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Impact of mining on environment: A case study of Taita Taveta County, Kenya

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Research on the impacts of mining on the environment was conducted on nine purposive selected mining sites in Kamtonga and Mkuki, Taita Taveta County, Kenya. The FOLCHI method was adopted to quantify the environmental impact of mining activities in gemstone mining sites. The affected environment surrounding the pits was broken down into three components such as Topography, Vegetation and Air. The effect of the three components impacting factors, both directly and indirectly, from the mining activities was then calculated for each Environmental Component and computed averages (magnitude) presented in table format. The findings showed that mining activities contributed to environmental and landscape changes, leading to loss of indigenous-trees, shrubs, grassland, forests, natural ecosystems and agricultural and grazing land. Mining activities contributed to air pollution. Even with the existence of environmental regulations and policies, the environment is still abused in Kenya, as a result, the country has lost considerable amount of forest cover due to mining activities. Government and non-governmental organizations should advocate for afforestation, re-afforestation and restoration of forests. Environmental Impact Assessment and Environmental Audit should be conducted in line with mining regulations in Environmental Management and Coordination act 1999 (amended 2019) in Kenya.

Key words: Mining activities, environmental elements, waste piles, sustainable livelihoods, air pollution, forest restoration.

INTRODUCTION

Mining is a major economic activity in most developing countries (Kitula, 2006), particularly in rural sub-Saharan Africa. But the extraction and mining of these natural resources lead to some adverse effect on the environment. In many developing countries, unregistered and illegal small-scale mining is widespread leading to

environmental deterioration (Bush, 2009; Hilson, 2009). The study areas were Kamtonga and Mkuki in Taita Taveta County (TTC), located in the Coastal region of Kenya. The population of Taita Taveta County is 340,671 (KNBS, 2019) having grown from 284,657 in 2009. Mwatate Sub County population has an estimate of 1.95% of the county population which has grown to 81659 people partly because of people migrating to town to establish businesses especially trading in precious stone called Tsavorite, found plentifully around Mkuki and Kamtonga areas. The county has become popular because of its gemstone minerals. With this knowledge, this study whose specific objective was to observe the impact of mining on the environment was conducted focusing on three elements namely; topography, air and vegetation. The research question was: What is the state of the environment in mining areas?

The literature on this subject revealed that mining has adverse impacts on societies and their cultural heritage (Sinnett, 2019). Vast land usage through mining has impacted the environmental standards of the county resulting in land degradation, famine and poverty. Other impacts concern health and safety of mineworkers and communities close to operations, including displacement, marginalization, and oppression of local people (Mwakumanya et al., 2016). Mining activities contribute to soil erosion, the formation of sinkholes, loss of biodiversity, soil and water chemical contamination. Mining activities also cause noise, dust and visual pollution (Cuba et al., 2014; Naja and Volesky, 2009).

Mining is an economic process that begins with exploration for and discovery of mineral deposits and continues through extraction and processing to closure and remediation of exploitation sites (Hoskin et al., 2000). Different forms of mining methods are used depending on the type of mineral being extracted. These methods have varying impacts on the environment. Four popular surface mining methods include open cast mining, open pit, quarrying and augering. All these involve the extraction of mineral material from the surface to underground mining where mines are accessed through shafts and tunnels; recovery of minerals through boreholes and underwater mining (Klop, 2009). Therefore, a working definition of mining could simply be "the extraction of minerals from the Earth".

On the one hand, mining generates wealth for companies, communities and countries. But at the same time, social vices such as prostitution, substance abuse, gambling, and incest have increased, including general destabilisation of families and livelihood (Akabzaa and Darimani, 2001; Gualnam, 2008). Mining has socio-economic impacts which include generating huge amounts of waste and pollution, disrupting indigenous livelihood, local economies and communities, destroying natural habitat and maybe leaving toxic legacy-acid mine drainage (AMD). Other major consequences include the loss of Flora and fauna, affected and destabilized ecosystem due to infected water, soil and loss of habitat. Some negative environmental impacts may persist for hundreds of years (Gosar, 2004).

Mining affects vegetation, farmlands, livestock and aquatic activities through pollution leading to effects in agriculture and food security (Hayes and Wagner, 2008). Mining tends to drive people away from sustainable livelihoods, for instance, farming to other livelihoods which may result in possible destruction of productive land resources. Such alternative changes lead to further destruction of the environment and expose peoples' livelihoods to unsustainable risk (Hilson and Banchirigah, 2009). Mined land remains unsuitable for industrial and agricultural purposes. Mining operations have devastating effects on nearby streams, rivers and surrounding vegetation. Consumption of contaminated toxic water and soil or plants cause diseases in people and animals and can result in death. Collecting runoff water using ponds would help but the problem would persist (Gupta and Gupta, 1998). Other environmental impacts of mining activities recorded in the literature include permanent scarring of land surfaces where wastes are dumped. Dangerous old deep mine holes which may subside vertically or horizontally, and damage buildings, roads and farmland, as well as alter the surface drainage patterns. More disturbances to residents and wild-life are caused by noise from blasting and transport in the mining areas (Bell et al., 2000).

Small – Scale mining activities are not confined to Africa but throughout the developing world. In Africa however, small –scale mining operations have been responsible for a wide range of environmental impacts. Because of the lack of advanced technology, operations are rudimentary and concern for environment minimal. This has resulted in constant and persistent environmental problems (Hilson, 2002). Mining activities have similar impacts on the environment in various countries. For example, in Ghana, despite all the legal measures put in place by the government, environmental degradation around most of the communities remains a major threat and concern (Mensah et al., 2015). In Kenya, large and small-scale mining activities are cited in most parts of the country such as in Migori, Kwale, Vihiga District and Lake Victoria to mention a few. Mining activities in Kenya have been associated with serious environmental impacts such as metal contamination in soil, health implications on human and animals, poverty and land conflicts (Okang'Odumo et al., 2014; Abuya, 2016).

Information about mining in Taita Taveta County generated a lot of attention as a location of minerals, particularly gemstones even though the economic impact of the vast existing natural resources extraction on local people and its effects on the environment has not been researched (Taita Taveta County, 2013). Natural

resources can provide poor counties with large revenue streams that can be used to alleviate poverty, and result in enhanced the much-needed peace and co-existence with other communities in the counties, who up to now are regarded as exploiters of community resources (Pegg, 2006). The absence of this might invite restlessness and conflict with outsiders, which the country would have to contend with sooner or later (Mghanga, 2011).

One of the necessary pre-conditions for sustainable development is a sustainable peace. Articles 43, 69 and 72 of the Kenya constitution record that inclusive policies and measures that ensure communities fully participate in conserving and deriving benefits from their local natural resources needed to be developed. The Republic of Kenya (2010), states that every person has social, economic and environmental rights including equitable sharing of accruing benefits from natural resources. This is also engraved in the Kenya Vision 2030 which encourages the sustainable exploitation of natural resources for National Development (Vision, 2007). In 2013 the Kenya government established the Mining and Petroleum Ministry which repealed the previous Act (1940). Later in 2016, a new bill (the Mining Act 2016) was created as a mining law that would meet the current mining requirement. One such requirement involved engaging Taita Taveta University (TTU) and Jomo Kenyatta University of Agriculture and Technology (JKUAT) personnel to conduct regular on-site training of miners on protective measures. Training on proper mining methods has helped to reduce the negative impacts of mining, particularly, the artisanal miners who are provided with technical and professional assistance to improve their production and reduce environmental degradation.

The general objective aimed at investigating and interrogating the impacts of extensive mining activities on communities' livelihoods to find ways of improving their living standards. Specifically, the content of the paper is to observe the environmental impact of mining on topography, air and vegetation and the state of the environment in mining areas. When dealing with extractive industries, it was important to consider and identify ways of maximizing positive effects on the lives of people while minimizing the negative effects (Obiri et al., 2016).

MATERIALS AND METHODS

Study area

This study was done in Taita Taveta County, located in the Coastal region of Kenya (Figure 1). The observations were made in Mwatate sub-county's minefields of Kamtonga, and Mkuki, on the geographical coordinates of 3°30'0" S, 38°23'0" E. These minefields were purposively selected as representative samples of the mining

industry in Taita Taveta because they were easily accessible, unlike those of Kasigau in Tsavo West. The county is divided into three major topographical zones. The upper zone, suitable for horticultural farming comprises of Taita, Mwambirwa and Sagalla hills region with altitudes ranging between 304 and 2,208 m above sea level. Mining takes place in the lower zones consisting of plains, where ranches and national game parks are placed. The third topographical zone covers Taveta region which although with volcanic features, has a potential for underground water and springs from Mt. Kilimanjaro. By a geological point of view, the Taita region is covered by the Mozambique belt, while the Taveta region is covered by the Tertiary Volcanic belt. The complex rocks of this belt underlie most of the Eastern African region between Ethiopia to the north and Mozambique to the South. The County is the main source of Tsavorite and ruby minerals.

Samplings

The observation was carried out in nine mining sites of Kamtonga and Mkuki areas of Taita Taveta County in Kenya. These purposively selected mines included; Shah mines, Ray mines, Shadrack (individual digger), International Mines, Mama Fatuma mines, Surface mining (group), Hardrock mines, Chawia Mining Community Based Organization (CBO) and Classic 1 Gemstone Mines. Purposive sampling method was used to focus on environmental characteristics around Kamtonga and Mkuki mining areas. These included nine mines comprising of large, semi and fully mechanized mining groups, Small artisanal mining groups and individuals doing manual mining and surface mining in Kamtonga and Mkuki areas of Mwatate sub-county. The researcher conducted the observational research in a real-life situation which yielded valuable insights on the issues of vegetation, topography and air around the mining sites.

Research approaches and data collection

The study used a structured observation approach to get information on the state of three environmental elements namely vegetation, topography and air. The focus was mainly on mining approaches, their characteristics and proximity to the urban infrastructure and neighbouring communities. In structured observation method, data is not collected using typical research methods like surveys and interviews. Instead, data is coded, and in this case, the researcher prepared record sheets or structured matrix with a listed preliminary list of issues to be observed at the selected mining areas. This method has both advantages and disadvantages. On the positive side, it is an easier and more systematic approach and likely to produce quantitative data which makes it easier to analyse and compare results at segmented times. For example, this study was done in August. The same areas could be observed quarterly and results compared. Therefore, it is a method that allows progressive research. Also, observer bias risk is smaller. The method, however, has its shortcomings in that the results may not be detailed and some data collected may not be useful for the research and therefore the results may not be detailed. Nevertheless, the advantages outweigh the negative outputs and the valuable information was obtained in this study.

Structured matrix of the impacting factors against the environmental components formed the data collection tool in the nine selected mining sites. The matrix was used to record the observations made in the affected environment surrounding the mining areas which was broken down into three components that included; topography, vegetation and air. The FOLCHI method was adopted to quantify the environmental impact of mining activities in
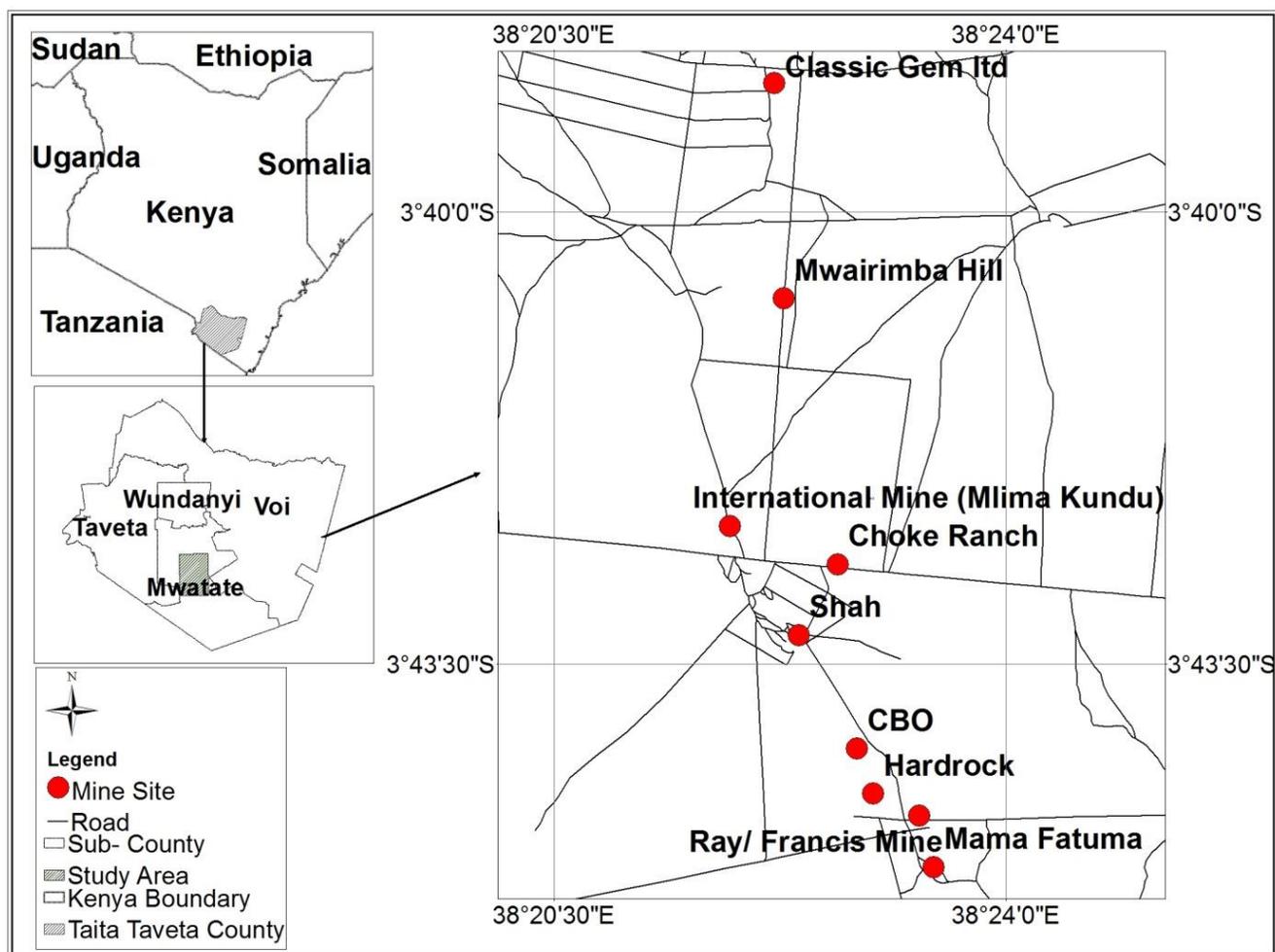
Figure 1. Map of the study area.
Source: Author.

gemstone mining sites (Folchi, 2003). The effect of the three components impacting factors, both directly and indirectly, from the mining activities was then calculated for each environmental component and computed averages (magnitude) presented in table format.

RESULTS AND DISCUSSION

Mining approaches and characteristics

Popular mining approaches used included excavation and removal of overburden (layers) in the underground and open-pit surface mining. The process negatively impacted soil structure and composition. Different processes of mining consequently rendered the soil infertile and barren to accommodate wildlife or flora and fauna. The mining activities revealed characteristics such as open pits below groundwater level, horizontal tunnels and shafts, strip mining and deep in the ground (Figures 2 to 5 and Table 1). Wherever these mining activities were conducted they resulted in deforestation and great damage around the pits on soil, vegetation, and grassland hence altering the topography of the area.

Mining in Kenya is mainly open-pit, a process that has created many large pits. Figures 2, 4 and 5 demonstrated the negative impact on the soil structure, its composition, fertility and landscape. There was complete biodiversity loss and wildlife activity had diminished. Open-pit mining often involved the removal of natively vegetated areas, rendering it as one of the most environmentally destructive types of mining method. This observation was the same wherever minerals are extracted. For example, gypsum extraction is done through open cast and quarrying methods as well. These methods like earlier indicated involved removing topsoil up to bedrock and make the mining areas bare and devoid of vegetation.

Figure 2. Open pit.

Figure 3. Horizontal tunnels and shafts.

The landscape is heavily impacted by drilling of holes, blasting, transportation and usage of heavy machines in the initial stages of the mining process (Brahma, 2007).

Mining operations proximity to urban infrastructure

Mining operations proximity to urban infrastructure was

measured in Kilometers and it emerged that most livelihood centres were quite far from the mining areas and its communities. At the mining site, there was no water reticulation system. Therefore, water is bought and delivered to those in the mining fields. The residential areas to the mining sites are about 20-40 km while the water sources ranged between 40-42 km. The distance from various mines in Kamtonga and Mkuki to the main shopping centres in Mwatate and Voi is 20-40 km (Table 2). There is a lot of activity in Mkuki and growth of the shopping Centre due to mining activities attracting selling and buying of the valuable gemstones.

Impacts of mining activity on topography

Mining activity influence on topography was observed on all the nine mine sites on a scale of 1-5 (none, damaged, moderately damaged, highly damaged and extensively damaged). Observation focused on valleys, plains, damp sites/piles, natural water head, hills and wetlands. Around all the mines there were no valleys, plains, hills and wetlands (Table 3). Dump piles were an eyesore in most of the mines. Most of the mining sites observed had dump piles causing moderate damage while others had highly damaged areas especially surface mining which caused extensive damages (Figure 1). Mining has interfered with water beds and rivers have dried up. Water resources have been adversely affected, as a result of forest destruction during mining, and have caused other water bodies to disappear.

Mining activities generate unique effects on landforms, shapes, structure and stream headwaters (Lechner et al., 2016). Only hydro-seeded grass and non-native tree species were found on the alkaline soils of reclaimed mining areas. Native plants did not grow again once removed for mining operations (Figures 6 to 9). This resulted in permanent loss of valuable land for agricultural activities and degradation lead to poverty for the current and future generations. Respondents in the study area depend on agriculture as the major source of food and income. Mining potentially causes serious land degradation. Rahimsouri et al. (2011) observed that mining and natural sources contributed significantly to soil pollution that in turn reduced agricultural productivity because of the toxicity of the chemical compounds which adversely affected biological functions. The impact of mining on the quality of soils around the mines cannot, therefore, be ignored as the cumulative effects of pollution loads on the soil and water resources alter the land use in the host communities (Omoti et al., 2016).

Mining activity influence on vegetation

In this study, the impact of mining activity on vegetation was also observed. Aspects of vegetation observed

Figure 4. Strip mining.
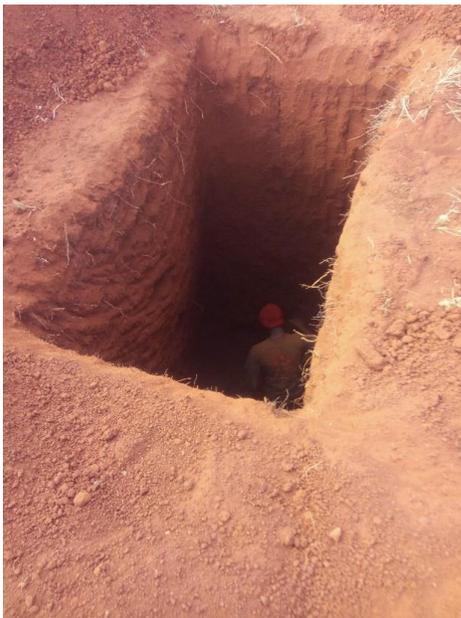
Figure 5. Deep in the ground.

included general categories of trees, shrubs and grass. Also, animal life around the mining area was observed. Observation from all the nine mining sites revealed similar characteristics where trees, shrubs and grass were sparsely populated (Figures 7 and 8 and Table 4). In surface and open pits mining, there was no grass as the method involved the removal of the topsoil that was fertile and supported the growth of land cover. Livestock life

was distributed all over the mining areas, located in variously owned ranches, but with moderate to dense distribution in some mining sites (Figure 4).

The natural habitation and indigenous trees were cleared. Mining activities had negative impacts on vegetation which included, deforestation, destruction of habitats, soil erosion, disruption of watersheds and pollution. The tendency of clearing the vegetation was to prepare trenches and pits to remove the minerals (Figures 2 and 7). Adjei (2007) also observed similar mining destruction of reserves upon which thousands of people depended for their food and livelihoods. Ogola et al. (2002) explained gold mining resulted in increased removal of vegetation in Migori County in Kenya. Global Forests Atlas (GFA) and World Wide Fund for Nature (WWF) reports state that mining is the cause for 7% of the deforestation in sub-tropics including 6,100 km^2 of Amazon forests. It is recorded that as Ghana got its independence, its forest estate was 8.3 million hectares, but mining activities reduced the cover to only 1.2 million hectares (Hilson, 2004).

According to Ross et al. (2016), it is revealed that mining affects environmental systems including water quantity and quality degradation and burying of streams headwater. After removal of vegetation, the bare ground remaining loses water through evaporation. Besides, destruction of natural land topography and landscapes, negatively affect water movement thus leading to either diversion or disappearing of such streams in the areas.

Impact of mining on air

Another aspect observed in this study was the mining effects on air. The study focussed on the levels of noise and dust as a result of blasting, transportation, tailing (mine dump) stockpiles, haul roads, exhaust emissions (car trucks, heavy equipment) and Gas emissions (Table 5). At the time of collecting this data most of the listed activities were sporadically performed. This posed as a limitation to the researcher regarding the consistency of the matrix used to record the observations made. For example, some mining sites conduct their blasting activity at night or early hours while some carry out theirs in the afternoons.

The dust from the blasting, transportation of materials, Exhaust Emissions (Cars, trucks, and heavy equipment) and gas emissions in surface mining was very thick, because of open mining methods used, and wind. The blasting observed during this study was done at 11 a.m and 6 p.m in some mines while the transportation of materials time was between 2 and 3 p.m. Gas emissions from trucks and heavy types of equipment like generators were unnoticeable during blasting where the mines were fully or semi-mechanized. Both dust and noise also depended on the horizontal tunnels shafts of the mining

Table 1. Types of mining approaches, techniques and characteristics.

| Mine characteristics | Mining type (number of mines observed) | | | Total |
	Mechanized	Surface mining	Open pit	
Pits below groundwater level	4	0	1	5
Horizontal tunnels and shafts	0	0	1	1
Strip mining	0	1	0	1
Deep in the ground	0	0	2	2
Total	**4**	**1**	**4**	**9**

Table 2. Mining operations proximity to urban infrastructure.

| Distance | Mining type proximity, (Km) | | | |
	Mechanized	Surface mining	Open pit	Total
Between residential area and mine (Km)	31.0	21.0	30.5	29.7
Between water sources and mines (Km)	30.8	1.0	20.5	22.9
Between shopping centres and mines (Km)	21.3	21.0	30.5	25.3

Table 3. Subjective assessment of the impact of the type of mining activity on topography.

| Topography | Mining approach | | | Total |
	Mechanized	(Specify)	Open pit	
Valleys	1.0	1.0	1.0	1.0
Plains	1.2	1.0	1.5	1.4
Dump piles	2.4	3.0	2.6	2.6
Natural Water Heads	1.1	1.0	1.0	1.1
Hills	1.0	1.0	1.0	1.0
Wetlands	1.0	1.0	1.0	1.0

Scale of 1-5 (1=none, 2=damaged, 3=moderately damaged, 4=highly damaged, 5=extensively damaged).

pits which stretched to between 200-400 m long. Increased activities of surface and underground mining led to increased dust production. The busy and speedy traffic in and out of the mining areas for mineral trading also resulted in a lot of dust and air pollution. Soils left unprotected during the removal of vegetation led to the production of intensive dust and wind erosion.

Air is polluted during excavation because small particles are easily dispersed by the wind (Fugiel et al., 2017). The quality of the air is reduced, resulting in poor human health, and diminished vegetation close to the mining areas (Ghorani-Azam et al., 2016). Fine and coarse particulate matter can reach the lungs leading to respiratory problems. Heavy dust plume production also affected visibility and the chemicals, from dust, released into the atmosphere killed the Flora and Fauna and also polluted the air, water and land.

Impact of mining activity on noise and earth vibrations

Noise and earth vibrations were produced during excavation activities. Vibrations were associated with many types of equipment used in mining operations, but blasting was considered a major source of the more disturbing noise and vibration. Vibrations affected the stability of infrastructures and homes of people living near mining operations. Most of the noise was caused by loading and unloading of rocks, power generations, shovelling, drilling, blasting, transport, and stockpiling (Tables 6 and 7). Only four of the mining sites had powered tractors and power generators. None of the mining sites owned a steel dumper or carried out such activities as chutting, ripping, and crash grinding. Nevertheless, there was no control of noise and vibration

Figure 6. Dump piles.

Figure 7. Abandoned mining trenches

effects, which could negatively affect the workers in the mining sector.

The effects of noise and vibrations can directly affect the health of the miners and their neighbours. Even so, miners observed were not protected against these mining hazards. There was a display of ignorance and negligence concerning the use of protective gears. It

could also be due to inadequate law enforcement by government agencies. A study by Chen et al. (2018) on coal and gas outburst hazards in Henan, China, revealed that lack of knowledge among people working in coal mining areas was blamed for their failure to use protective gear, which exposed them to injuries on heads, legs, hands and backs. Ignorance has led most miners to expose themselves to danger, sometimes even to the extent of losing their lives due to lack of protective gears (Friend and Kohn, 2018). Then there is an element of risk to nature, especially to wildlife. Therefore, environment and wildlife safeguard agencies, have an urgent need to be more proactive in policy and law formulation and also in their enforcement. Reluctance on the part of the authoritative governmental body has resulted in lack of their visibility. The two sectors can play a very important role in ensuring that forests do not critically face adverse impacts during mining. Also, enforcement of Environmental Impact Assessment (EIA) requirements is critical in predicting and planning for mitigation of impacts likely to emerge due to mining. This study goes hand in hand with that of Mwangi and Mutiso (2018); all of whom explain that there is need to develop a complete regulation in the forest and environment department to increase sufficient capacity for monitoring and enforcing various laws and regulations to ensure forests and the whole environment is well managed.

Conclusion

This study specifically observed the environmental patterns as affected by mining activities, and data collected was to answer the research question on how mining activities impacted the environment. The specific objective of the study was to observe the mining impact on the environment on three elements namely; topography, air and vegetation. Observation of approaches and characteristics of all nine mining areas revealed similarity of the sparsity of trees, shrubs and grass because of removal of fertile soil. Deforestation, damaged vegetation, destruction of habitats, disruption of watersheds and pollution was also noticed. The study results revealed that clearing of trees, shrubs and grassland during mining preparations destroyed the top fertile soil which led to land degradation, groundwater contamination, persistent noise and air pollution. Opencast mining as observed in the study area has severely altered the landscape. It has suppressed and prevented vegetation. Dump piles were an eyesore in most of the mines observed. Forests have been converted into grasslands and most of the natural habitation and indigenous trees have been eliminated. Farmlands have not been spared. Native plants, once removed for mining operations, do not grow again, resulting in permanent loss of valuable land for

Figure 8. Damaged vegetation cover.

Figure 9. Abandoned mining pits.

Table 4. Impact of mining activity on vegetation within proximity of mines between 0-1 km.

Vegetation	Mechanized	(Specify)	Open pit	Total
Trees	2	2.5	2.6	2.3
Shrubs	2.5	2.5	2.3	2.4
Grass	3	1	1.8	2.2
Animal life	3.7	3.5	3.5	3.6

(Scale 1-5)1=none (ground is bare) 2=sparse 3=moderate and lush 4= dense and lush 5= very dense and green.

Table 5. Excavation activities.

Excavation	Mechanized	(specify)	Open Pit	Total
Blasting	2.0	5.0	2.7	2.6
Transportation of materials	3.5	5.0	4.3	4.0
Wind erosion	3.3	4.0	3.0	3.3
Fugitive dust from tailings facilities	2.0	2.0	3.7	2.6
Stockpiles	1.0	2.0	1.3	1.3
Waste dumps	2.8	4.0	3.7	3.3
Haul roads	2.8	3.0	3.7	3.1
Exhaust emissions (cars, trucks, heavy equipment)	3.8	5.0	3.7	3.9
Gas Emissions	2.8	5.0	2.5	3.4

The scale of 1-5 (1=none 2=Very thin 3= Thin 4=Thick 5= Very thick).

Table 6. Mining activities that produce noise.

Activities	Mechanized	(Specify)	Open Pit	Total
Transport	2.0	4.0	3.0	2.7
Vehicle engines	2.0	3.0	2.8	2.4
Drilling	1.8	4.0	2.8	2.4
Blasting	2.3	4.0	1.8	2.2
Ripping	2.0	1.0	2.0	1.9
Power generations	1.3	3.0	2.3	1.9
Stock pilling	1.3	1.0	1.5	1.3
Shovelling earth	1.3	1.0	1.3	1.2
Loading and unloading into steel dumpers	1.0	1.0	1.0	1.0
Chutes	1.0	1.0	1.0	1.0
Crash grinding	1.0	1.0	1.0	1.0

Scale 1-5 (1=none 2=minimum 3=moderate 4=loud 5=very loud).

agricultural activities which leads to poverty for the current and future generations. The respondents from the study area depended on agriculture as the major source of food and income. There was a loss of plant biodiversity which directly affected domestic and wild animals. There were many abandoned open pits which endangered both human and wildlife. Little administrative and legal sanction has been instituted to contain the pollution, despite uncontrolled dust in the air and the fact that

miners are not protected against mining hazards. Efficient monitoring mechanisms on mining activities by large and small miners are lacking in Kenya hence the environment is not protected. Even though there are many environmental regulations and policies on paper, the environment is still abused in Kenya, as a result, the country has lost forest cover due to mining activities.

This study recommends that relevant administration personnel could oversee the rehabilitation and restoration

Table 7. Mining activities that cause earth vibrations.

Activities	Mechanized	(Specify)	Open pit	Total
Drilling earth	4	4	3.5	3.8
Power generation earth	2	3	2.5	2.3
Blasting earth	1.5	4	1.8	1.9
Transport earth	1.8	2	2	1.9
Vehicle engines earth	1	1	1	1
Loading and unloading into steel dumpers earth	1	1	1	1
Chutes earth	1	1	1	1
Shovelling earth	1	1	1	1
Crash grinding earth	1	1	1	1
Stockpiling Earth	1	1	1	1

Scale 1-4 (1=none 2=minimum 3=moderate 4=very loud).

of areas degraded by mining are restored by making sure pits are backfilled, soil piles are removed and re-afforestation and waterways sources are restored for sustainable environmental protection. Environment and wildlife safeguard agencies have an urgent need to be more proactive in policy and law formulation and also in their enforcement. Reluctance on the part of the authoritative governmental body has resulted in lack oftheir visibility. The two sectors can play a very important role in ensuring that forests do not critically face adverse impacts during mining. It is suggested that the concerned government departments, put in place mining regulations that will secure wildlife and their habitat during mining and enforce subsequent restoration of the excavated areas to original status. Environmental legal instruments such as Environmental Social and Impact Assessment, Environmental Audit and Social and Environmental Assessment should be conducted in line with mining regulation, Environmental Management and Coordination act 1999 (amended 2019) in Kenya. These regulations should be enforced jointly by the ministries of environment, water and health.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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