IOSR Journal of Humanities And Social Science (IOSR-JHSS)
Volume 25, Issue 9, Series 7 (September. 2020) 47-61
e-ISSN: 2279-0837, p-ISSN: 2279-0845.
www.iosrjournals.org

Gold Mining Industry and Its Implications on the Environmentin Kakamega South Sub-County, Kakamega County, Kenya

Alwang'a R.[1]Mulinya C.[2] and Mabonga J.[1]

1. Department of Geography, Masinde Muliro University of Science and Technology P.O Box 190,50100, Kakamega Kenya.

2. Department of Geography, Kaimosi Friends University College(A constituent college of Masinde Muliro University of Science andTechnology) P.O Box 385 50309 Kaimosi, Kenya

ABSTRACT

The gold mining industry provides employment and mineralsthat are in demand. Both large-scaleand artisanal and small-scale gold mining have resulted in environmental degradation in different parts of the world. Artisanal and small-scale gold mining is a growing livelihood activity that is undertaken mostly in rural areasin Kenya because of the limited employment opportunities as well as the need to supplement farm earnings. However, this has led to land degradation and this threatens food security and the livelihoods of a majority of the population who reside in these areas as they depend on small-scale and subsistence agriculture. In view of the above, the study sought to assess the impact of the gold mining methods on the environment in Kakamega South subcounty. The study adopted a descriptive survey designand employed random and purposive sampling techniques. The data was collected by administering questionnaires, conducting interviews, making observations and holding focus group discussions. The data collected was analyzed using SPSS to generate frequencies. The findings showed that gold mining activities had resulted in environmental degradationevidenced by observable effects such as dust at crusher location sites, coloration in stream water, high noise levels, gaping holes, land subsidence, scanty vegetation and exposed plant roots as a result of soil erosion in some sites.

Key Words:Gold mining,Artisanal mining,Impact,Environment

Date of Submission: 05-09-2020 Date of Acceptance: 20-09-2020

I. INRODUCTION

Gold mining actvities have been practised for thousands of years due to the demand for the mineral in the making of jewellery and minting currency among other uses.Economic growth has been achieved in countries where gold is mined as the main mineral as it is a major foreign exchange earner,employs a large number of people and has led to the development of related industries and infrastructure.The benefits are however being realised at great environmental costs as gold mining is associated with widespread environmental degradation (Awudi, 2002; Waugh, 2002).

Gold mining is undertaken at either large-scale or artisanal and small-scale mining level.The artisanal and small-scalemining sector is just as important as the large-scale mining sector when it comes to employment and mineral contribution as it infact, employs more people than large scale-scale mining and contributes just as much in mineral production (Fritz, McQuilken, Collins , & Weldegiorgis, 2018).According to Bryceson and Geenen (2016) gold is the main mineral mined in a number ofdeveloping countrieswhereartisanal and small-scale mining is dominant.

Artisanal and small scale mining is mainly carried out using simple tools by miners working as individuals or in groups who operate informally. It is mainly practiced in rural areas where it is viewed as being more economically beneficial than other activities such as agriculture.Artisanal and small-scale gold mining is however more associated with widespread environmental degradation as a result of poor mining practices by an unskilled workforce that operates informally(Hentschel, Hruschka, & Priester, 2003).

The informal nature of the artisanal and small-scale mining sector in many developing countries makes it difficult to improve environmental performance.This is because whereas licensed artisanal and small-scale miners are more responsible with the environment,the unregistered artisanal and small-scale miners fail to rehabilitate the land after their activities since legal action cannot be taken against them (Africa Center for Economic Transformation (ACET), 2017).The difficulty in monitoring activities and enforcement of environmental regulations in artisanal and small-scale mining is also because of the inaccessibility of the sites and itinerant nature of the job (Hentschel, Hruschka, & Priester, 2003; Hanai, 2003).

Whereas Kenya is endowed with a variety of minerals and has a great potential for mineral exploitation, Kenya's economy is agriculturally based and sustains over 80% of the population. Inaddition, only 20 % of Kenya's total land surface is arable land and this supports 70 % of the population. Gold mining in Kenya is mainly of artisanal and small-scale nature and is mainly carried out in rural areas where a majority of the country's population reside and depend on the land for subsistence farming (Republic Of Kenya, 2017).

Agriculture and artisanal and small-scale mining seem to have a complimentary relationship. This is because many families turn to artisanal and small-scale mining to supplement their farming earnings and invest in farm inputs (Fritz, McQuilken, Collins & Weldegiorgis, 2018). The negative impacts of artisanal and small-scale mining on the land however can affect agricultural production which shows that a complimentary relationship does not exist between agriculture and artisanal and small-scale mining.

Artisanal and small-scale gold mining and agriculture are not complimentary particularly where artisanal mining becomes the dominant occupation. This is because of the itinerant nature of artisanal and small-scale gold mining and lack of rehabilitation of degraded land which leads to low production of food and cash crops. This is even worse in areas where open cast mining which is a key feature of artisanal mining is dominant as the method requires more land and involves excavation of top soil over large areas (Africa Center for Economic Transformation (ACET), 2017).

Land subsidence resulting from underground gold mining hampers agricultural activities such as crop cultivation due to the danger posed by the wide gaping holes that develop on the land. In addition, the subsidence alters the slope of the land thus increasing the speed of surface runoff, this increases the rate of soil erosion from the surrounding areas. The eroding of the top soil results in lands having infertile soils that cannot support crop cultivation. The negative environmental impacts of gold mining such as water pollution, soil erosion and land degradation have an impact on agricultural production thus threatening food security and the livelihoods of many people who depend on agriculture. It is against this background that this study seeks to document artisanal gold mining practices in Kakamega South subcounty, their impacts on the environment and make recommendations for best mining practices and policy action.

II. METHODOLOGY

2.1 STUDY AREA

Kakamega South subcounty is located in Kakamega County in the Western region of Kenya. The sub county lies between latitude 0^0 10' 0'' and 0^0 15' 0'' North of the Equator and Longitude $34^0$41'0''and $34^0$46 '30''East of the Prime Meridian. The sub county covers an area of 146. 2km^2.It is divided into four wards which are; Idakho East, Idakho South, Idakho Central and Idakho North.

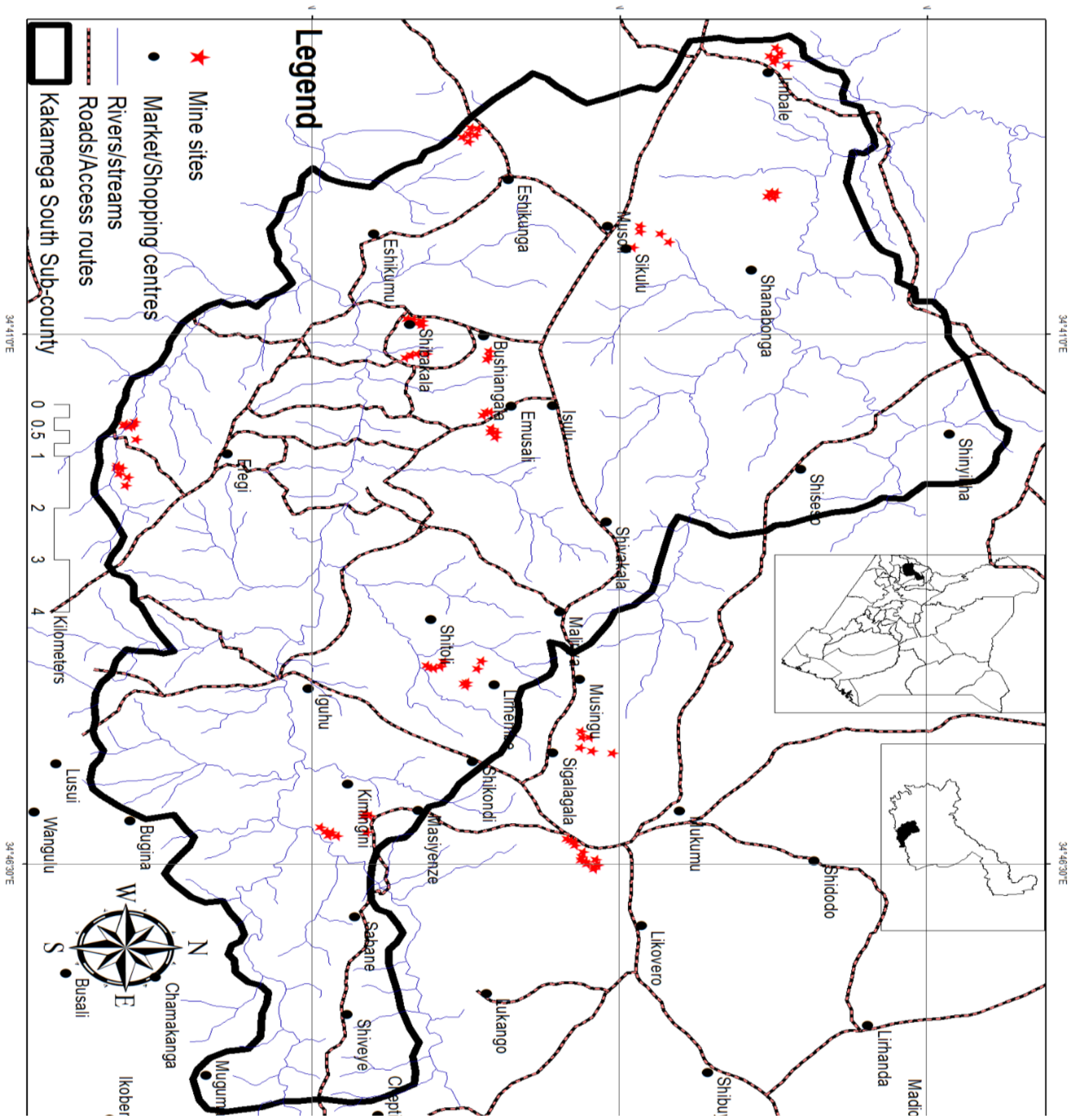

Figure 1 Map of Study Area, Kakamega South Subcounty, Kenya
Source; Researcher, Field Data (2020)

The population of Kakamega south subcounty based on the 2019 Kenya Population and Housing Census is 111,743 of which 58,524 are female while 53,219 are male. The population density stands at an average of 764 persons per square kilometre. The sub county lies within altitude 1240 metres and 2000 metres above sea level and the area is well drained with permanent rivers. The annual rainfall in the area ranges from 2000 mm to 2200mm. The rainfall pattern is evenly distributed all year round and is bimodal having two rainy seasons, the long and short rains. The long rains start in March and end in June while the short rains start in August and end in November. December, January and February are dry months. The main economic activity carried out in the area is subsistence farming. The land parcels are small and are mainly used for food production. According to Huddleston (2007) the geology of the area has formation belonging to the Nyanzian volcanic and the Kavirondian systems. The Nyanzian system is associated with gold bearing auriferous quartz veins which occur mainly from the underground geology.

2.2DATA SOURCES AND COLLECTION METHODS

The study made use of both primary and secondary data sources. Data collection methods employed were interviewing, observations, questionnaires and focus group discussions (FGDs). Secondary data was obtained from published and unpublished sources and existing studies such as theses, journals, magazines, newspapers, government policy documents and electronic websites. The questionnaire was the primary tool administered to all artisanal miners.

Interviews were held with the owners of land where mining activities were taking place or had ceased and personnel from the environment office, mines department and mining company. The researcher utilized an observation checklist during data collection. There was observation of the activities such as mining methods and level of degradation of the environment. Focus group discussions were held with the 24 residents neighbouring the mine sites in the four wards with each group having 6 members. This was to validate information given by the respondents regarding the impact of gold mining on the environment and the effectiveness of the measures used to mitigate against the adverse impacts of gold mining.

Validity was ensured by ascertaining that the items on the instrumentswere relevant to the objectives and content. This was done by critically examining the items on the instruments. Reliability was improved by pre-testing the questionnaire to evaluate it for ease of understanding and the suitability of the general order of the items on the questionnaire. Data collected was analyzed both quantitatively and qualitatively using standard statistical packages to extract information on levels of environmental degradation and respondents' perceptions on impact of gold mining on environment.

2.2 SAMPLING PROCEDURE

The study adopted a descriptive survey design. All the 60 mine sites were used in the study. Random sampling was employed to select a total of 240 artisanal miners representing 30 % of the target population to take part in the study. Purposive sampling was employed in selecting 2 key informants from the mines department, mining company and environment office as well as 60 household heads who were owners of land where gold mining activities were on-going or had ceased and 24 household heads who were neither land owners in the areas where mine sites were located nor involved in gold mining but were residents neighbouring mining sites. These were residents who were closest to the mine sites.

III. RESULTS AND DISCUSSIONS

There was need to establish the impact of the gold mining activities on the environment.The respondents were asked to give their views on whether their gold mining activities had any negative impact on the environment. They were also asked if gold mining had resulted in effects such as land dereliction, heaps of mine wastes around the sites, water pollution, air pollution, bare ground at the sites, unproductive farmlands and soil erosion.

3.1The Impact of the Gold Mining Methods on the Environment.

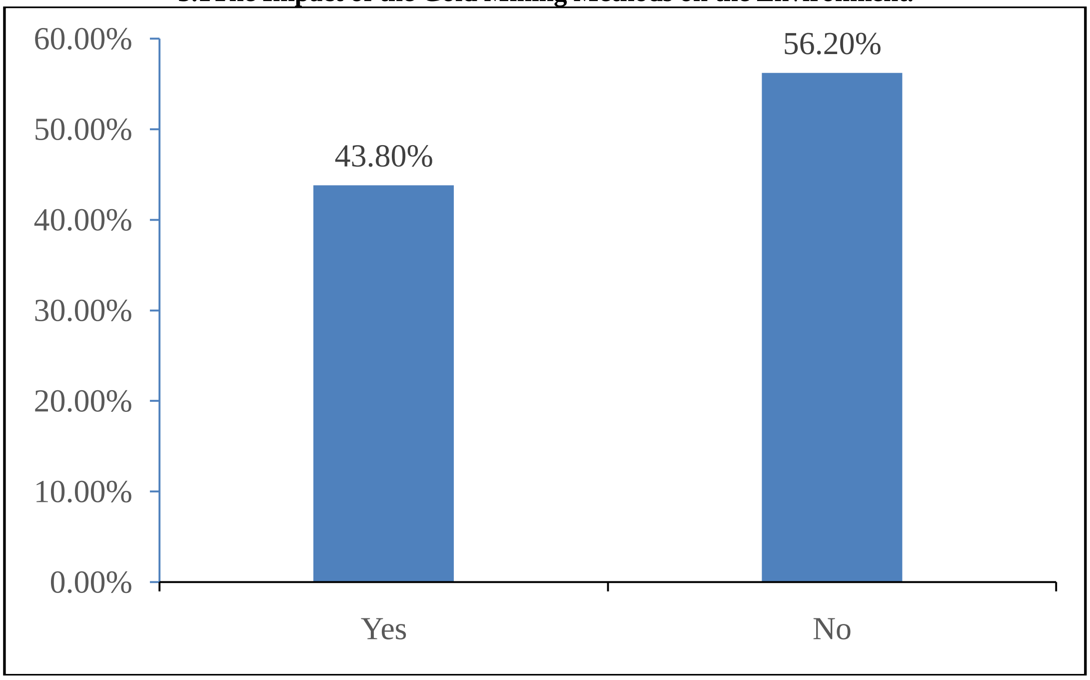

Figure 2 Respondents' view on gold mining activities effect on the Environment

Source; Researcher, Field Data (2020)

Table 1 Responses on environmental impact of gold mining based on education level

	Do you think that the methods you use for gold mining affect the environment negatively?		
Level of education	Yes	No	Total
Primary Level	17	74	91
Secondary Level	65	44	109
Tertiary Level	10	0	10
Total	92	118	210

The study evaluated the respondents' views on the effects of gold mining activities on the environment. On this, the study established that 43.8% of the respondents agreed that the gold mining activities had some impact on the environment while 56.2 % did not think that the gold mining activities had any impacts on the environment. The respondents' attitudes towards environmental issues were also influenced by their low level of education that resulted in their lack of understanding of the impact of their mining activities on the environment. This is because a majority of respondents with primary level of education did not acknowledge gold mining as having a negative impact on the environment. According to Cooke (2017), the low level of education of most artisanal and small-scale miners makes them not to understand the impact their activities have on the environment.The study established that gold mining had resulted in environmental degradation. The findings of the study are in consonance with those Hentschel, Hruschka and Priester (2003) that artisanal and small-scale gold mining results in widespread environmental degradation as a result of poor mining practices.

3.2 Land dereliction

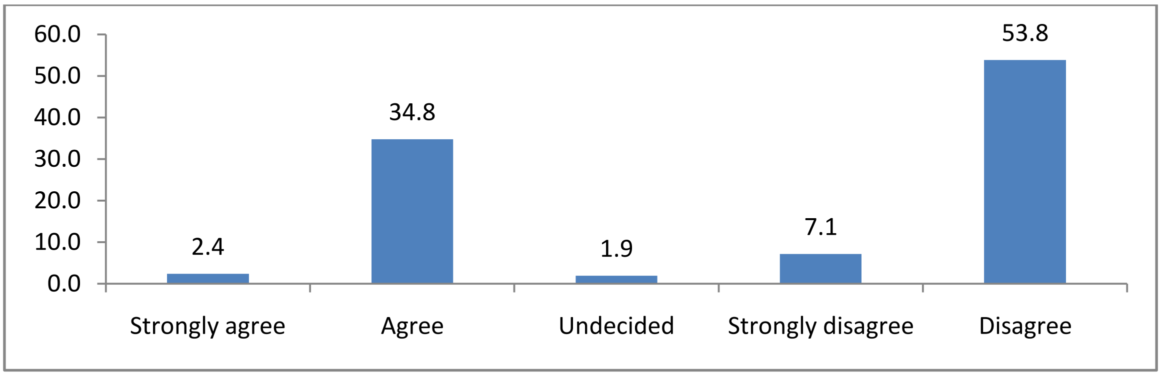

Figure 3 Respondents' perception on observable impacts of gold mining activities on land
Source; Researcher, Field Data (2020)

The study established that the majority of respondents 60.9% were of the view that gold mining did not result in land dereliction while 37.2% were of the view that gold mining resulted in land dereliction. 1.9% of the respondents were undecided on whether gold mining resulted in land dereliction.

3.3 Heaps of mine waste around the site

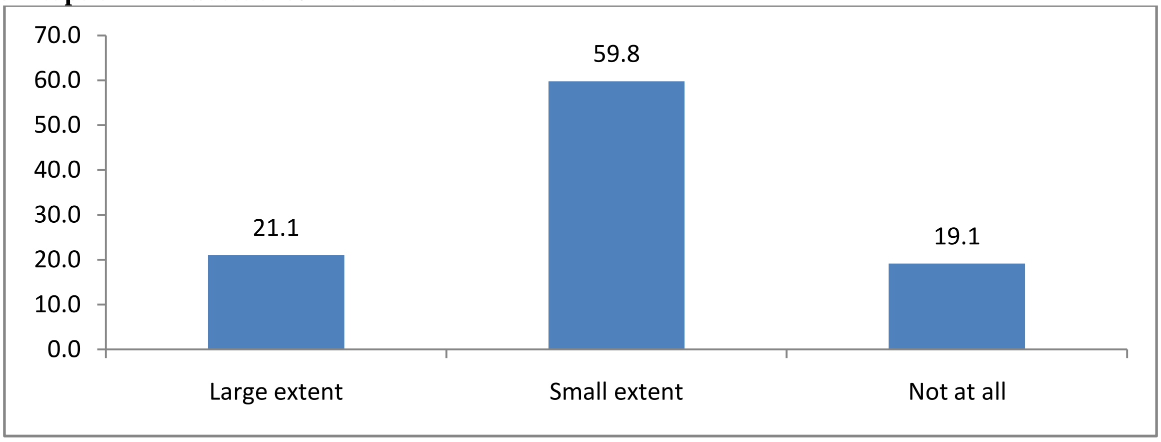

Figure 4 Respondents' perception on observable impacts of gold mining activities as heaps of mine waste around the sites (Source; Researcher, Field Data 2020)

Heaps of mine waste is one of the negative impacts associated with gold mining. There was need to establish whether gold mining had resulted in heaps of wastes around the sites. The study established that 21.1% of the respondents were of the opinion that gold mining resulted in heaps of mine waste around the site to a large extent while the majority 59.8% agreed that the practice resulted in heaps of mine waste in the areas around the site to a small extend. They also stated that the mine wastes occupying the land were an eyesore.19.1% of respondents who carried out open cast mining however felt that gold mining did not result in heaps of mine waste around the sites. Their opinion may have been influenced by the fact that they found the waste useful. This, as they said, was becausethe waste was used to backfill the shafts and to fill up gulleys on loose surface roads in the area cut by running water during heavy rains.

Although some respondents felt that the activities did not lead to land dereliction because the area excavated was small, the study established that there were many excavations that had resulted in land dereliction because of the gaping holes in addition to ground subsidence experienced in some areas that rendered the land useless for agriculture or construction of buildings. Ground subsidence had also interfered with the soil structure affecting the fertility of the soil, thus rendering the land unsuitable for other uses (Siachoono, 2010; Hilson,2002). These findings are in consonance with those of (Africa Center for Economic Transformation (ACET), 2017) that artisanal and small-scale gold mining cannot play a complimentary role with agriculture because of the industry's negative environmental impact except in cases where there is underground gold mining that does not result in cave-ins.

3.4Water pollution

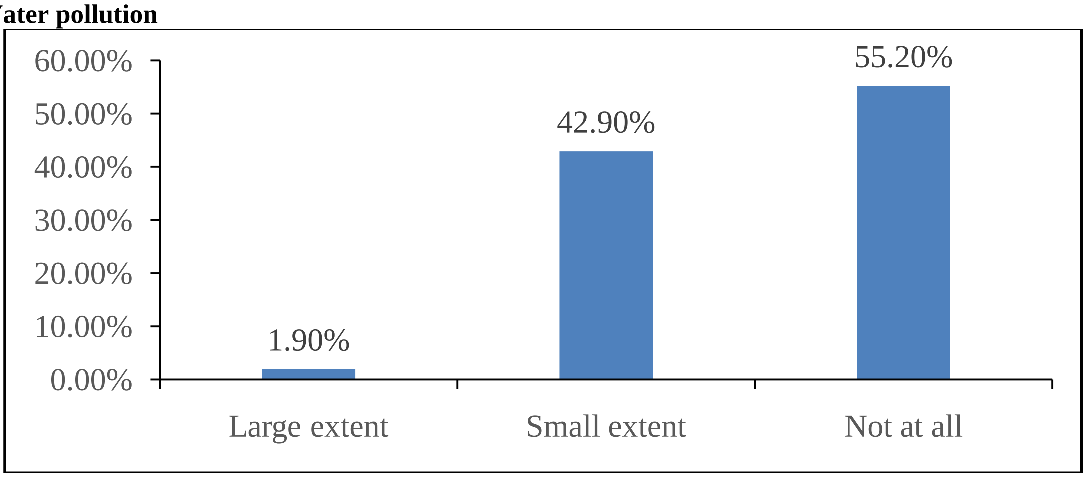

Figure 5 Respondents' perception on water pollution as an effect of gold mining

Source; Researcher, Field Data (2020)

Water pollution is another effect of gold mining on the envrironment hence the need to establish if this was the scenario at this study site. It was established that a majority of the respondents that is, 55.20% felt that the gold mining activities did not result in water pollution at all while 42.90% of the respondents felt that gold mining resulted in water pollution to a small extent. Only 1.90% of the respondents felt that gold mining did result in water pollution to a large extent. The respondents who felt that gold mining did not result in water pollution stated that it was because if the processing was done in rivers then the continuous flow of water would wash away the mercury and sediment deposited in water during processing and this would not impact the quality of water. This response showed that a majority of them did not understand the impact of gold mining activities on water quantity and quality.The respondents who acknowledged water pollution as result of gold mining said that it is because the processing of the ore in rivers made the water dirty. This was corroborated by findings from a focus group discussion where some of the respondents stated that it was hard for them to get access to clean water as the processing of the ore in the rivers made the water dirty. The processing of gold in the rivers and the pouring of waste water back into the rivers resulted in murky waters that showed an increase in riverturbidity.

The study established that gold mining activities had resulted in poor water quality as a result of processing of the ore in rivers. The water which was poured back in the rivers also contained mercury that had been used in amalgamation. Some shafts were also located in valleys close to rivers and the waste from the piles flowed into the water bodies during heavy rains resulting in siltation of the water bodies. Pumping out of ground water from shafts had also affected the water quantity in the area as revealed by respondents who stated that rivers had become smaller and attempts to drill wells had been futile because of the lowering of the water table. These findings are consistent with those of (United Nations Industrial Development Organization (UNIDO) ,2006) that panning as well as amalgamation at river margins results in contamination of the water

3.5 Air pollution

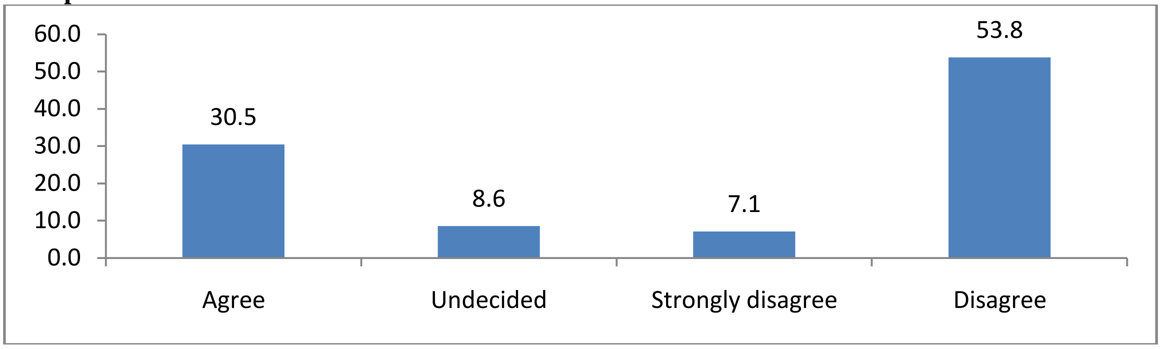

Figure 6 Respondents' perception on air pollution as an impact of gold mining activity
Source; Researcher, Field Data (2020)

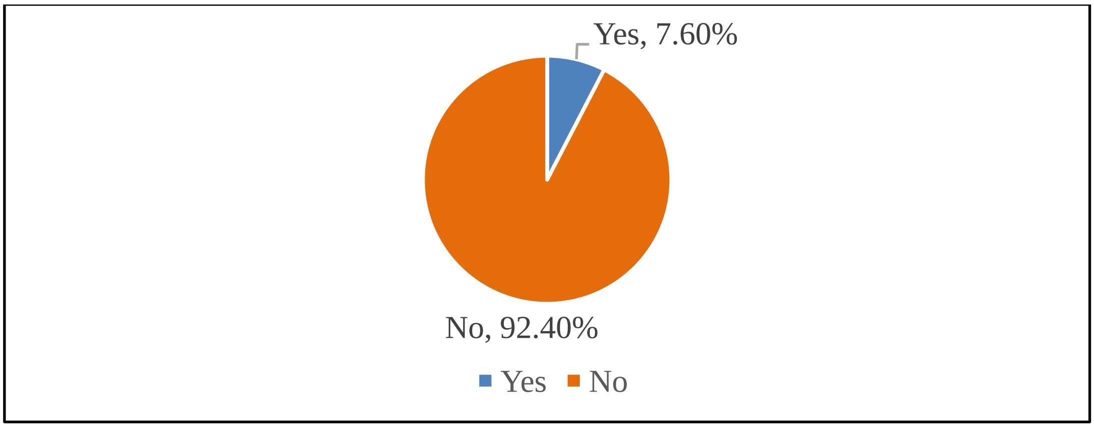

Figure 7 Response on new health problems experienced after starting work as gold miners. Source; Researcher, Field Data (2020)

The study established that a majority of the respondents that is, 60.9% were of the view that gold mining methods did not result in air pollution, 30.5% agreed that gold mining resulted in air pollution while 8.6 % could not make up their minds on whether gold mining methods resulted in air pollution or not. The respondents who acknowledged air pollution as an effect of gold mining activities had an in-depth understanding of the same as they stated that the dust emitted at crusher sites because of crushing of dry ore was a source of air pollution.

These respondents also acknowledged other sources of air pollution in the sites such as exhaust fumes from generators that were used to power machines pumping out groundwater as well as mercury vapour from burning of amalgam. It was also noted that the crushers were located inpoorly ventilated buildings thus exacerbating the situation. The respondents who were of the view that gold mining did not result in air pollution and those who were undecided expressed a lack of understanding of the issue air pollution.

The respondents were also asked if they had experienced any new health issues since they started gold mining activities. A few of them, that is 7.60% stated that they had experienced new health problems while 92.40% of the respondents stated that they had not experienced any new health problems since they started gold mining. Those who stated that they had experienced new health problems were those who were mainly involved in crushing of the ore in sites where ball mill crushers were located. They said the new health problems they experienced were; persistent coughing, headaches, eye irritation and mild noise induced hearing loss. These respondents also said that they associated the health problems they were experiencing with the gold mining activities. This, they said was because they worked in the poorly ventilated buildings the whole day where the crushing of the dry orewas done without protective gear such dust masks and ear muffs and hence were exposed to a lot of dust and noise.

The study established that there was air pollution as a result of gold mining in the areas where crushing of the dry ore was being carried out. This is in consonance with Ogola, Mitullah &Omulo (2002) who give the main source of air pollution at gold mining sites as the silica dust from the quartz veins hosting gold that is produced during the crushing of the ore.

3.6 Noise Pollution

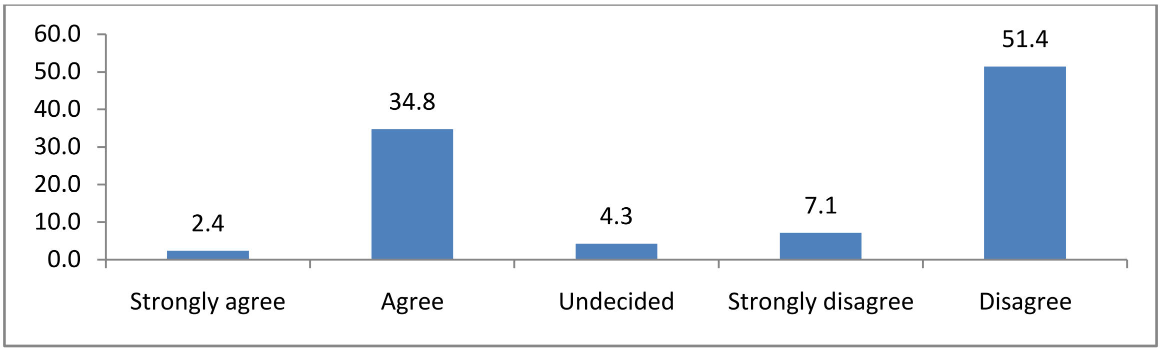

Figure 8 Respondents' perception on noise pollution as an impact of gold mining activity
Source; Researcher, Field Data (2020)

The study established that 58.5% of the respondents were of the opinion that gold mining methods did not result in noise pollution while 37.5 % of therespondents agreed that gold mining resulted in noise pollution because of the noise produced by crushers and motorized pumps at the working sites. A few of them, that is, 4.3% were however undecided as to whether or not gold mining activities resulted in noise pollution. Those who did not acknowledge noise pollution and those who were undecided also stated that they spent a considerable amount of time at crusher sites hence were used to the noise and did not find it irritating. Few respondents however also stated that they were experiencing new health problems such as mild noise induced hearing loss that they did not have before and associated these to gold mining activities.

To assess the impact of the gold mining activities on the environment, the study sought to find out if gold mining activities resulted in noise pollution.From observation it was clear that crushers in centralized places for crushing ore were the main sources of noise pollution with some sites having up to three crushers. The noise produced by the crushers was loud and irritating that it was not possible to hold a conversation at the sites. This was validated by the Focus Group Discussions where residents living close to the sites stated that the noise from the crushers and motorized pumps was a nuisance as it interfered with sleep and rest. The situation was made worse by the fact that some shafts which had been sunk in valleys were flooded during the heavy rains and the pumps had to run continuously for more than 24 hours so as to reduce the water levels to enable the miners to resume their work.

3.7 Bare ground at the site

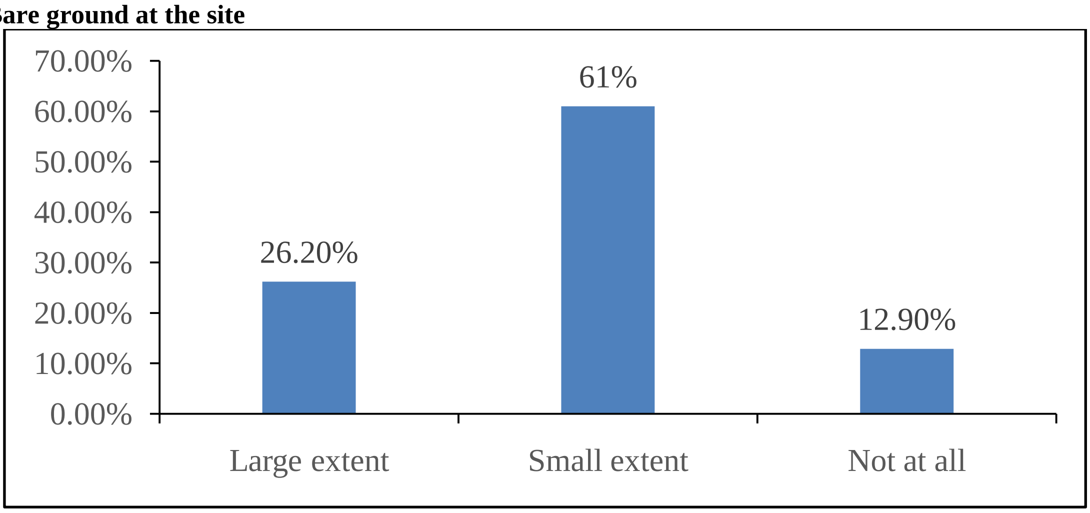

Figure 9 Respondents' perception on bare ground as an impact of gold mining activity
Source; Field Data (2020)

The study established that majority of the respondents that is, 87.2% were of the opinion that gold mining activities had resulted in bare ground at the site. They attributed this to clearing of vegetation at the excavation sites and cutting trees in the area around the sites to get timber for use in supporting of the mine shafts and tunnels in order to prevent mine collapse. The timber was also used in construction of makeshift structures for storage of mining equipment such as the generators for powering machines used for pumping out ground water and ball mill crushers. This was further confirmed by responses from FGD discussions where one respondent stated that;

“*It is becoming harder for us to get wood for our domestic use as a lot of vegetation has been cleared and trees cut to provide timber for use in mining, we now source the wood from areas which are far from our homes unlike in the past where we would get the wood from our farms.”*

The few respondents that is, 12.90% who felt that gold mining did not result in bare ground at the site felt that the area that had been cleared for excavation was too small to have any impact.

3.8 Unproductive farmlands

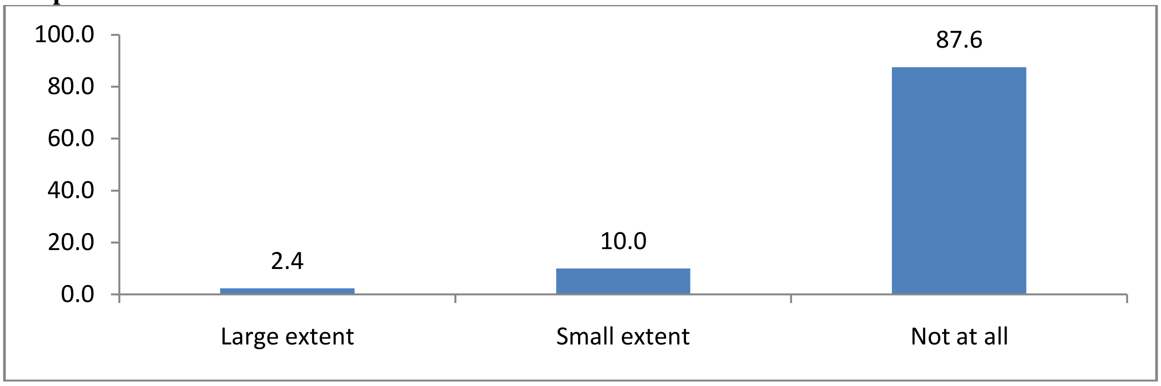

Figure 10 Respondents’ perception on unproductive farmlands as an impact of gold mining activity

Source; Researcher, Field Data (2020)

The study established that majority of the respondents that is, 87.6% were of the opinion that gold mining did not result in unproductive farmlands. A few of them, that is2.4% of the respondents however felt that gold mining had resulted inunproductive farmlands to a large extent while 10.0% acknowledged that although gold mining had resulted in unproductive farmlands, it was to a small extent.

Those who were of the opinion that gold mining had not resulted in unproductive farmlands stated that the area excavated was small. In addition, the respondents stated that some of the money acquired from the gold mining activities was used in buying farm inputs e.g. fertilizers hence felt that gold mining had a positive contribution towards agriculture. This gave the impression that gold mining and agriculture were complimentary.

Further investigation through observation and focus group discussions revealed that there were negative environmental impacts such as ground subsidence in some sites including farms that made it impossible to do cultivation. Shafts on lands where mining had ceased were not properly backfilled and the land was left with gaping holes. Some of the mine waste forming piles at the mine sites were transported by surface runoff and ended up on farmlands during heavy rains. The respondents who stated that gold mining resulted in destruction of farmlands also said that it was because the water pumped out from the mines and left to flow on their farms affected crop production. Members of a focus group discussion also expressed the same with one member stating;

“The underground tunnels dug are a threat to our property and farm lands as we live in fear of the land sinking as we have seen in other areas. If the miners continue digging holes and leaving them uncovered, we shall have no farm lands in the near future. The water they pump out of the mines and leave to flow on the land also affects the soil.’’

The study therefore established that it was difficult for artisanal and small-scale gold mining in Kakamega south subcounty to play a complimentary role with small-scale subsistence farming because of the negative environmental impacts of gold mining.

3.9 Soil erosion

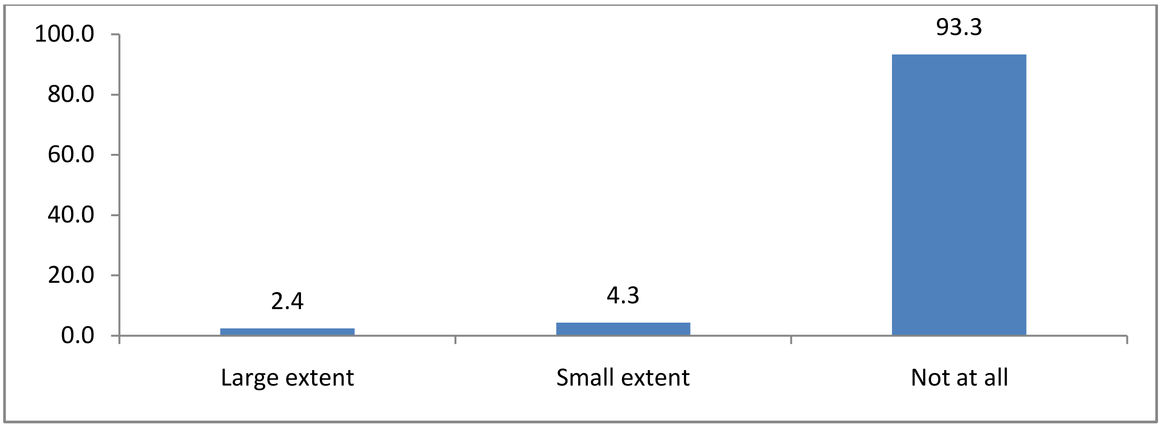

Figure 11 Respondents' perception on observable impacts of gold mining activities on soil erosion
Source; Researcher, Field Data (2020)

The study sought the respondents' perceptions regarding the impact of gold mining activities on soil. The study established that only 6.7% of the respondents felt that their gold mining activities resulted in soil erosion. The majority of the respondents that is, 93.3% felt that gold mining methods did not result in soil erosion. This was because of lack of knowledge about soil erosion among the respondents.The study also established that gold mining had resulted in a lot of waste in form of soil and waste rock that was piled at the sites during extraction. A lot of waste was generated because the mineral was located deep beneath the surface and a large amount of overburden had to be removed in order to reach it. Artisanal gold mining also involved exploitation of low-quality ore meaning that, the mineral concentration in the rock was in small amounts and, therefore, a lot of ore is extracted for processing in order to get a substantial amount of gold. This was corroborated by the respondents who stated that they had to process at least two sackfuls of crushed ore in order to get a gram of gold if they were lucky because in most cases processing the same amount always yielded much less than a gram. These findings were in consonance with those of Gweth (2003) and Olalde (2016), who attribute the much waste generated in gold mining to exploitation of marginal deposits of low-quality ore.

IV. CONCLUSIONS

The study established that gold mining activities had resulted in environmental degradation. This was evidenced byhuge piles of mine waste occupying land in the sites where mining was ongoing, siltation and coloration of stream water as a result of processing of the ore in streams and alluvial mining. There was also land subsidence in some of the sites, bare ground and exposed tree roots resulting from soil erosion. In some sites, shafts had been sunk in valleys close to rivers. There were gaping holes in sites where mining activities had ceased. Stagnant pools of water were in sites where there was reworking of tailings and a lot of dust was emitted at crusher sites as well as loud noise from the crushers and machines used to pump out ground water.

The adverse impacts of the gold mining activities were not just limited to the sites wherethere was extraction of the ore,crushing andat water sources suchas rivers where processing of the ore was carried out but also in homesteads .As the study established, it was at only two sites where the miners were given a daily wage for their work, in all the others sites miners shared the ore extracted as a form of payment, each miner then proceeded to carry out the processing at a place of their own choice with most of them opting to do this in their homes. Crushing, sluicing, amalgamation and roasting of the amalgam therefore took place in several homeswith the waste water containing mercury being disposed off by pouring on the ground in the homesteads. Mercury is harmful to human life.

V. RECOMMENDATIONS

Due to the demand for minerals and the need to earn a living, mining activities will continue to be carried out for years to come. Case studies of successful rehabilitation in the mining industry point to the fact that mining can be carried out in an environmentally sustainable manner. It is, therefore, imperative that measures are undertaken to ensure that gold mining activities in Kakamega south are carried out in an environmentally sustainable manner. The study, therefore, recommends the following measures to achieve the same.

i. Training of the miners on best mining practices on environmental protection and safety. The training should emphasize on the benefits of using the best mining practices to the miners as this will inspire the miners to put them into practice. Those charged with the responsibility of training the miners should take into account the demographic characteristics of the miners such as level of education and work experience and come up with programmes suitable for each group of miners. The training sessions should actively involve the miners.

ii. The government should help by carrying out geological prospecting and demarcation of areas for registered groups of artisanal miners. This will prevent haphazard exploitation and frequent migration of the miners, thus helping keep track of them and make them accountable for their activities.

iii. There should be centralized controlled ore processing by setting up a center owned by miners' co-operative where a subsidized fee can be charged for use of equipment like crusherswhere processing activities such as crushing, washing, sluicing, panning, amalgamation and roasting of amalgam can be done in the area a considerable distance from homes ,farms and water sources. Rain water harvesting can be done at the centers and the water used for processing the ore to reduce on over reliance on streams as sources of water. Ground water pumped out of mines can also be collected and used in ore processing.

iv. Washing and amalgamation of the ore in special ponds lined with cement and disposal of tailings in pits lined with plastic sheeting and red clay soil containing oxides that holds the mercury in place to prevent water and soil pollution that results from pouring of the waste water containing mercury on the ground in homes and in rivers.

v. Miners should use simple home-made retorts in roasting gold mercury amalgam to capture mercury emissions. This will help to prevent air pollution.

vi. There should be construction of well-ventilated buildings for crushers to prevent dust accumulation as well as use of protective gear for miners such as masks and ear muffs to prevent silica dust inhalation and protect against excess noise produced by crushers.

vii. To prevent mine shaft collapses, artisanal miners should explore the use of other options to support the shafts such as metal rods which give high support capacity and can easily be re-used in other mines. Instead of wood, alternative material should be used in construction of sheds at mine sites as well as buildings for crushers. This will reduce over reliance on wood, thus reducing the cutting down of trees.

viii. Mine waste stabilized with cement should be used to prevent ground subsidence. Covering the openings of active shafts to prevent water from surface run-off from getting into the mines will also help to prevent ground subsidence.

ix. For successful revegetation, there should be careful removal, handling and storage of top soil to be used in rehabilitation. Breaking up of compacted soil at mine sites at closure of the mining operations will improve infiltration and plant root penetration, thus facilitating successful revegetation. Vegetation restoration should then involve use of native plant species to accelerate ecological succession.

x. Open cast mine pits can be lined with clay to reduce water loss and be utilized for composting animal manure. This will ease the financial cost of purchasing fertilizer for small-scale farmers in the area as well as making good use of the pits.

REFERENCES

[1]. Africa Center for Economic Transformation (ACET). (2017). The Impact of expanding artisanal and small scale mining on small holder agriculture in West Africa. A case study of Burkina Faso, Ghana and Sierra Leone. Retrieved from http://www.acetforafrica.org

[2]. Akhonya, C. (2014). Let the trees grow as mining flourishes. Climate Change News, 10.

[3]. Ali, S. H. (2008). Mining in China: A primary Ecological and Human Health Concern. ChIna EnvIronment Series(10), 97 - 109.

[4]. Alt, S., Jenkins, A., & Lines-Kelly, R. (2009). Saving soil - A landholder's guide to preventing and reparing soil erosion. NWS Department of Primary Industries.

[5]. Armah, F. A., Boamah, S. A., Ouansah, R., Obiri, S., & Luginaah, I. (2016). Working conditions of male and Female artisanal and small-scale gold miners in Ghana:Examining existing disparities. The Extractive Industries and Society, 3(2), 464-474.

[6]. Aswathanarvana, U. (2003). Mineral Resources Management and the Environment. Amersfoort: A.A. Balkema Publishers.

[7]. Awudi, G. B. (2002). The Role of Foreign Direct Investment (FDI) in the mining sector of Ghana and the Environment. Conference on Foreign Diret Investment and the Environment (pp. 7-8). Paris: OECD. Retrieved from www.oecd.org/dataoecd/44/12/1819492.pdf

[8]. Barreto, M. L., Schein, P., Hinton, J., & Hruschka, F. (2018). The Impact of Small-Scale Mining Operations on Economies and Livelihoods in Low-to Middle-Income Countries. Somerset: Pact Global UK.

[9]. Bennett, L. (2017). Deforestation and climate change. Retrieved from http://www.climate.org

[10]. Bhebhe, D. (2009). The Environmental Damage Caused by Gold Panning in Gwanda District Zimbabwe. Masters Dissertation Submitted in partial fulfilment of the requirements of the Masters Degree in the

DisasterRisk Management at the Centre For Disaster Risk Management Education AndTraining at the University Of The Free State. University of the Free State.

[11]. Bitala, M. F., Kweyunga, C., & Manoko, M. L. (2009).).Levels of heavy metals and cyanide in soil sediment and water from the vicinity of North Mara Giold Mine in Tarime District, Tanzania. CCT.

[12]. Bland, A. (2014, February 14). The Environmental Disaster that is the Gold Industry. Retrieved from Smithsonian.com: https://www.smithsonianmag.com/science-nature/environmental-disaster-gold-industry-180949762/

[13]. Blodgett, S. M., & Kuipers, J. R. (2002). Underground hard-rock mining: Subsidence and hydrologic environmental impacts.

[14]. Brooks, R. R., Chiarucci, A., & Jaffre, T. (n.d.). Revegetation and stabilization of mine dams and other degraded terrain Ch. 10.

[15]. Bryceson, D. F., & Geenen, S. (2016, February 17). Artisanal Frontier Mining of Gold in Africa:Labour Transformation in Tanzania and the Democratic Republic of Congo. African Affairs, 115(459), 296–317.

[16]. Cagan, S. (2014). Mining Challenges in Colombia's El Choco. Locomotive or Streamroller? Revista: Harvard Review of Latin America, pp. 44-62.

[17]. Carr, D. D., & Herz, N. (1989). Concise Encyclopedia of Mineral Resources. Oxford: Pergamon Press.

[18]. Cooke, J. A., & Johnson, M. S. (2002). Ecological restoration of land with particular reference to the mining of metals and industrial minerals: A review of theory and practice. Environmental Reviews, 10(1), 41-71. doi:10.1139/a01-014

[19]. County Government of Kakamega : The Department of Finance, Economic Planning & Investments. (2018). Kakamega County Integrated Development Plan 2018-2022. Retrieved from County Government of Kakamega: https://kakamega.go.ke/download/county-integrated-development-plan-2018-2022/?wpdmdl=4552

[20]. Cremers, L., Kolen, J., & de Theije, M. (2013). Small-Scale Gold Mining in the Amazon:The Cases of Bolivia,Brazil,Colombia,Peru and Suriname. Amsterdam: CEDLA.

[21]. Ellis, H. (2003). Mining and Quarrying. State of the Environment Report.

[22]. Eshiwani, F. (2014, October). Effects of Quarrying Activities on the Environment in Nairobi County: A Case Study of Embakasi District. (Research Project, University of Nairobi). Nairobi: University of Nairobi.

[23]. Extractives Herb. (n.d.). Supporting good management of mining, oil and gas resources artisanal and small scale mining.

[24]. Finger , S. E., Church, S. E., & Holmes, C. W. (2007). Potential for successful ecological remediation, restoration, and monitoring .. In S. E. Church, P. von Guerard, & S. E. Finger, Integrated Investigations of Environmental Effects of Historical Mining in the Animas River Watershed, San Juan County, Colorado (p. 1065). Reston, Virginia:: U.S. Geological Survey.

[25]. Fritz, M., McQuilken, J., Collins , N., & Weldegiorgis, F. (2018). Global Trends in Artisanal and Small-Scale Mining: A Review of Key Numbers and Issues. Manitoba: The International Institute for Sustainable Development.

[26]. Funoh, K. N. (2014). The Impacts of Artisanal Gold Mining on local livelihoods and the environment in forested areas of Cameroon. Center for Internal Forestry Research.

[27]. Gitt, M. J., & Dollhopf, D. J. (1991). Coal waste reclamation using automated weathering to predict lime requirement. Journal Environmenal Quality, 20, 285-288.

[28]. Global Alliance on Health and Pollution (GAHP). (2014, November). Artisanal and Small-Scale Gold Mining and Mercury Contamination. Retrieved from Global Alliance on Health and Pollution: http://gahp.net/wp-content/uploads/2017/02/ASGM-and-mercury-contamination-Letterhead.pdf

[29]. Goudie, A. (1981). The Human Impact: Man's Role in Environmental Change. Oxford: Basil Blackwell Publisher Limited.

[30]. Gunson, A. J., & Jian, Y. (2001). Artisanal Mining in the People's Republic of China. International Institute for Environmental Development (IIED) and World Business Council for Sustainable Development (WBCSD).

[31]. Hanai, M. (2003). Formal and Garimpo Gold Mining and the environment in Brazil Mining and The Environment Case Studies from the Americas. Retrieved from http://www.idrc.ca/books/focus/828/chapter5.html

[32]. Hartman, H. L., & Mutmansky, J. M. (2002). Introductory Mining Engineering.2nd ed. New Jersey: John Wiley & Sons.

[33]. Hentschel, T., Hruschka, F., & Priester, M. (2003). Artisanal and Small-Scale Mining:Challenges and Opportunities. London: International Institute for Environment and Development and WBCSD. Retrieved from http://pubs.iied.org/pdfs/9268IIED.pdf

[34]. Hilson, G. (2002). A Contextual Review of the Ghanaian Small-Scale Mining Industry. London: International Institute for Environment and Development and WBCSD. Retrieved from http://pubs.iied.org/pdfs/G00722.pdf

[35]. Hore-Lacy, I. (2004). Uranium Mining ,Processing and enrichment. Encyclopedia of Energy, 6, 317-328.

[36]. Huddlestone, A. (2007). Geology of the Kakamega District. Geological Survey of Kenya.

[37]. Kathuri, N. J., & Pals, D. A. (1993). Introduction to Education Research. Njoro: Egerton University.

[38]. Kombo, D. K., & Tromp, D. L. (2006). Proposal and thesis writing: An introduction. Nairobi: Paulines Publications Africa, 814-30.

[39]. Koschmann, A. H., & Bergendahl, M. H. (1968). Principal Gold-Producing Districts of the United States.US Geological Survey. Geological Survey Professional Paper 610, 211, 253.

[40]. Kothari, C. R. (2004). Research Methodology. Methods and Techniques. New Delhi: New Age International Publishers.

[41]. KPMG Advisory Services Limited. (2016). Analysis of the Mining Act 2016. KPMG Advisory Services Limited.

[42]. Kundu, N. K., & Ghose, M. K. (1988). Status of soil quality in subsided areas caused by underground coal mining. Journal of Soil and Water conservation, 25(2), 110-113.

[43]. Lang, J. R., & Baker, T. (2001). Intrusion-related gold systems: the present level of understanding. Mineralium Deposita, 36(6), 477-489.

[44]. Levin-Nally, E. (2014, October 23). Global Trends in Artisanal and Small-Scale Mining: What do these Mean for Mongolia? Retrieved from Levin Sources: http://www.levinsources.com/blog/global-trends-in-artisanal-and-small-scale-mining-what-do-these-mean-for-mongolia

[45]. Machariah, L., Iteyo, C., & Simiyu, R. (2016). Nature of conflicts resulting from artisanal gold exploration in Ikolomani Subcounty, Kakamega County - Kenya. The International Journal of Social Sciences and Humanities invention, 3(7), 2457-2466.

[46]. Madejon, E., de Mora, A. P., Felipe, E., Burgos, P., & Cabrera, F. (2006). Soil amendments reduce trace element solubility in a contaminated soil and allow regrowth by natural vegetation. Environment pollution, 139, 40-52.

[47]. McCarthy, T., & Rubridge, B. (2005). The story of Earth and Life. Cape Town: Struik Publishers (Pty) Ltd .

[48]. Misra, K. K. (2002). Management of Land Use ,Landscape and Biodiversity, Towards a sustainable Cement Industry. Battelle.

[49]. Muchira, J. (2018, November 12). Kenya to ban use of mercury in gold mines. Retrieved from The East African: https://www.theeastafrican.co.ke/business/Kenya-to-ban-use-of-mercury-in-gold-mines/2560-4845754-10fe3l8z/index.html

[50]. Mudd, G. M., Weng, Z., Memary, R., Northey, S. A., Giurco, D., Mohr, S., & Marson, L. (2012). Future greenhouse gas emissions from copper mining: Assessing clean energy scenarios.

[51]. Mugenda, O. M., & Mugenda, A. G. (2003). Research Methods: Quantitative and Qualitative Approaches. Nairobi: Acts Press.

[52]. Mwangi, S. N. (2014, May). An Assessment of Environmental Impacts of Quarrying Activities in Ndarugo Area, Kiambu. Research Project, Kenyatta University. Nairobi: Kenyatta University.

[53]. Nartey, V. K., Nanor, J. N., & Klake, R. K. (2012). Effects of quarrying activities on some selected communities in the lower Manya Krobo district of the Eastern region of Ghana. Atmospheric and Climate Sciences, 2, 362-372.

[54]. Neingo, P. N., & Tholana, T. (2016). Trends in Productivity in the South African gold mining industry. Journal of the Southern African Institute of Mining and Metallurgy, 116(3), 283 - 290.

[55]. Norgate, T., & Haque, N. (2010). Energy and greenhouse gas impacts of mining and mineral processing operations. Journal of Cleaner Production, 18(3), 266-274.

[56]. Norman, N., & Whitfield, G. (2006). Geological journeys. Cape Town: Struik Publishers (Pty) Ltd.

[57]. Ochieng, G., Kiaka, R., & Kecha, A. (2017). Women pay the cost of mercury pollution in ASGM in Migori,Kenya. Women &Environment(98/99), 34 - 37.

[58]. Odanga, I., & Kamau, M. (2017, March 01). Hopes High for Kakamega Peasants who have been Sitting on a Gold Mine Literally. Retrieved from Standard Digital: https://www.standardmedia.co.ke/article/2001231068/hopes-high-for-kakamega-peasants-who-have-been-sitting-on-a-gold-mine-literally

[59]. Ogola, J. S., Mitullah, W. V., & Omula, M. A. (2002). Impact of Gold mining on the environment and human health. Environmental Geochemistry and Health, 24, 141 - 158.

[60]. Ogola, J. S., Mitullah, W. V., & Omulo, M. A. (2002, June). Impact of Gold mining on the environment and Human Health: A Case Study in the Migori Gold Belt ,Kenya. Environmental Geochemistry and Health, 24(2), 141-157.

[61]. Olaide, M. (2016, January 15). What's left in the wake of South Africa's abandoned gold mines. Retrieved from Greenbiz: https://www.greenbiz.com/article/whats-left-wake-south-africas-abandoned-gold-mines
[62]. Organization, U. N. (2006). Manual for training artisanal and small-scale Gold miners. Vienna,Austria: UNIDO.
[63]. Ramkat, R. (2017). Restoration Strategies and Community Attitudes Towards Mine Pit Hazards In Kakamega County, Kenya. A Masters Thesis Masinde Muliro University. Kakamega: Masinde Muliro University. Retrieved from http://ir-library.mmust.ac.ke
[64]. Republic Of Kenya. (1999). The Environmental Management and Coordination Act, No.8 of 1999. Nairobi: Government Printer.
[65]. Republic Of Kenya. (2009). Kenya Population and Housing Census Report 2009. Nairobi: Government Printer.
[66]. Republic Of Kenya. (2010). The Constitution of Kenya, 2010. Retrieved from Kenya Law: http://kenyalaw.org/kl/index.php?id=398
[67]. Republic Of Kenya. (2016). The Mining Act of Kenya 2016. Nairobi: Government Printer.
[68]. Republic Of Kenya. (2017). Sessional paper No.1 0f 2017 on National land use policy. Nairobi: Government Printer.
[69]. Republic Of Kenya Ministry of Mining. (2016). Mining and Minerals Policy.Sessional Ppaer No. 7 of 2016. Republic Of Kenya Ministry of Mining.
[70]. Ripley, E. A., Redman, R. E., & Crowder, A. A. (1996). Environmental Effects of Mining. Delray Beach Florida: St. Lucie Press.
[71]. Ruttinger, L., & Sharma, V. (n.d.). Climate change: A foreign policy perspective.
[72]. Sanders, D. W. (n.d.). Slippong land: Soil erosion problems and soil conservationr requirements. Rome: Land and Water Development Division. Food And Agriculture Organization FAO.
[73]. Sheoran, V., Sheoran, A. S., & Poonia, P. (2010). Soil reclamation of abandoned mine lang by revegetation: A review. Internal Journal of Soil Sediment and Water, 3(2).
[74]. Shilaro, P. M. (2000). A Failed Eldorado: British Trusteeship, Luhyia Land Rights and the Kakamega Gold Rush,. Dissertation Submitted to the College of Arts and Sciences at West Virginia University. West Virginia: West Virginia University.
[75]. Siachoono, S. M. (2010). Land reclamation efforts in Haller Park, Mombasa. International Journal of Biodiversity and Conservation, 2(2), 19 - 25.
[76]. Sieber , N. L., & Brain, J. (2014). Health Impact of Artisanal Gold Mining In Latin America:A Mining Boom Brings Risk From Mercury Contamination. Revista: Harvard Review of Latin America, pp. 66-69.
[77]. Siegel, S., & Veiga, M. M. (2009). Artisanal and Small-Scale Mining as an Extralegal Economy: De Soto and the redefinition of ``formalization. Resources Policy, 34(1-2), 51-56.
[78]. Spiegal, S. J., Agrawal, S., Mikha, D., Vitammery, K., Le Billion, P., Veiga, M., & Paul, B. (2018). Phasing out mercury?Ecological economics and Indonesia's small-scale gold mining sector. Ecological economics, 144,1-11.
[79]. Stähr, F., & Schütte, P. (2016). Responsible Gold Sourcing from Artisanal and Small-Scale Mining: Scoping Study on Developing Pilot Supply Chains. Hannover: Bundesanstalt für Geowissenschaften und Rohstoffe.
[80]. U. S. Department of Agriculture, Natural Resources Conservation Service. (2001). Glossary of Terminology commonly used in Mining and Reclamation Technology. Tucson, Arizona: NRCS, Tucson Plant Materials Center.
[81]. U.S. Geological Survey, U.S. Department of the Interior. (2017). Mineral Commodity Summaries 2017. Washington: U .S. G eological Survey.
[82]. Uglow, D. (1999). Mitigating the environmental Impacts of Artisanal Qarrying. Consideration of awareness and incentives. Mining and environment research network.
[83]. UNDP SEA for the Mining Sector in Kenya. (2017). Strategic Environmental Assessment (SEA) for the Mining Sector in Kenya. Nairobi: UNDP SEA for the Mining Sector in Kenya.
[84]. United Nations Environment Programme (UNEP). (2017). Building capacity for environmental sustainability in artisanal and small scale mining in Africa.
[85]. United Nations Industrial Development Organization. (2006). Manual for training artisanal and small-scale Gold miners. Vienna, Austria: UNIDO.
[86]. Veiga, M. M., Nunes, D., Klein, B., Shandro, J. A., Velasquez, C., & Sousa, R. N. (2009). Mill Leaching: A Viable Substitute for Mercury Amalgamation in the Artisanal Gold Mining Sector? Journal of Cleaner Production, 17(15), 1373-1381.
[87]. Von Bertalanffy, L. (1968). General System Theory.Foundations,Development,Applications. New York: George Braziller.
[88]. Waugh, D. (2002). Geography: An Integrated Approach. Cheltenham: Nelson Thorne Publishers.

[89]. WNA (World Nuclear Association). (2017, October). In Situ Leach (ISL) Mining of Uranium. Retrieved from World Nuclear Association: http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/in-situ-leach-mining-of-uranium.aspx
[90]. World Health Organization . (2017, March 31). Mercury and Health. Fact Sheet. Retrieved from World Health Organization : www.who.int/mediacentre/factsheets/fs361/en
[91]. World Wide Fund for Nature. (2008). Principles of Environmental Systems. World Wide Fund for Nature.
[92]. WWF. (2008). Principles of Environmental Systems. WWF.
[93]. Yager, T. R., Bermúdez-Lugo, O., Mobbs, P. M., Newman, H. R., & Wilburn, D. R. (2005). The Mineral Industries Of Africa. U.S. Geological Survey Minerals Yearbook, 1.1 - 1.24.
[94]. Yeboah , J. Y. (2008, August). Environmental and Health Impact of Mining on Surrounding Communities: A Case Study of AngloGold Ashanti in Obuasi. A Thesis submitted to the Department of Geography and Rural Development, Kwame Nkrumah University of Science and Technology. Kumasi: Kwame Nkrumah University of Science and Technology.

Alwang'a R. "Gold Mining Industry and Its Implications on the Environmentin Kakamega South Sub-County, Kakamega County, Kenya." *IOSR Journal of Humanities and Social Science (IOSR-JHSS)*, 25(9), 2020, pp. 47-61.