%**	**37.6%**	**12.9%**
Quarrying has led to development of roads	**52.9%**	**29.4%**	**17.6%**
Source of construction materials in the area	**61%**	**32%**	**7%**

From the table majority of the respondent in agreement with existing economic benefits in the study area. 55.3% agreed and 27.1% of the respondents strongly agreed that quarrying activities has led to creation of employment in the area especially for the youths. This is confirmed by the fact that demographic characteristics of respondents indicated that majority of the quarry workers were of age between 21years and 35 years.

During the survey, it was observed that hotels and shops within the area are most supported by quarry workers who are their regular customers, hawkers were also among those who benefited from presence of quarry as they sell their merchandise to the quarry workers. Additionally, it was noted that county government also collect revenue in form of taxes from quarry owners and from the business people contributing to the county's economic development. Other benefits noted include development of access road which improves accessibility in the area. The findings correspond to that of Wangela (2013) who reported that stone quarrying in Ndarugo area in Kiambu had led to economic growth in the area citing job creation, road development and improvement of local businesses in the area among other developments. The finding also concurs with that of Orimba (2020) who noted that quarrying other than creating employment it also brings about sustainable economic development through increased amount of taxes earned by the county government.

4.6 Existing mitigation measures to counteract negative impacts of quarrying activities

The study examined whether there were existing mitigation measures geared to reduce negative impacts of quarrying activities in the study area. Respondents were subjected to indicate measure currently in place that reduce the negative impacts. The findings are displayed in Figure 4.15 below.

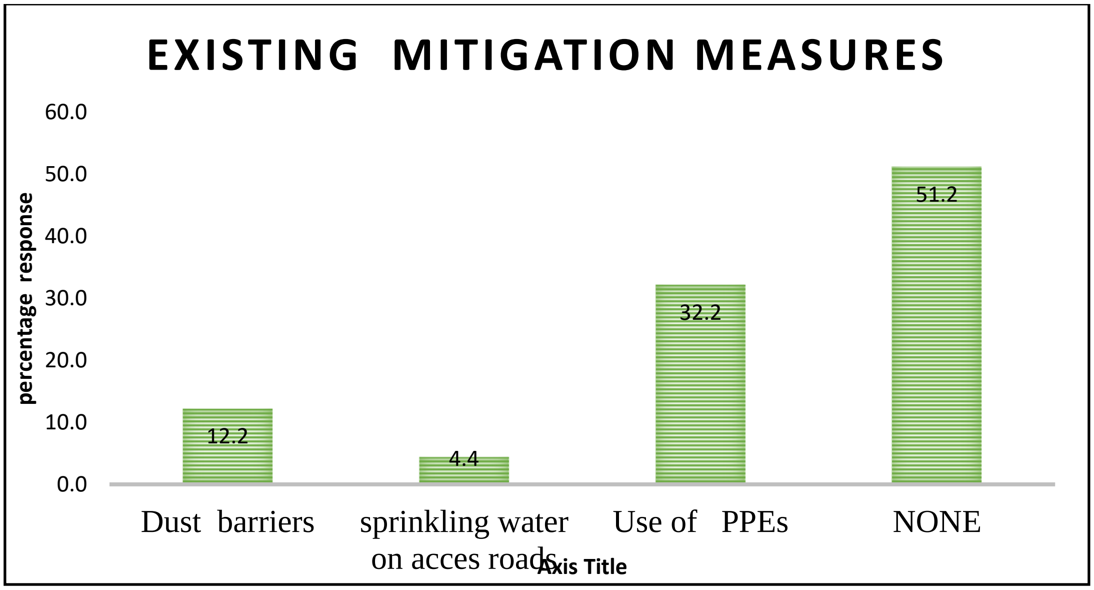


Figure 4.15 shows respondents' views on whether or not there exist mitigation measures

From the findings more than half, 51.2 % indicate inexistence of measures put in place to mitigate negative impacts of quarrying activities. The use of PPEs was indicated by 32.2% which was common among the quarry workers.

During an interview with some quarry owners, they explained that at their capacity they could not rehabilitate quarried land due to the cost involved. Further probing unveiled that some quarry owners actually leased the land for a period of time and thus the responsibility for rehabilitation is left at the cost the owner of the land. Only few of the quarry managers had plans to mitigate impacts of quarrying activities. Those who indicated dust barriers (12%) as existing mitigation measures were further asked to indicate the type of dust barriers in place. Majority indicated that they had planted trees along their fences to reduce dust penetrations into their compounds.

Despite acknowledgment of environmental guidelines provided by NEMA, none of the quarry managers and owners adhered to the measures, this was attribute to the fact that majority of the quarries had not acquired license for their operation. In fact, NEMA environmental officer noted the quarries in the study area operate illegally since they haven't acquired license for their operation. Conflicting mandates of NEMA and ministry of environment among others issues in the county were noted to hinder effective environmental monitoring and management in the county.

4.5.6 Proposed mitigation measure by the respondents

Respondents particularly indicated measures addressing the effects that directly affecting them. Watering of access roads to suppress dust were indicated by majority 33%, creation of dust barriers 27%, use PPEs were indicated by 27%, policy enforcement and rehabilitation of quarried land by backfilling tallied least percentage 8% (Figure 4.16).

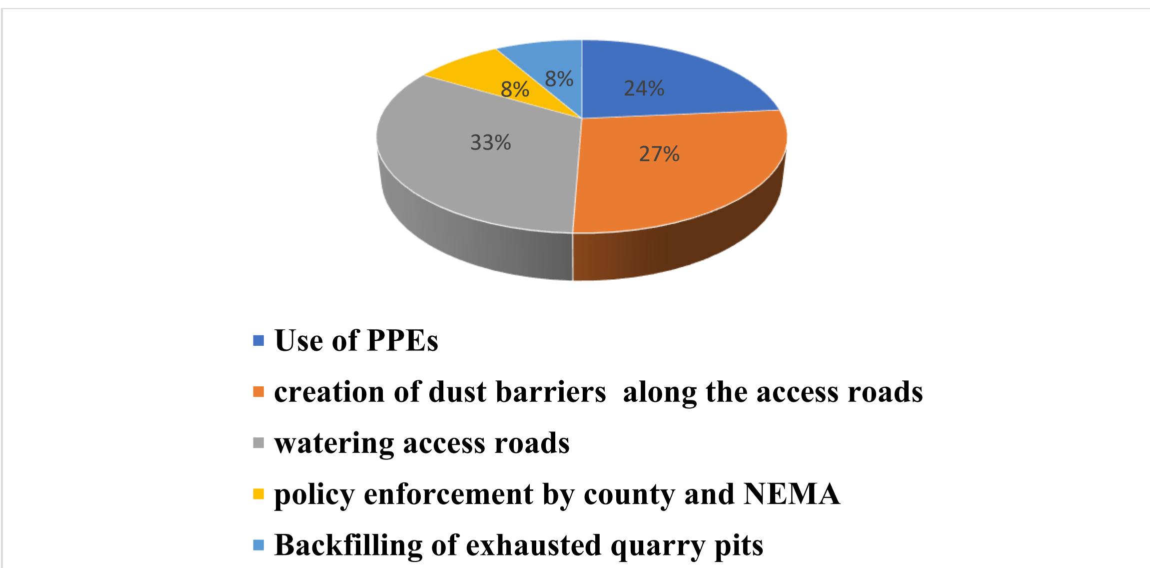


Figure 4.16 Mitigation measures for the negative impacts quarrying activities

Respondents were particularly concern with measures that will alleviate the effects of dust in the area. This indicate that dust issues have persisted for a long time in the study area especially during the dry seasons. The recommended measures can be realized if all the stake holders are involved especially the enforcing agencies and the county government.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary of the Findings

5.1.1 Land Cover Change Quarrying Activities

Spatial analysis of landcover change for the four epochs 1985,1995, 2010 and the current year 2022 showed tremendous changes in vegetation cover. Between 1985 and 1995, vegetation land cover class reduced by 18.70%, while area under non-vegetation had increased by same amount 18.70% (296,100 m^2) The losses in vegetation land cover class let to an increase in the area under non- vegetation. Between 1995 and 2010, the area under vegetation land cover class increased by 598,500 m^2 while area under non-vegetation increased by 38.81%. That is, vegetation land cover class was interfered with in this period and vegetation land cover class was converted to non-vegetation land cover class.

Between 2010 and 2022, vegetation land cover decreased by 18.24% although areas under non-vegetation land cover class changed positively during this period. That is, area under non-vegetation land cover class increased by 288000 m^2 (18.24%). Thus, much of vegetated converted to non-vegetation cover class (quarried land).

Survey data correspond to spatial data in that changes on the landscape were strongly attributed to quarrying activities in the study area. From the finding, 63.53% of the housed hold heads who had been residents the study area for longer time compare to quarry workers indicted that current landscape is scarred, rocky and some areas bare compare to pre quarrying state which was more vegetated. The current scarred landscape is due large active and in active quarry pits coupled with huge heaps of quarry waste dominating the area resulting to unpleasant visual impression. Vegetation alteration was also noted during the study with 40% of the respondents indicating very severe while 48% indicated severe. Correlation statistics between landscape degradation and vegetation loss indicate moderate correlation (r=0.384, at 0. 01sig. level, p>0.005). Air pollution also was noted during the study having quarry dust as a major pollutant affecting both quarry workers and resident. Respondents also noted dust settled on their crops especially for residents along the access roads to the quarry sites.

The study also noted change in land use practices having quarrying activities replacing previously practiced land uses such as crop farming, grazing and residential in the study area with 41.2% indicating that quarrying as the currently practiced activity. Due to vegetation destruction in the study coupled with scarred and bare landscape grazing is no longer viable, despite some area having regenerated the original indigenous vegetation is no longer present for the cattle to forage.

5.1.2 Socio-economic Impacts of Stone Quarrying

The study examined safety measures, health issues, emerging social issues and economic benefits arising due to stone quarrying in the area. On the awareness of safety measures by quarry workers; the study noted that larger percentage (71.67%) of the respondents were aware of safety measures needed in quarry operation. In spite of high level of awareness of safety measures, most of the quarry workers (56.67%) were not having PPEs during their operation in the quarry and thus were exposed to dust, physical injuries and related health issues. The respondents noted that they had suffered from ailments such as coughing, eye irritation, asthma physical injuries and hearing problems.

Social issues highlighted in the study include displacement of the people with 41.2% of the respondents strongly agreeing and 44.7% agreeing that quarrying has caused displacement affecting social-cultural activities in the study area due to quarry operation which was confirmed by landlord who indicated that their tenants were relocating to other areas. Influx of new people and conflicts were among other social ramification of stone quarrying in the area. Furthermore, respondents noted that influx of people to the area had led to change in social fabrics resulting to increased cases of insecurity and crimes in the area.

Quarrying activities have brought about economic gains in the area indicated by respondents such as employment opportunities, local economy improvement spurred by increased population in the area. Other realized gains perceived by the respondent is development of access roads though not in good conditions.

5.1.3 Mitigation Measures

The study found that there are very little efforts put to mitigate negative impacts of quarrying activities, more than half (51.2%) of the respondent noted that actually there were no measures put in place. Only few of the quarry workers put their personal measures such as putting on PPEs to protect themselves. Absence of mitigation measures is attributed to the fact that quarries in the study area were not licensed and thus implying that impact assessment were not done and thus the owner did not have environmental management plans (EMPs).

5.2. Study conclusions

Quarrying activities in Narok Town Ward has led to undesirable environmental outcomes including degradation of landscape, vegetation alteration and lowering air quality caused by dust production.

The study also concludes that the quarrying activities has brought about negative social issues such as change in social fabrics, conflicts, relocation and health related issues in Narok Town Ward

The study further concluded that there are inadequate mitigation measures put in place to mitigate negative impacts of quarrying activities in the study area.

Generally, the negative impacts of stone quarrying in the study area outweighs the economic gains the cost involving restoration of quarried land is much higher as indicated by very low efforts among the respondents to put measures to at least mitigate negative social and environmental impacts of quarrying activities.

5.3 Recommendations

The study recommended the adaption of various alternatives to quarrying materials in order to reduce the need stones from quarries. These include; the used of plastic blocks made from a mixture of melted plastic and sand, the use of glass design houses which uses less construction stones and the use of shipping containers to build houses and other housing structure.

The Study also recommends strict authorization and effective regulations of quarrying activities by agencies, NGOs and communities in order to minimize negative environmental and social impacts of quarrying activities.

Finally, the study suggested that County government, National government and other stakeholders should put in place plans to rehabilitate and restore already degraded landscape. Community education and sensitization on environmental, socio- economic impacts and safety measures should also be encouraged in study area.

5.4 Recommendations for further study

- **i.** Further studies to be carried out in the effectiveness of existing quarry regulation in regard to sustainable resource utilization in Narok town Ward
- **ii.** Research on community awareness of environmental and social impacts of quarrying activities should be done.

REFERENCES

Abate, Z. (2016). Impacts of Stone quarrying on environment and livelihood of local community in Addis Ababa Peri-Urban Areas: The case of Hana Mariam Cobble Stone Quarry Site. *AAU Institutional Respiratory*, http://etd.aau.edu.et/handle/123456789/6299

Akanwa, A., Onwuemesi, F., and Chukwurah, G. (2016) Effects of opencast quarrying technique on vegetation covers and environment in South-Eastern Nigeria. *American scientific Research Journal for Engineering, Technology and Science, 21*(1) 227-240

Alvarez Martinez, J. M., Suarez-Seoane, S., & De Luis Calabuig, E. (2011). Modelling the risk of land cover change from environmental and socio-economic drivers in heterogeneous and changing landscapes: The role of uncertainty. *Landscape and Urban Planning*, *101*(2), 108–119

Anunda, C. N. (2014). Assessment of environmental impacts of stone quarrying activities in Nyambera location Kisii County (Masters research project) Kenyatta University.

Ata-Ezra, A. J. (2016). Assessing the effects of stone Quarrying; the case study of Wenchi Municipality in Brong Ahofo Region of Ghana (Doctoral dissertation). Doi https://hdl.handle.net/123456789/9177

Bamgbose T. O., Omisore O.A., Ademola A. O., & Oyesola O. B. (2014).Challenges of quarry activities among rural dwellers in Odeda local government area of Ogun state. *Research Journal of Agricultural and Environmental Sciences, 3*(1),49-55.

Banez, J., Ajon, S.M., Bilolo, R., & Dailyn, J. M. (2010) Report on quarrying and its Environmental Effects. Bicol University.

Bewiadzi, S., Aumbomu, R. & Glover-Meni, N. (2018). Searching and Cracking: Stone quarrying, livelihood and environment in the Daglama Quarry Site in the Ho Municipality. *West African Journal of Applied Ecology, 26*, 149–166.

Borm, P. J., Tran, L., & Donaldson, K. (2011). The carcinogenic action of crystalline silica: a review of the evidence supporting secondary inflammation-driven genotoxicity as a principal mechanism. *Critical reviews in toxicology*, *41*(9), 756-770.

Brown, D. G., Walker, R., Manson, S., & Seto, K. (2004). Modeling land use and land cover change. *Land change science: observing, monitoring and understanding trajectories of change on the earth's surface*, 395-409.

Chatterjee, N. (2010). The basalt stone quarries of eastern India. The basalt stone quarries of eastern India. *International Journal of Environmental Studies, 67*(3),439-457

Chowdhury, M., Hasan, M. E., & Abdullah-Al-Mamun, M. M. (2020). Land use/land cover change assessment of Halda watershed using remote sensing and GIS. *The Egyptian Journal of Remote Sensing and Space Science*, *23*(1), 63-75.

Creswell, J. W. (2012). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research* (4th ed.). Pearson

Balcha, D. & Oyda, S. (2021)"Assessing the impact of stone quarrying on the landscape, crop and grazing land degradation in Loma Bosa district, Dawuro zone, southern Ethiopia", *International Journal of Scientific Research in Civil Engineering (IJSRCE),5(*2), 79-91, URL*:* https://ijsrce.com/IJSRCE215222

David, L. (2007) Anthropogenic geomorphological and after use problem of quarrying; case studies from UK and Hungary. Geografia *fisicae Dinamica Quanternaria*, *30*,161-165.

Dawish, T., Khater, C., Jomaa, I., Stehouwer, R., Shaban, A. & Hamaze, M. (2010). Environmental Impacts of Quarries on Natural resources in Lebanon. *Land Degradation Develop 22*,345-358

Dentoni, V., Massacci, G., & Radwanek-Bąk, B. D. (2006). Visual impact of quarrying in the Polish Carpathians. *Geological Quarterly*, *50*(3), 383–390.

Dong-dong, z., Yu-shan, S., Le, L., (2009). Study on sustainable landscape of abandoned quarries. *Planet science*, *1*(1)1107-1113. https//: doi.org/1016/. j. proeps2009.09.170

Endalew, A., Tasew, E., & Tolahun, S. (2019). Environment and social impacts of stone quarrying: South Western Ethiopia, in case of Bahir Dar Zuria Wereda Zenzelma Kebele. *International Journal of Research in Environmental Science*, *5*(2), 29-38.

Eshiwani, F. (2014). Effects of quarrying activities on the environment in Nairobi County: a case study of Embakasi district. *University of Nairobi Research Archive*, *October*, 1–78. http://hdl.handle.net/11295/77162

Flavenot, T., Fellous, S., Abdel krim, J., Baguette, M. & Coulen, A. (2014). Impacts of quarrying on genetic diversity, an approach across landscape and overtime. *Conservation Genetics*, *16*(1), 181-194, https://doi.org/10.1007/s10592-0140650-8

George, A., & John, D. B. (2018). Africa's Mineral Economies Breaking their Dependence on Mining. Available at: www.nai.diva-portal.org

Government of Kenya (GoK). (2010). Strategic Environmental Assessment of the National Spatial Plan (NSP) 2005-2025. Nairobi, Kenya: Ministry of Environment and Mineral Resources.

Ghose, M. K. (2012). Environmental impact assessment of mining projects. CRC Press.

Groom, M. J., Meffe, G. K., Carroll, C. R., & Andelman, S. J. (2006). Principles of conservation biology (3rd ed.). Sinauer Associates, Inc.

Hassan, S. (2009). Assessment of land use and land Degradation in the North-Western Part of Bangladesh using Landsat Imagery (Master's Thesis) Division of Geoinformatics, Royal Institute of Technology (KTH*)*,

Haule, H., Ringo, J., Luvinga, K., Kawanga, S., Magengo, G., & Morsardi, L., (2016). Effects of limestone mining on deforestation and degradation in Mbeya region, Tanzania. *The international journal of modern social science, 5*(2), 117-132

Horwell, C.J., Williumson, B.J., Donalson, K., Le Blond, B.S., Damby, D.E. & Bowen, L. (2012) The structure of volcanic cristo bolite in relation to toxicity; relevance forth variable crystalline silica hazard. *Particles and Fiber toxicology, 9(1)44.*

IUCN. (2004). *Guidelines for Quarrying and Restoration of Quarried Areas*. Gland, Switzerland: IUCN

KNBS (2019) Population and housing census Narok County.

Kibii, J. C. (2020). Social and environmental effects of stone quarrying in Tuloungoi sub-location, Baringo county (Masters research project) University of Nairobi

Kim, K., Kabir, E., & Kabir, S. (2015) A review on the human health impact of airborne particulate matter. *Environment International, 74,*136-143.

Lad, R.J. & Samant, J.S., (2014). Environmental and social impacts of stone quarrying -A case study of Kolhapur district. *International Journal of Current Research and Academic Review 6*(3),5664-5669.

Langer, W. (2016). Sustainability of aggregates in construction. In *Sustainability of construction materials* (pp. 181-207). Woodhead Publishing.

Lillesand, T., Kiefer, R. W., & Chipman, J. (2015). *Remote sensing and image interpretation*. John Wiley & Sons.

Lu, D., & Weng, Q. (2007). A survey of image classification methods and techniques for improving classification performance. *International Journal of Remote Sensing, 28*(5), 823-870.

Mayhew, R. J (2014) *Malthus; the life and legacies of untimely prophet*. Cambridge: The Belknap press Harvard University.

Melody, M. (2017) Assessment of Environmental Impacts of Quarrying Operation in Ogun State, Nigeria. *Journal of Engineering and Technology, (2*), 2

Mengaki M. E., & Kaliampakos D. C. (2006). Landscape analysis as a tool for surface mining design. *Environment and Planning B: Planning and Design.* 33,185-196. https://doi.org/10.1068/b31005

Milgrom T. (2008). Environmental aspects of rehabilitating abandoned quarries: Israel as a case study. *Lands cape and Urban Planning, 87* (3),172179.

Misthos L., Pavlidis A, Menegaki M., Krassanakis V. (2018). Exploring the Perception of Mining Landscapes Using Eye Movement Analysis. *ET4S, (44),*23. https://doi.org/10.3929/ETHZ-B-000225616

Mugenda, O. & Mugenda, G. (2013). *Research methods: Quantitative and qualitative approaches*. Nairobi: Acts Press.

Mugenda, O. & Mugenda, G. (2003). Research methods and Lab Graphics, Nairobi-multi-Variate logit approach. World Bank Economic Review, 14(2), 287-307. Oxford University Press.

Mukindu, J. & Waweru, S. (2016). Perception on quarrying activities and post quarried land use along River Ndarugu Kiambu County (Master's thesis). University of Nairobi, Kenya.

Musah J.A. (2009) Assessment of sociological and ecological impacts of sand and Gravel mining. A case study of East Gonja District (Ghana) and Gunnarsholt (Iceland). Final Report, Land Restoration Training Program. Keldnaholt, Iceland.

Mbandi, J.I. (2018) Assessment of environmental impacts of quarrying in Kitengela (Masters dissertation), *University of Nairobi.*

Nairuko, A., Simon O., Mabwoga S.O., (2020). Impacts of Socio-Economic Activities on Land Use and Land Cover Changes in Narok North Sub-County, Kenya. Maasai Mara university repository, *14*(10), 1–16. https://doi.org/10.9790/2402-1410020116

Nanos, N. O., Anikwe, M. A. N., & Nwite, J. N. (2015). Impact of limestone quarrying operations on quality standards of soil and water at Ewekoro (Nigeria) mining site. *Journal of Environmental Protection*, 6(9), 959-969. https://doi.org/10.4236/jep.2015.69086

Narok County government, (2018) County integrated development plan 2018-2022.NGC.

Nartey, V. K., Nanor, J. N., & Klake, R. K. (2012). Effects of quarry activities on some selected communities in the lower Manya Krobo District of the Eastern Region of Ghana. *Atmospheric and Climate Sciences, 2,*362-372.

Nawaz, F., Hamidullah, S., & Fayaz, A. (2004, November,19-23). The effects of mining on geomorphology; detection of changes by using remote sensing technique. Proceedings of the International Society for Photogrammetry and Remote Sensing Annual Conference, Istanbul, Turkey.

Nwibo, A., Ugwuja, E., Nwambeke, N., Emelumadu, O., & Ogbonnaya, L. (2012) Pulmonary problems among quarry workers of stone crushing industrial site at Umuoghara, Ebonyi state, Nigeria. *The international Journal of Occupational and Environmental Medicine.3*(1),178-185

Olusegun, O., Adeniyi, A. & Adeola, G. (2009). Impact of granite quarrying on the health of workers and nearby residents in Abeokuta, Ogun State, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, *2*(1).

Onačillová, K., Gallay, M., Paluba, D., Péliová, A., Tokarčík, O., & Laubertová, D. (2022). Combining Landsat 8 and Sentinel-2 Data in Google Earth Engine to Derive Higher Resolution Land Surface Temperature Maps in Urban Environment. *Remote Sensing*, *14*(16), 4076.

Opondo, E. O., Ajayi, D. D., & Makindi, S. M. (2022). Impacts of quarrying activities on the environment and livelihood of people in Border II sub-location, Nyando sub-county, Kisumu County, *Kenya. Environmental Quality Management,* 1–14. https://doi.org/10.1002/tqem.21881

Orimba, P. (2020). Assessment of the Kenya quarry sustainability performance in Nairobi City County. (Research project) University of Nairobi

Punmia, B.C. & Jain, A.K. (2013). *Basic civil engineering*. New DELHI: Laxmi Publication Ltd.

Roy, D. P., Huang, H., Boschetti, L., Giglio, L., Yan, L., Zhang, H. H., & Li, Z. (2019). Landsat-8 and Sentinel-2 burned area mapping-A combined sensor multi-temporal change detection approach. *Remote Sensing of Environment*, *231*, 111254.

Saliu, M., Lawal, A., & Atigro, V.U. (2014). Analysis of the dust generated from point source in relation to the distance from the point of generation in the Polish Carpathians. *Geogical Quarterly*, 50(3), 383-390.

Simon, D. (2010). *Cities, capital, and development: urbanization in the third world*. Oxford University Press.

Temesgen, G., Bantider, A., & Silassie, H. G. (2014). Land degradation in Ethiopia: causes, impacts and rehabilitation techniques. *Journal of Environment and Earth Science, 4(9), 98-104.*

Tischew, S., Baasch, A., Grunert, H., & Kirmer, A. (2014) How to develop native plant communities in heavily altered ecosystems: Example from large scale surface mining in Germany. *Applied Vegetation science,17*(2), 288-301

Townsend, P.A., Helmers, D.P., Kingdon, C.C., McNeil, B. E., de Beurs, K.M., & Eshleman, K.N. (2009). Changes in the extent of surface mining and reclamation in the central Appalachian detected using 1976-2006 Landsat time series. *Remote sensing of Environment,113(1), 62-72*

Tribhuwan, R. D., & Patil, J. (2009). *Stone quarry workers: Social security and development issues*. Discovery Publishing House.

United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects 2018.UN

UNEP. (2020). Sustainability reporting in the mining sector report. United Nations Environment Programme.

UNDP & UN Environmental Program. (2018). Managing mining for sustainable development: A source book. United Nations Development Programme. Bangkok, Thailand.

Ukpong E., (2012). Environmental impact of aggregate mining of crush rock industry in Akamka local government area of cross river state. *Nigerian journal of technology 31(2*), 128-138

Von Bertalanffy, L. (1951). General system theory, a new approach to unity of science. 5. Conclusion. *Human biology*, *23*(4), 337-345.

Walker L.R., & del Moral R., (2003) *Primary Succession and Ecosystem Rehabilitation*. Cambridge University Press.

Wangela S. W., (2013). Effects of Dimension Stone Quarrying activities in Ndarugo Area of Kiambu County. (Unpublished Masters Research Project) University of Nairobi

Wanjiku, E. M. (2014). Socio-economic benefits and environmental impacts of Thika Road superhighway. (Masters research project) Kenyatta University

Waweru, S.W., Njoroge, B.J. and Adimo, O.A. (2018) Management status and perceptions of post quarried sites in Ndarugu, Kiambu County.*African Journal of Environmental Science and Technology* 12, (8), 268-282. DOI: 10.5897/AJEST2018.2474

APPENDICES

Appendix I: The Normalized Difference Vegetation Index and Vegetation Density Maps

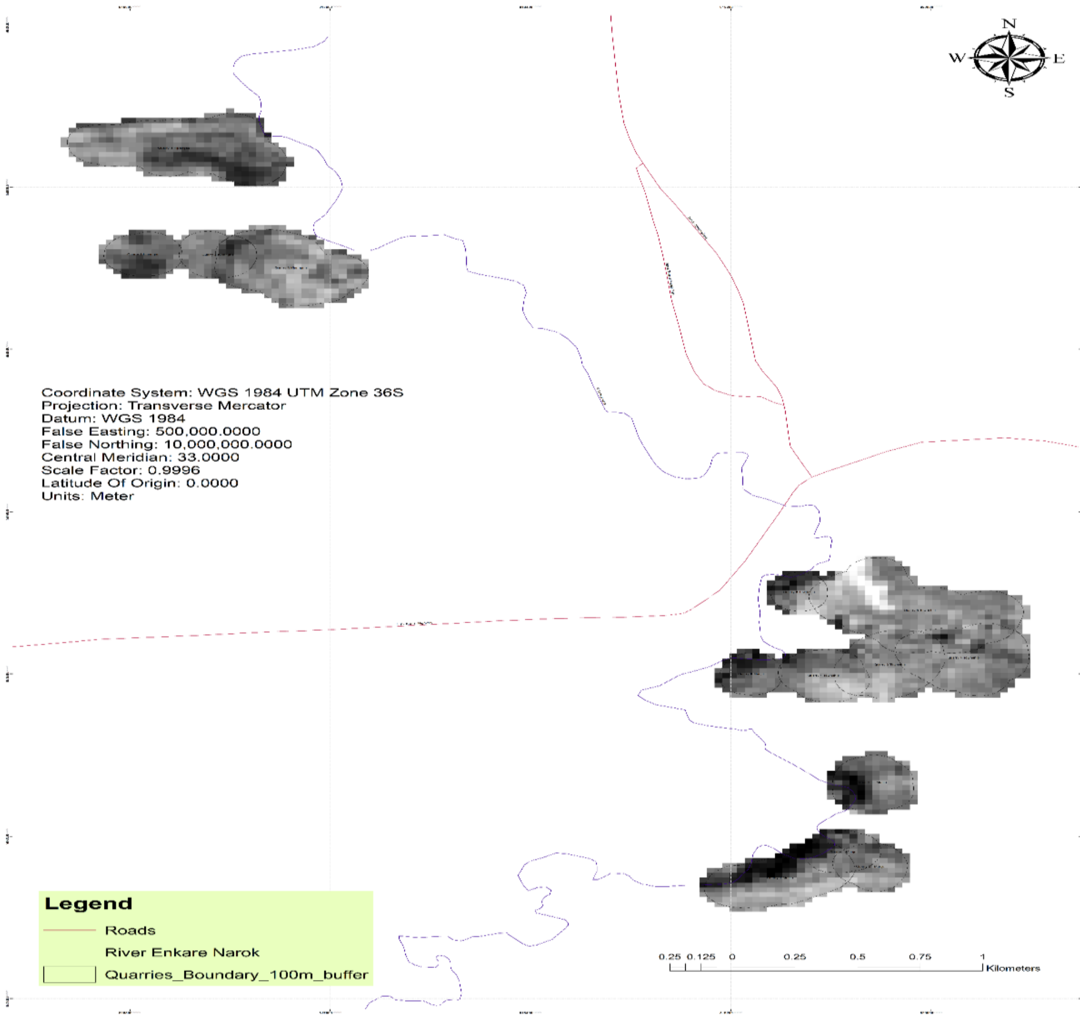
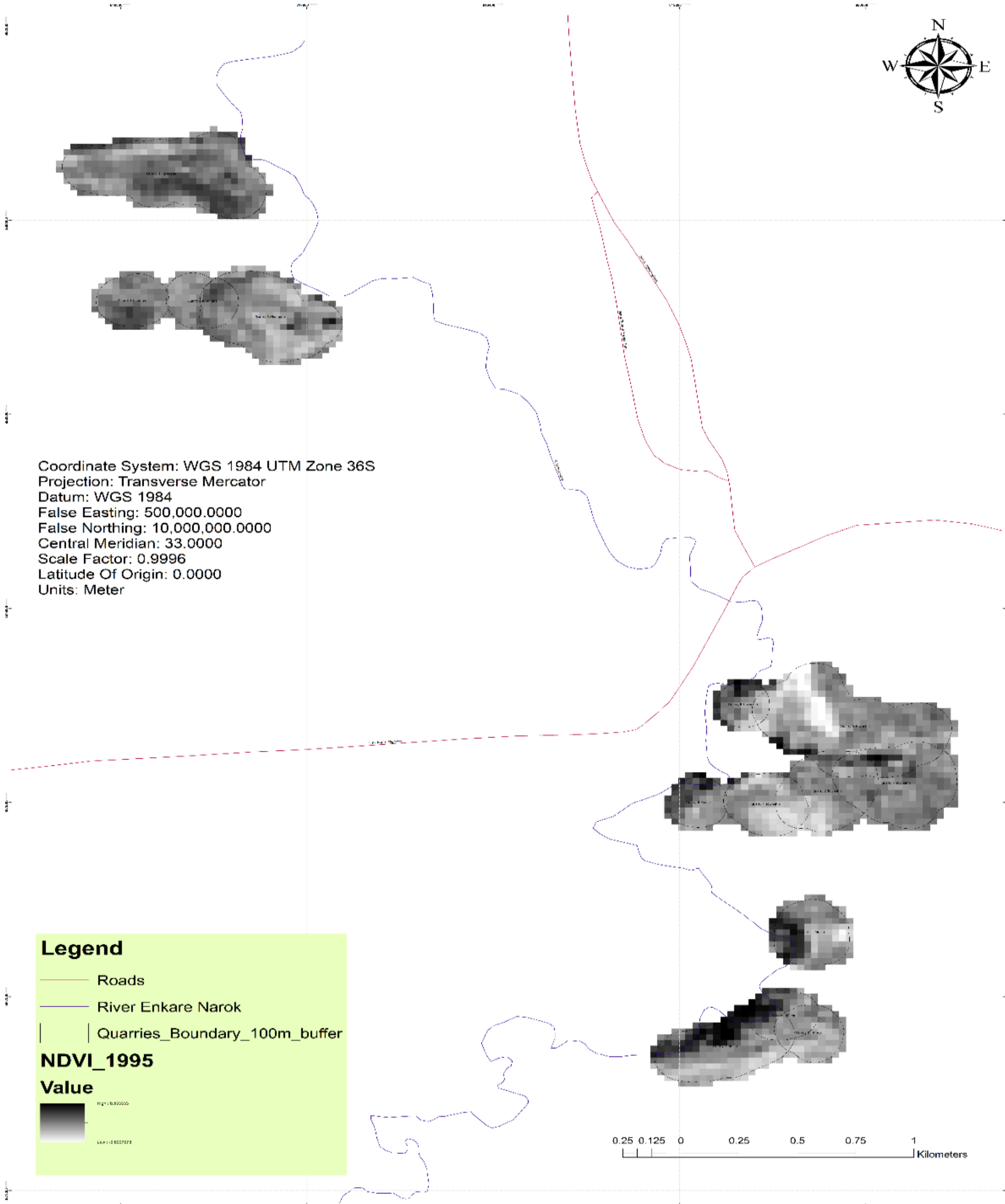


Figure 5.3a: NDVI map for year1985, grey scale



.

Figure 5.3b: NDVI map for year 1995, grey scale.

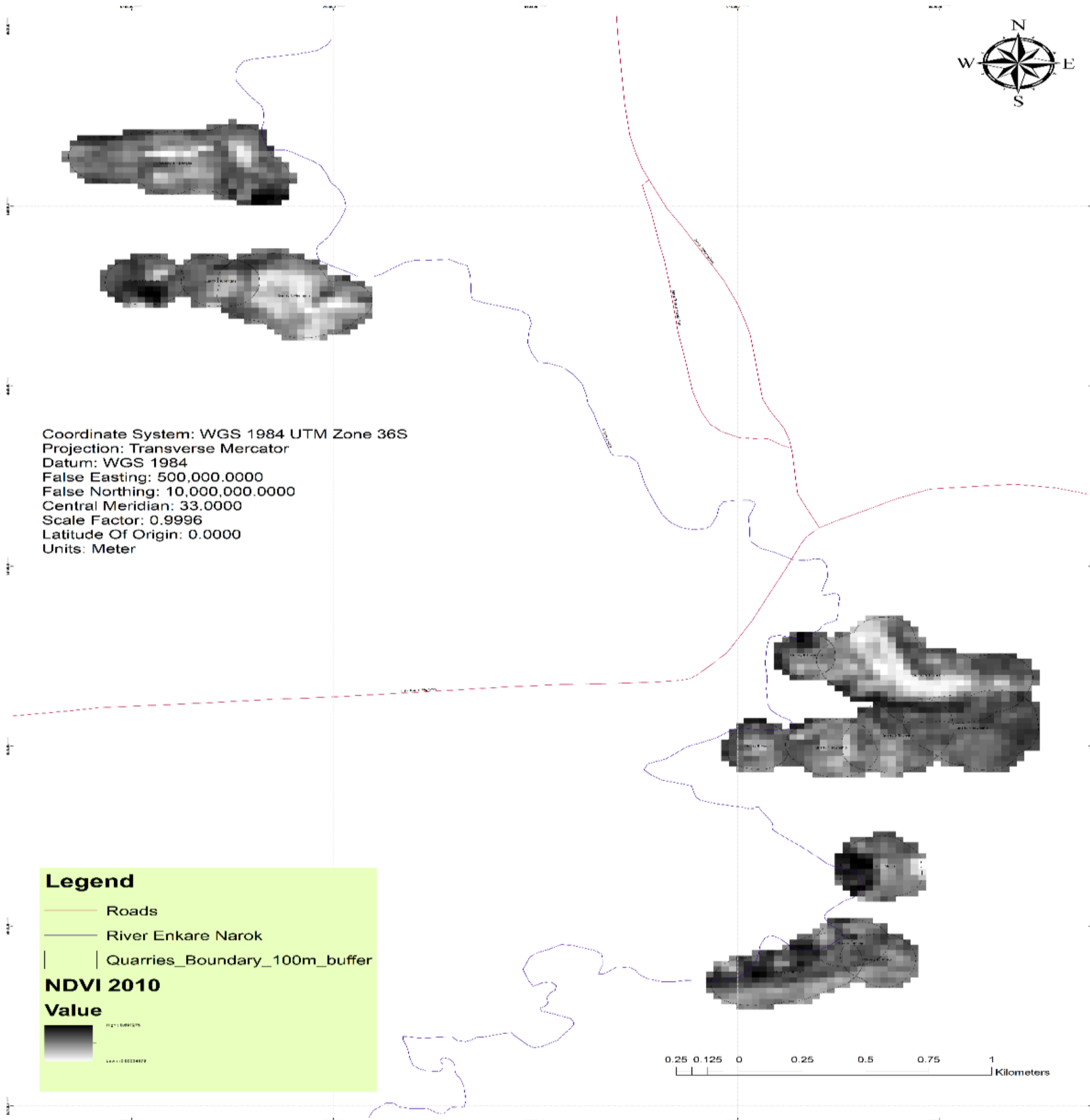


Figure 5.3c: NDVI map for year 2010, grey scale.

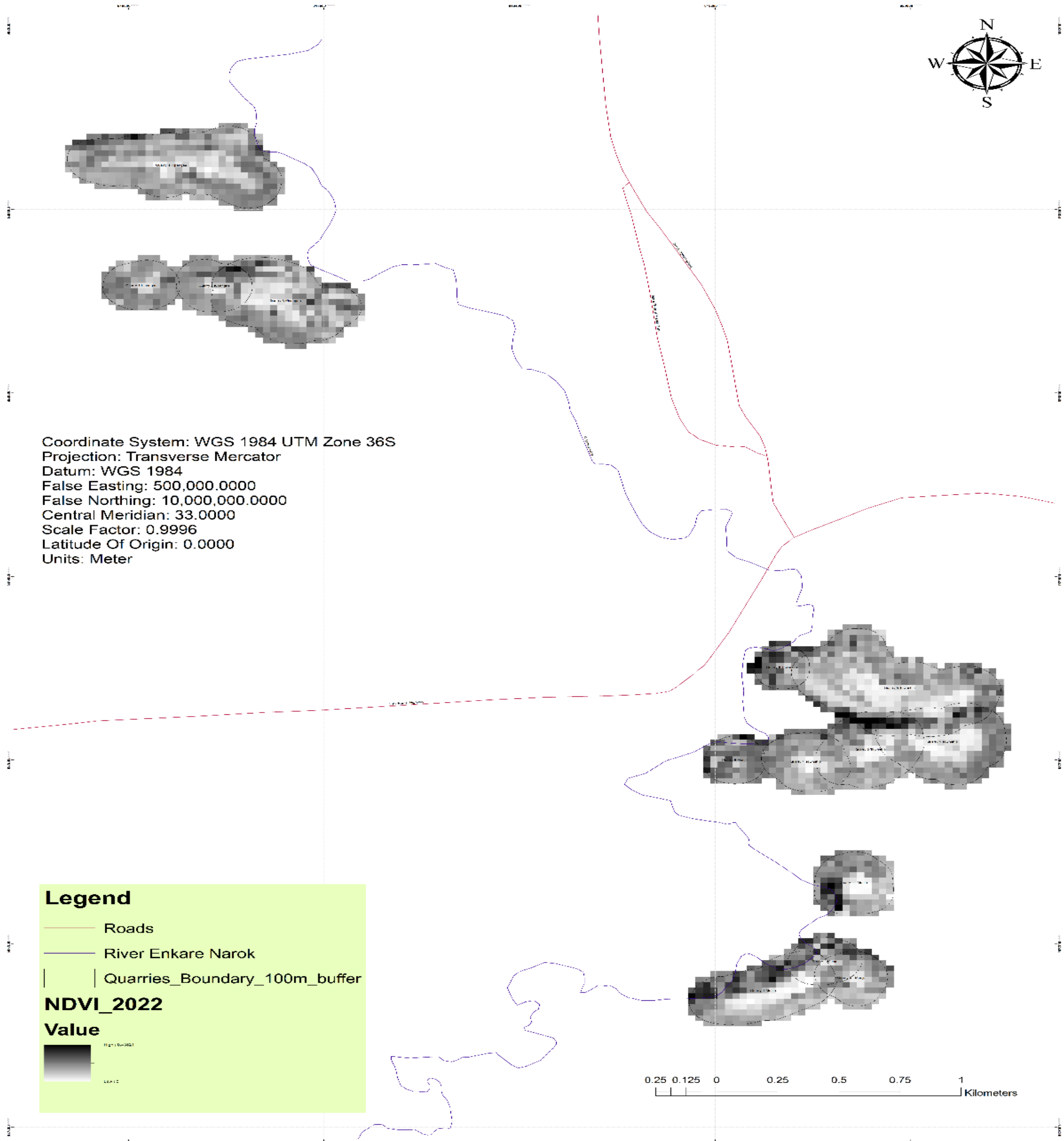


Figure 5.3d: NDVI map for 2022, grey scale.

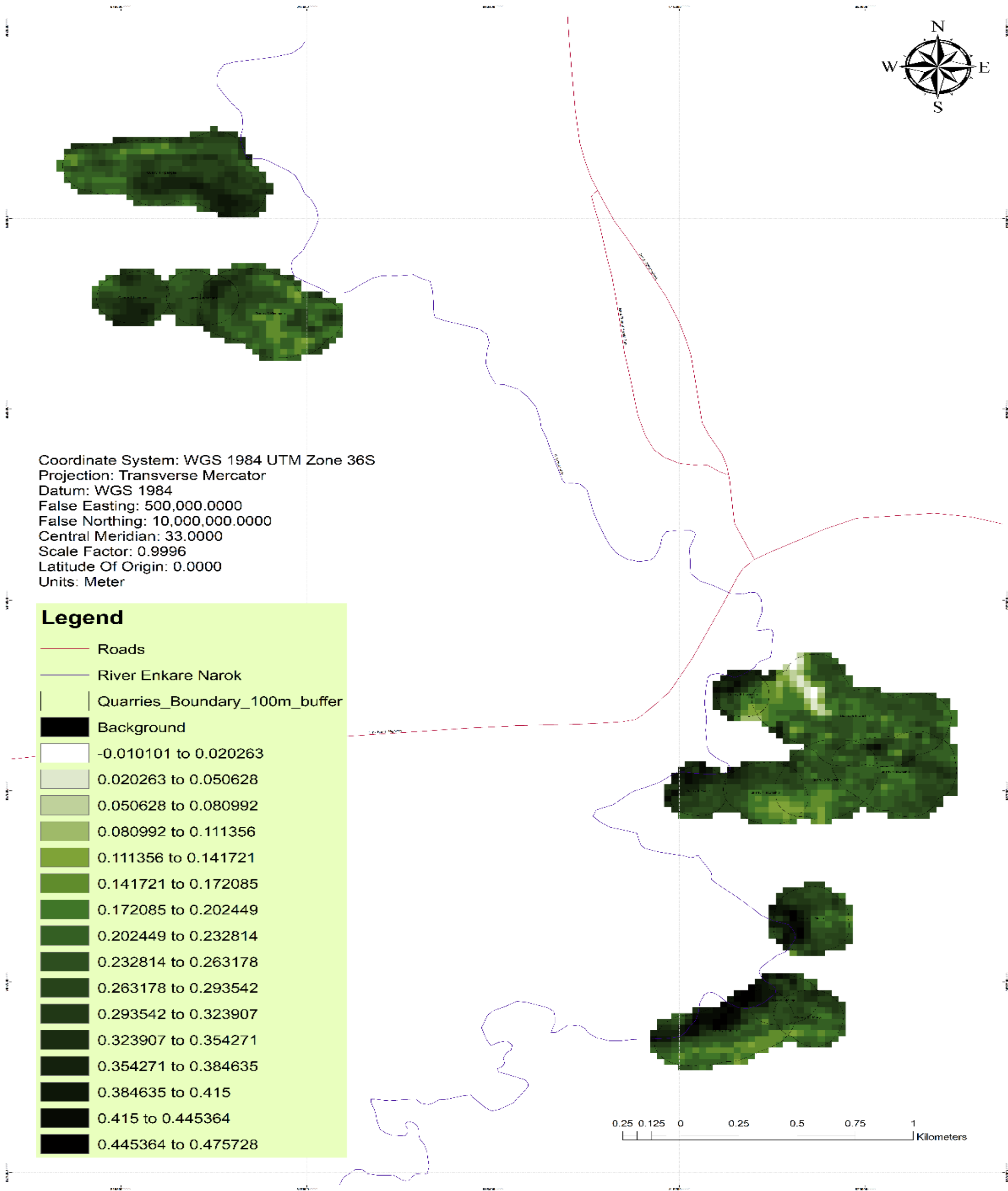


Figure 5.4a: Density Slices for NDVI - 1985 Image

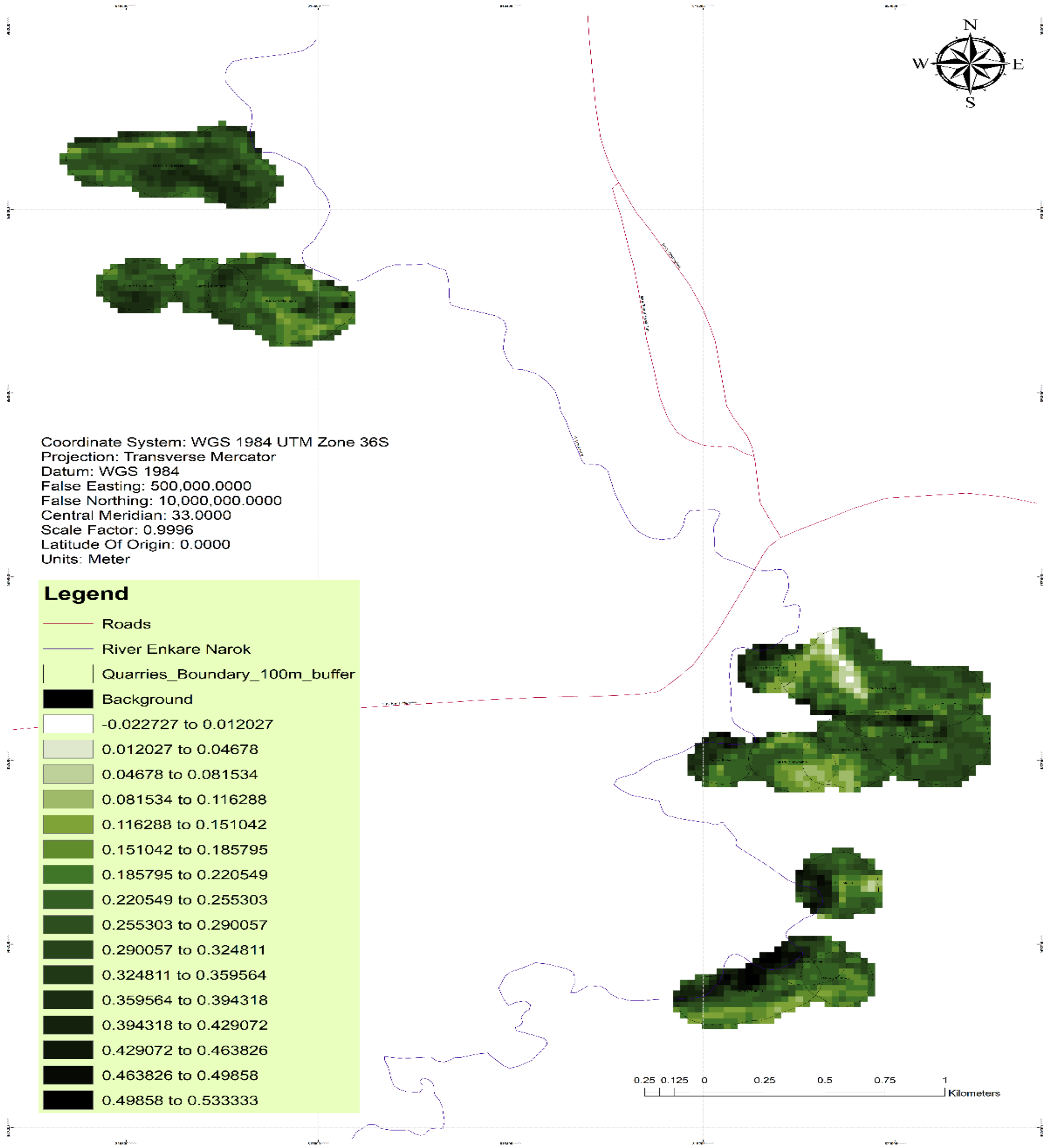


Figure 5.3b: Density Slices for NDVI - 1995 Image

Figure 5.3c: Density Slices for NDVI - 2010 Image

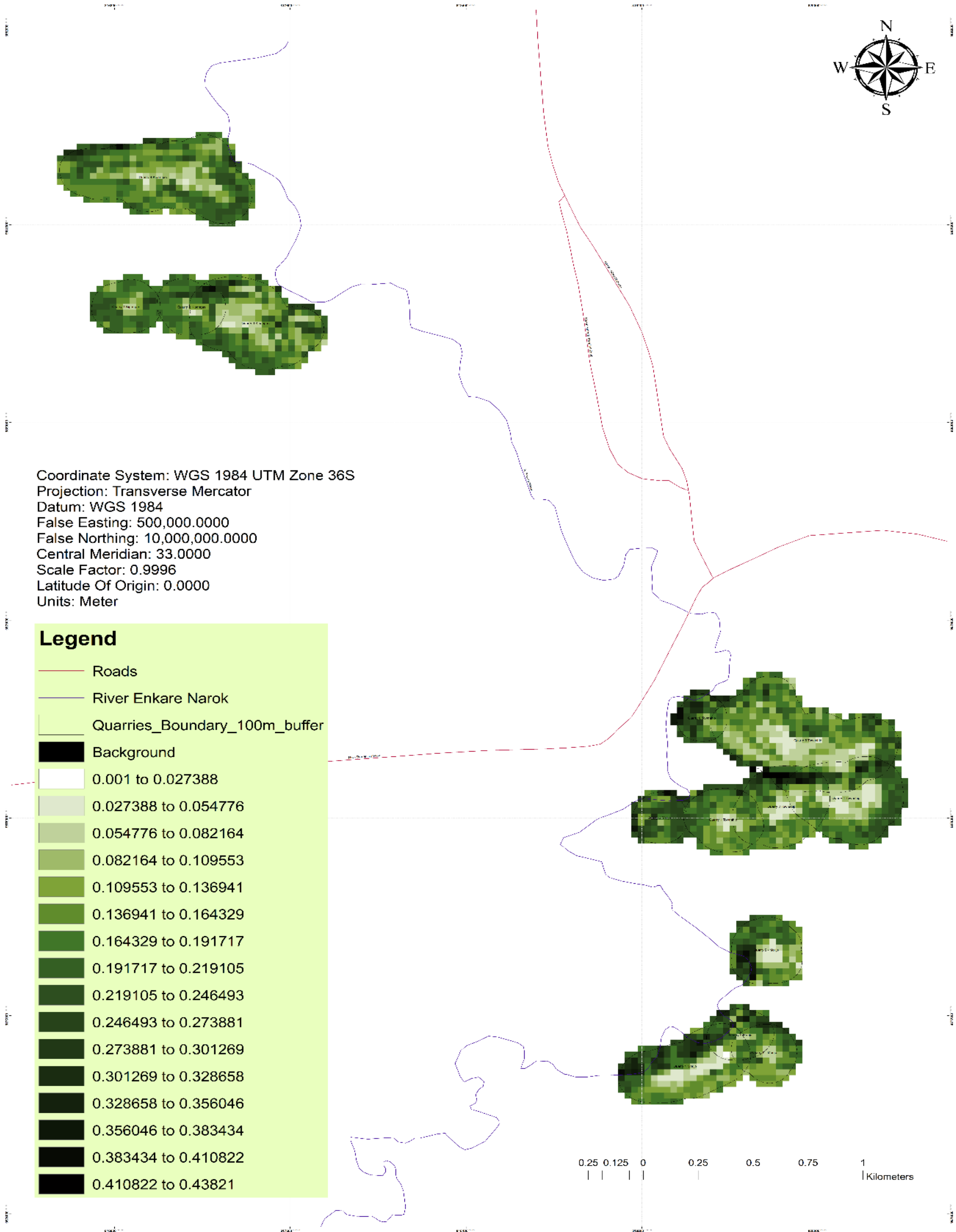


Figure 5.3a: Density Slices for NDVI - 2022 Image

Appendix II: Plates taken during the field survey


Plate 4.1 vegetation destruction caused by quarrying activities

Plate 4.2 Vegetation by the access road to quarry site covered with dust

Plate 4.3. Showing effect of quarry waste on vegetation

APPENDIX III: Research Questionnaire for the Residents

Dear respondent

I am a master's student at Maasai Mara University undertaking investigative research which is a requirement for a Ward of master's degree. This survey is aimed to assess the impacts of stone quarrying in Narok North. Your personal data and responses will be used for academic purposes only. Your positive responses will be highly appreciated.

SECTION A: BACKGROUND INFORMATION

1. Gender: Male [ ] Female [ ]
2. Age: Below 18 [ ] 18-20 yrs. [ ] 21-30 yrs. [ ] 30-40yrs [ ] 40-50 yrs. [ ] Above 50 yrs. [ ]
3. Level of education: None [ ] Primary [ ] Secondary [ ] College [ ] University[ ]
4. Marital status: Single [ ] Married [ ] Widowed [ ] Divorced [ ]

SECTION B: ENVIRONMENTAL IMPACTS OF STONE QUARRYING

a) Landscape

i. How would you describe the landscape appearance in the past 10 years?

Vegetative [ ] Bare [ ] Scarred [ ] Rocky [ ] don't know [ ]

ii. How would you describe the current state of landscape?

Vegetative [ ] Bare [ ] Scarred [ ] Unchanged [ ] Can't tell [ ]

iii. Do you agree that quarrying is a major cause of vegetation loss in this area?

Strongly agree [ ] Agree [ ] Disagree [ ] Strongly Disagree[ ]

iv. Quarried areas are being refilled after the closure of the site

[ ] yes [ ] No

b) land use changes

v. What were the land use practices in this area before quarrying?

Farming [ ] , Grazing [ ], residential [ ]

vi. Indicate the current land use in the area

Quarrying [ ] Crop farming [ ] Grazing [ ] Residential [ ]

c) Air and water pollution

a) Indicate how you agree with the statement in Table below (A-agree, SA- strongly agree, D-disagree, SD- strongly disagree) please tick where applicable.

Statement	**A**	**S. A**	**D**	**S.D**
Quarrying activities is the main source of dust in the area				
Dust from the quarrying activities causes discomfort in the area				
Dust settles on plants/ crop surfaces				
Dust produced affect crop production				
Quarrying activities contribute to water pollution				
Water collected from the roof contain dust				
Dust from the quarry is the main cause of respiratory illnesses in the area				

d) Noise and excessive vibration

a) Do you think quarrying activities is the main source of noise in the area?

Yes [ ] No [ ]

b) What is the main source of noise in the quarry?

Machines and trucks [ ]Blasting [ ] Both [ ] None of the Above [ ]

c) Please describe the severity of the noise pollution

Not severe [ ] Severe [ ] Very severe [

<u>Section C: Socio- Economic Impacts</u>

a. Health issues

i. Do you agree that quarrying operation has brought about health issues in the area?

Strongly Agree [ ] Agree [ ] Disagree [ ] strongly disagree [ ]

ii. How was your health before quarrying activities started?

Very good [ ] Good [ ] Fair [ ] poor[ ]

iii. How would you describe your health since quarrying started? Very good [ ] Good [ ] Fair [ ] poor[ ]

iv. Has any member of your household suffered illnesses related to quarrying operations? Yes [ ] No[ ]

v. If yes in the question(iv) how frequent have they been treated for such cases? Once [ ] Twice [ ] More than twice [ ]

vi. In the Table below tick the ailment(s) that a member in your household has been treated for.

Ailment	**Yes**	**No**
Cough		
Sneezing		
Pneumonia		
Asthma		
Eye irritation		
Wheezing chest		
Malaria		
Hearing problems		
Physical injuries		

vii. Are there cases of deaths reported that could be related to quarrying activities? Yes[ ] No [ ]

viii. How do you agree with the following statements? (A-agree, SA-strongly agree, D- disagree, SD-strongly disagree

Statement	**A**	**SA**	**D**	**SD**
Quarrying in the has led to displacement of some residents				
Quarrying has led destruction of cultural sites				
Quarrying has led insecurity				
Quarrying has led to influx of new people				
Quarrying has led to increased conflict among community members				

b) Economic benefits of stone mining

i) Indicate how you agree with the following statements provided in the Table below

(Key: SA- strongly agree, A- agree, D-disagree, SD- strongly disagree)

Statement	**A**	**SA**	**D**	**SD**
Quarry has created employment				
This quarry site supports the local economy				
New roads have been developed due to stone quarrying				
Quarry managers donates construction materials to residents				
People around this quarrying depend wholly on the quarry for their livelihood				

ii) In your own view describe any other economic benefits resulting from quarrying………………

………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

Section D: Mitigation measures

I. Are there any mitigation measures that have been put in place to reduce negative environmental and social effects of quarrying activities? Yes [ ] No [ ]

II. If yes in(**I**) above which ones……………………………………………………….

………………………………………………………………………………………

……………………………………………………………………………………….

III. How effective are the methods mention in (**II)?**

Very effective [ ] Effective [ ] Not effective at all [ ] N/A []

IV. Indicate which of the following measures can be used to mitigate negative impacts of quarrying activities.

i. Use of PPEs [ ]
ii. Creation of dust burrier along the access roads [ ]
iii. Watering of access road to suppress dust [ ]
iv. Policy and law enforcement by NEMA [ ]
v. Backfilling of exhaust pits[ ]

Appendix III: Questionnaire for quarry workers

I am a master's student at Maasai Mara University undertaking investigative research which is a requirement for a Ward of master's degree. This survey is aimed to assess the impacts of stone quarrying in Narok North. Your personal data and responses will be used for academic purposes only. Your positive responses will be highly appreciated.

SECTION A: BACKGROUND INFORMATION

1. Gender: Male [ ] Female [ ]
2. Age: 16-20 yrs. [ ] 21-30 yrs. [ ] 30-40yrs [ ] 40-50 yrs. [ ] Above 50 yrs. [ ]
3. Level of education: Primary [ ] Secondary [ ] College [ ] University[ ]

5. Marital status: Single [ ] Married [ ] Widowed [ ] Divorced [ ]
6. Are you a resident here?
   Yes [ ] No[ ]

SECTION B: Stone mining

i. How long have you been working in this quarrying site?
   1-5 yrs, 5- 10 yrs 10-20 yrs.
   Above 20yrs [ ]
ii. What is your monthly income in Kenyan shillings?
   5,000 below [ ] 5,000-10,000 [ ]
   10000-15000 [ ] 15,000- 20,000[ ], 20,000 above [ ]
iii. Describe your work in this quarry
   Breaking stones [ ] Blasting [ ]
   Loading stones [ ] Excavation [ ]
   Driver [ ] cutting and shaping dimensional stones [ ]
iv. Do you have training experience pertaining the above-mentioned work?
   Yes [ ] No [ ]
v. Are you aware of any safety measures in quarrying activity? Yes [ ] No [ ]
vi. Do you have safety gears? Yes [ ] No [ ]
vii. Do you put on safety gears while working? Yes [ ] No [ ]

viii. In your opinion what are the advantages of using safety gears as a quarry worker?.......

…………………………………………………………………………………………….

……………………………………………………………………………………………

Section C: Environmental issues

a) Do you think quarrying has caused environmental damage? Yes [ ] No [ ]

b) If yes in (a) above, describe severity;

Not severe [ ] severe[ ] Very severe [ ]

c) Indicate in severity of the following impacts in the area

SN	**Damage**	**Very severe**	**Severe**	**Not severe**
1	Vegetation destruction			
2	Land degradation			
3	Air pollution			
4	Contamination of water			
5	Excessive noise and vibration			

d) Kindly describe any other environmental damage caused by quarrying in this area

……………………………………………………………………………………………

…………………………………………………………………………………………….

Health issues

Have you ever suffered ailments / diseases related to quarrying activities?

Yes [ ] No [ ]

Indicate whether you have ever suffered from ailments below

Disease	**Yes**	**No**
Chest pains		
Dry cough		
Physical injuries		
Asthma		
Hearing impairment		
Eye irritation		

Describe any other ailment you have suffered related to your work in quarry……

……………………………………………………………………………………………

………………………………………………………………………………………………

Section D: Mitigation measures

I. Are there any mitigation measures that have been put in place to reduce negative environmental and social effects of quarrying activities? Yes [ ] No [ ]

II. If yes in(I) above which ones? ……………………………………….

……………………………………………………………………………………

…………………………………………………………………………………….

III. How effective are the methods mention in (II)?

Very effective [ ] Effective [ ] Not effective at all [ ]

V. Indicate which of the following measures can be used to mitigate negative impacts of quarrying activities.

vi. Use of PPEs [ ]

vii. Creation of dust burrier along the access roads [ ]

viii. Watering of access road to suppress dust [ ]

ix. Policy and law enforcement by NEMA [ ]

x. Backfilling of exhaust pits[ ]

Appendix IV: Interview guide for quarry manager

Dear respondent

I am a master's student at Maasai Mara University undertaking investigative research which is a requirement for a Ward of master's degree. This survey is aimed to assess the impacts of stone quarrying in Narok North. Your personal data and responses will be used for academic purposes only. Your positive responses will be highly appreciated.

1. Name of the company____
2. Gender: Male [ ] Female [ ]
3. When was this quarry established? _______________
4. Did you acquire license for the establishment of the quarry? Yes [ ] No[ ]
5. What is the size of the land used for quarrying? ____________
6. What was the land use in this land before starting quarrying? ______________________
____
____
____
7. How many workers are there in your quarry? ____________
8. What is the nature of employment of your workers: casual [ ] ,contract [ ], permanent [ ]
9. What are the challenges facing workers in the quarry? ____________________________
____
____
10. Do you compensate sick or injured workers in your quarry? Yes [ ]
11. What are safety precautions you have provided for your quarry workers? __________
____
____
12. How has quarrying affected the local community? _________________________
____
13. Are you aware of environmental impacts caused by this quarry? Yes [ ] No [ ]
14. What are the measures you have put in place to mitigate impacts?____
____
____

APPENDIX V

Interview guide for NEMA officials and officials from department of environment

1. How many quarries are licensed in Narok town Ward?
2. Among those licensed, are they complying with environmental guidelines related to mining and quarrying?
3. How often do you do environmental audit in the quarries in the Ward?
4. Are there complains pertaining effects of quarrying activities?
5. How have you respondent to the complaints

APPENDIX VI: Research Permit

REPUBLIC OF KENYA

NACOSTI

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **807653**

Date of Issue: **28/July/2022**

RESEARCH LICENSE

This is to Certify that Mr.. FESTUS BARCHOK KIPROP of Maasai Mara University, has been licensed to conduct research in Narok on the topic: ASSESSMENT OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS OF STONE QUARRYING ACTIVITIES IN NAROK NORTH for the period ending : 28/July/2023.

License No: **NACOSTI/P/22/19383**

807653

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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