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Research Article

Inhabitant Perception on the Effects of Artisan Mining on Rangelands in Gedarif State (Eastern Sudan)

Muna Mahjoub Mohamed Ahmed[1, *], **Nahla Shareef Tambel**[2]

[1]Institute of Environmental Studies, University of Khartoum, Khartoum, Sudan
[2]Ministry of Animal Wealth and Rangeland, Department of Technology Transfer and Extension, Khartoum, Sudan

Abstract

The present study was initiated with the objective to learn about people's (including herders, farmers, miners) perception on the effect of artisan mining on rangelands vegetation cover and soil contamination. The area of study covered AlSada village located at the northern part of Gadarif state. Three sites were selected according to mining activities, and rated as high, medium and low activities. These were one with extensive mining activity (site 1), with medium activity (site 2) and one without activity selected as reference site (site 3) with minimum or low mining activities. Satellite images were taken for the area under study before and after mining activities (2008 – 2013) to confirm vegetation and wetland changes due to artisan mining activities. Animal herders, farmers and miners at AlSada village were addressed with a semi-open questionnaire.. The results showed a decrease in vegetation cover and wetland areas amounted to 397.64907 km and 3.614427 km for the vegetation cover and wetlands respectively. Field visits revealed the deterioration rangelands and loss of animals' live. Rangeland condition was excellent before mining than after mining as expressed by most (~70%) of the respondents. Rangeland condition was rated as poor after mining by ~49%. This was confirmed by herders, farmers and miners although herders and farmers showed higher percentages in expressing the negative effect of mining on rangelands. Most (~78%) agreed that pasture deteriorated as indicated by the appearance of undesirable plant species. Rangelands were affected by problems of land tenure, expansion of agriculture that affected migratory routs and conflicts as expressed by most of the respondents (~87%). Most complaint about inadequate and contaminated water (77%), conflicts with gold investors (~95%), and non-state sponsors (82%). Most (~64%) feed their animals on natural pasture and crop residue (~70%) but not (77%) on concentrate, or pasture outside the area (~71%). Drilling caused by mining activities could be felt by most of the respondents (~96%) leading to the disappearance of unpalatable range species. Pasture' contamination with mercury and its poising effect were expressed by most of the respondents (~85%). Most (~73%) disagree that mining as excellent alternative to pastoralists, or add burden to the area (~54%) or improve development to the area (~72%). Herders seek veterinary assistance (~88%), or move to other areas with better pasture (~72%). Many (~98%) would turn to sell part or all their animals.

Keywords

Inhabitants' Perception, Artisan Mining, Rangeland

[*]Corresponding author: munamm789@yahoo.com (Muna Mahjoub Mohamed Ahmed)

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1. Introduction

Butana area is a vast area lying between the Blue and the White Nile, it provides a good pasture lands for livestock coming from 7 states concentrating in this are during the rainy season. Recently, droughts have been exacerbated by the introduction of rain fed agriculture and operations of gold exploration and climate change leading to high pastoral load after the concentration of animals in specific areas, known as the only excavator in the east and central region of Sudan, the lack of pastoral land in the central and southern areas compared to agricultural land 6.3%, plays a large role in some of the harassment suffered by herders and animals, where they stay for 9 months without finding enough feeding, this is forcing them to enter the forbidden areas such as the Dindar barn, Ethiopian lands and agricultural projects. The policies of the barn are a great concern of the shepherds, take 50% of the grazing area (Murah) if the barn is attacked [1].

Mining started in Butana area in February 2010 and as random mining and these is practiced by individuals and use the mercury in the extraction of gold and also practiced by companies and it has a negative impact on the agriculture and pastoral sectors. Traditional mining areas have attracted many pastoralists and farmers. 16 mining companies exist in the area encroaching into the natural pasture.

In recent years, Sudan has witnessed a wide range of gold-mining operations by artisan miners in many states in the country. As of 2016 about 2 million people from all parts of the country participated in gold mining activities. Despite the rising importance of gold mining in the national economy, the gold industry in general seems improperly managed as artisan gold mining in the country takes place on geographically extensive territories, while the government administrative bodies have often insufficient resources to monitor the mining activities. Generally mining is considered an unfriendly human activity in relation to the environment. It causes destruction of the natural landscape, pollution of surface and subsurface waters, air and soil. Vast areas of rangelands were shifted to several investment activities such as mining in Butana area and other states. In addition to reduction of land area, spreads of drain waters resulting from these activities and that are highly contaminated may affect plants and causing death to livestock in some cases. Popular wide scale gold mining is widely spread. Devastating mining practices have led to deforestation and loss of some indigenous species. Traditional miners just look for gold anywhere. It is worth mentioning that all the operations in these areas are outside the framework of the Mineral Resources Development [7].

2. Materials and Methods

2.1. Study Area

Study area: Gadarif State is located in the eastern part of the Sudan. It lies between longitudes 33-36oE and latitudes 14-16oN with an area of approximately 78,000 km2. According to 1993 population census data, about one million inhabitants live in Gadarif State. About 90% population of Gadarif are farmer. The average population density was estimated at 10 people per square kilometer. Based on rainfall amount and main agricultural characteristics the area is divided into three main agro-ecological zones. The southern zone with highest rainfall ranging from 600 to 900 mm, the central zone with medium rainfall about 500-600 mm, and northern zone with very little rain fall <500 mm. The Gadarif produces 17 and 30% of total sesame and sorghum production in Sudan, respectively, with significant impact on the food security of the country.

The area under study is located in the northern western part of the state known as Al-Sadda. Population is estimated at more than 5000 distributed over four villages and about 650 House Hold (HH) (8 person / HH). most of the population are involved in agriculture and animal herding. A questionnaire was conducted to learn about villagers' perception of artisan gold mining in the area.

2.2. Data Collection

2.2.1. Primary Data

Questionnaire

Questionnaires were designed for both key informants and households in the villages of Al-Sadda. The population size estimated according to Stephen Thompson's equation which is the most popular formulas for calculating the minimum size of a study sample from a study community.

Where:

Sample size in (4) villages = 5200

The number of households (HH) in (4) villages = 650

The sample size selected = 383

Key informants questionnaire addressed government, administrators and mining companies to learn about their opinion of the impacts artisan mining on land contamination, rangelands and livestock productions.

The questionnaire designed for pastoralists, farmers and miner was learn about perception of the effects of mining on rangeland degradation, livestock suffering from range shortage and pollution hazards due to irrational mining activities. A total of 383 respondent participated on this questionnaire from the village of Al-Sadda.

Field visits and direct observations

Field visits and direct observations were conducted through visiting the area under study taking photographs documenting degraded rangelands dead animals and miners

while involved in mining activities and also accumulating heaps of mine tailing.

2.2.2. Secondary Data

The secondary data covered (a) Government documents and records in the relevant departments, (b) Written reports, thesis, pamphlets, papers, articles, photos and maps, aerial photography and cartographic material.

2.3.3. Data Analysis

Chi square analysis was used to determine the Pearson correlation to measure the strength of a linear relationship among the different parameters under study (IPM SPSS 25 package).

The study was based on the data information deduced from remote sensed Landsat multispectral (MSS) images, American land sat satellite for the images. Satellite imagery and aerial photographs were used as tools to analyze vegetation changes for the periods (2008 – 2013). The data were treated on the computer programs, to compare the changes that have occurred in the region in the year (2013). Also satellite photographs were obtained to see changing and the deterioration in the vegetation of the region due to mining activities.

3. Results

3.1. Satellite Images

Remote Sensing data was using on detection of changes in vegetation cover in study area due to mining activities for the years 2008-2013 showed decrease in vegetation cover. It was shown that in the year 2008 vegetation cover was about 1170.04 km^2 and wetland 729.93 km^2 interspersed with sand 395.15 km^2 and bare land 3823.98 km^2 (Figure 1), this was compared with the measurements obtained in the year 2013 due to mining activities. It was shown that 1019.78 km^2 is made up of rocks, while land use due to mechanized and semi mechanized farming covered 858.88 km^2. Bare land was 3838.52 km^2 which was considered to affect vegetation cover and wet land which were shown to be scattered among few areas with smaller proportions at 397.64 km^2 and 3.614 km^2 respectively (Figure 2).

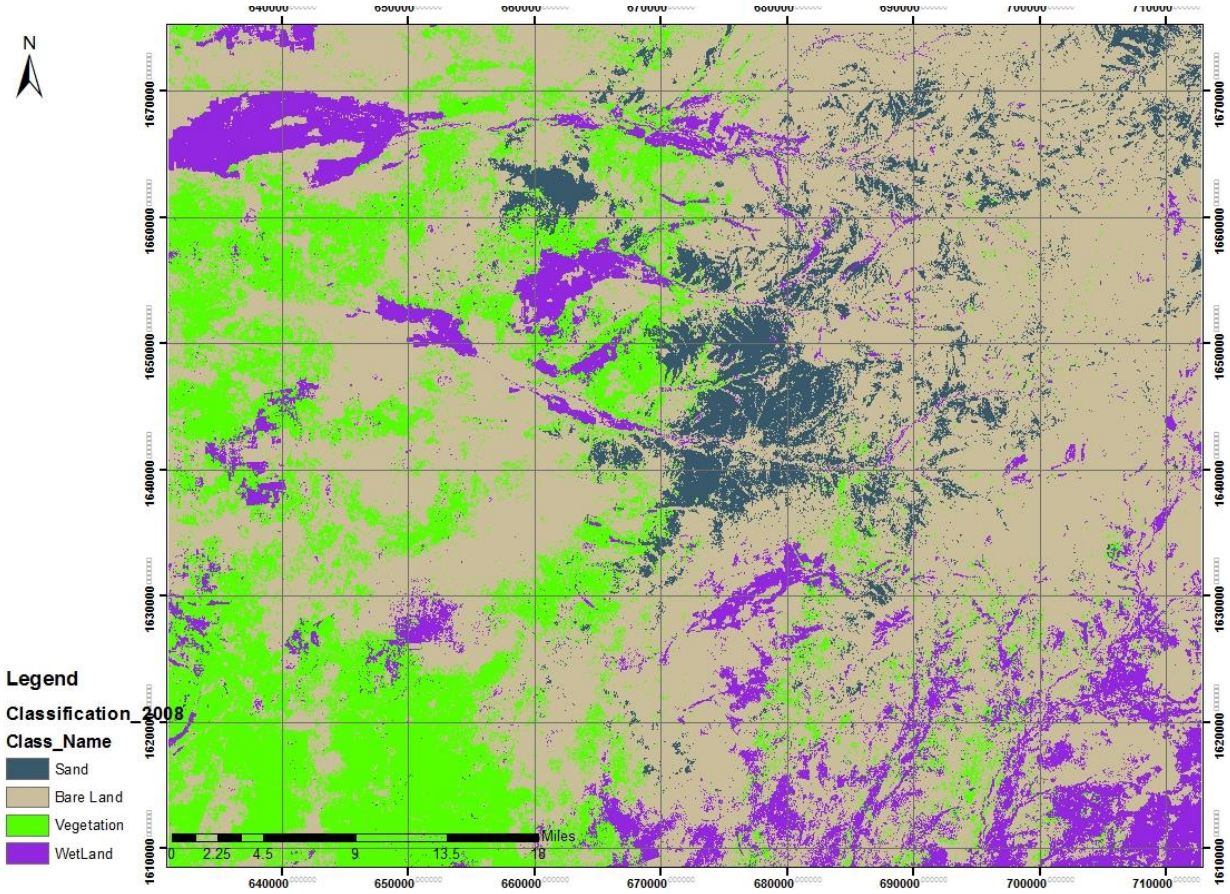
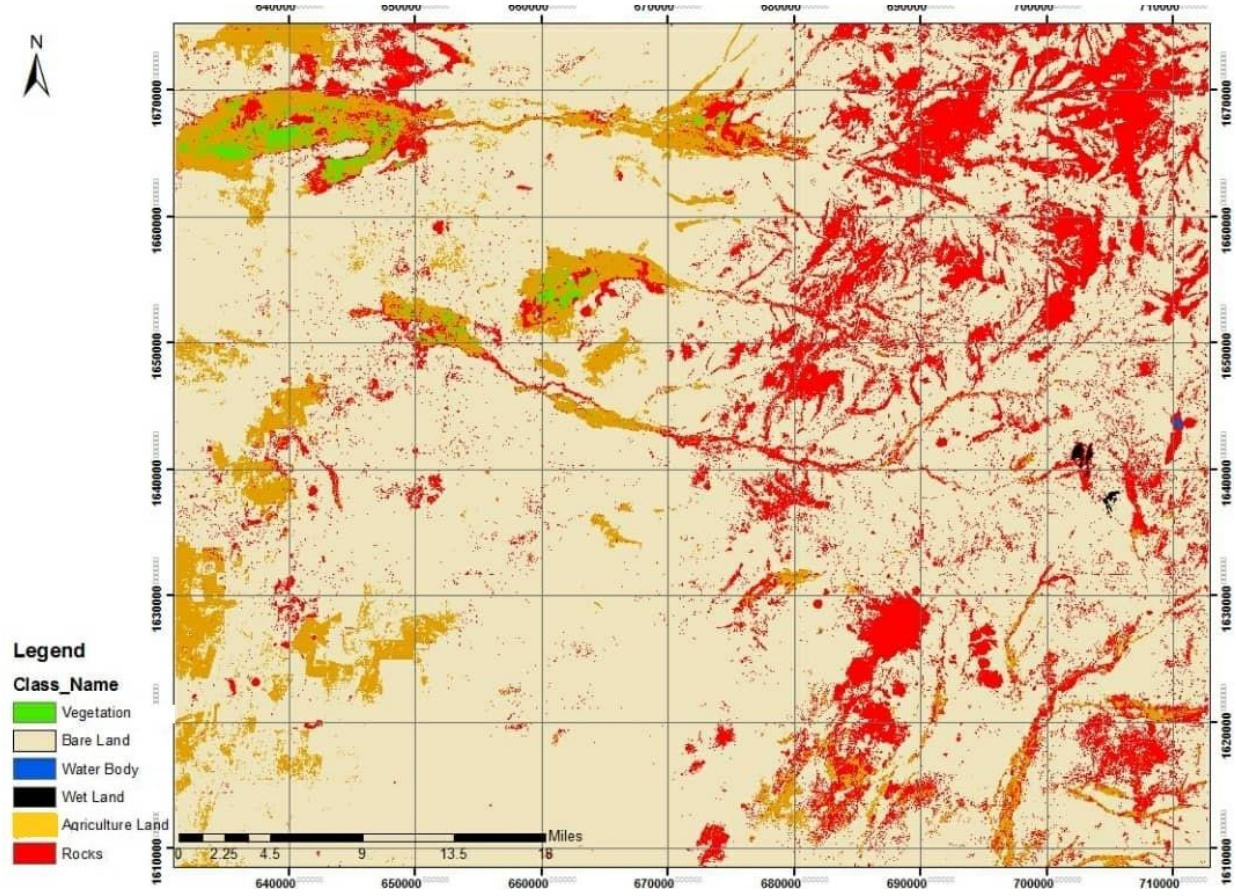


Figure 1. *Changes in vegetation cover, wet and bare lands for the area under study in 2008.*



Source: http:// earthexplorer.usgs.gov

Figure 2. *Changes in vegetation cover, wet and bare lands for the area under study in 3013.*

3.2. Field Visits and Observations

Field visits and close observation as focused in mining activities showed that showed land the clear desertification around villages (Figure 3), rangelands' degradation (Figure 4), grazing land pasture scarcity (Figure 5) and animal death either due to range shortage or poisoning due to mining activities (Figure 6).

3.2.1. Key Informants Visits

Key informants included both Sudanese Mineral Resources Company (SMRC) and administrate. SMRC pointed to hazards of artisan gold mining in the area due to the pollution of cyanide and mercury that could affect the soil, water and air, this could be exacerbated as more mining areas are explored. They expressed the strong measures that should be put in place for environment protection. The administrative added that people working in gold mining should stick to the personal protection measures to reduce or exposure to pollution hazards.

Figure 3. *Al-Sadda village suffering from desertification.*

Figure 4. Rangeland deterioration.

Figure 5. Animal grazing deteriorating rangelands.

Figure 6. Animals' deaths caused by range shortage or range poisoning.

3.3. Respondents' Response

3.3.1. Rangeland Status/Animal Production

Rangeland condition was excellent before mining than after mining as expressed by most (~70%) of the respondents, rated as good by ~29%. Rangeland condition was rated as poor after mining by ~49% (Table 1). This was confirmed by herders, farmers and miners although herders and farmers showed higher percentages in expressing the negative effect of mining on rangelands. Statistical significance ($p<0.00$) was detected between respondents' opinion in rating rangeland conditions as excellent before mining as after mining (chi-square test Table 2). Drilling caused by mining activities could be felt by most of the respondents (~96%), although most (~78%) agreed that pasture area was deteriorated as indicated by the appearance of undesirable plant species and so they have to purchase crop residue and concentrates as animal feed. Rangelands were affected by problems of land tenure, expansion of agriculture that affected migratory routs and conflicts as expressed by most of the respondents (~87%). Their animals were affected by poor veterinary care and diseases (~75%) as well as insecurity of animals' theft and looting (~72%). Most complaint about inadequate and contaminated water (77%), conflicts with gold investors (~95%), and non-state sponsors (82%) (Table 3).

Deterioration of rangelands condition had led to the disappearance of unpalatable range species; these were 2 types with frequencies of 207 and percentage ~54%, 4 type with 151 frequencies, and percentage ~39%, 5 types with 6 frequencies and 1.6%, and 7 types with 19 frequencies and 4.9%. After mining frequencies had decreased, for type 1 frequencies were13 and 3.3%, for 2 types frequencies of 295 frequencies and 77%, for 3 types, frequencies 69 with 18% and for 4 types frequencies were 6 with 1.6% (Table 4).

As far for animal feed resources, most (~64%) of the respondents agree that they feed their animals on natural pasture but most (77%) disagreed to feed their animals on concentrate, most (~70%) agree to feed their animals on crop residues of rain fed agriculture and most (~71%) disagree to feed their animals on pasture outside the area of study (Table 5).

Table 1. Respondents' opinion on the effect of mining on rangelands' condition.

Pasture status		Excellent	Good	Not bad	Poor
before mining	N*	270	113	00	00
	%	70.5%	29.5%	0.0%	0.0%

Pasture status		Excellent	Good	Not bad	Poor
after mining	N	00	7	188	188
	%	0.0%	1.6%	49.2%	49.2%

N*= Number of respondents

Table 2. Chi-square test results for respondents' perception on changes in rangelands' condition.

Phrases	Chi-square value	df	Sig.	Median	Opinion
Pasture status before mining	10.246	1	0.00	4.00	Excellent
Pasture status after mining	27.574	2	0.00	2.00	Not bad

Table 3. Respondents' opinion on the effect of mining activities on some aspects.

Items		Agree	Disagree
Drilling caused by mining activities	N	370	13
	%	96.7%	3.3%
Narrow pasture and undesirable plants, lack of fodder, high price of crop residues and concentrate and lack of pasture rehabilitation	N	82	301
	%	21.3%	78.7%
Lack of tenure, expansion of agriculture, pasture path and conflict between farmers and pastoralists	N	333	50
	%	86.9%	13.1%
Inadequate and contaminated drinking water	N	295	8
	%	77%	23%
Poor veterinary care and animal diseases	N	289	94
	%	75.4%	24.6%
Theft, looting and insecurity	N	276	107
	%	72.1%	27.9%
Conflict with gold investors outside the state	N	364	19
	%	95.1%	4.9%
Conflict with non-state sponsors	N	314	69
	%	82%	18%

Table 4. Respondent' opinion about changes in some plants species frequencies and percentages before and after mining.

Items	Before mining		After mining		
Number of plant types ↓	Frequencies	Percentage	Number of plant types	Frequencies	Percentage
3 types	207	54.1%	1 type	13	3.3%
4 types	151	39.3%	2 types	295	77%
5 types	6	1.6%	3 types	69	18%

Items	Before mining		After mining		
Number of plant types ↓	Frequencies	Percentage	Number of plant types	Frequencies	Percentage
7 types	19	4.9%	4 types	6	1.6%
Total	383	100.0%	Total	383	100.0%

Table 5. Animal feed resources in area of Study.

Items		Disagree	Agree	Don't know
Animal feeding depends on natural pastures	N	113	245	25
	%	29.5%	63.9%	6.6%
Animal feed depends on concentrated feed	N	295	63	25
	%	77%	16.4%	6.6%
Animal feed depends on the residues of rain-fed agriculture	N	69	289	25
	%	18%	75.4%	6.6%
Animal feeding depends on natural pastures outside the state	N	270	88	25
	%	70.5%	23%	6.6%

3.3.2. Risk Effects Arising from Mining Activities

Risk effects of mining activities on pasture status and risk on animal lives are shown by Table 6. It was shown that most of the participants agreed (~85%), but most disagreed about the appearance of new symptoms or return of symptoms of diseases that had disappeared (~92%) and also the appearance of rashes and osteoporosis (~87%) as well as fracture of legs due to falling in mining pits (~88%). Also nearly 60% disagreed about animal death. Risks to human health was due to chemical use and mining residue pollutants agreed by ~70%, however, most (~88%) disagree risks due to food or water contamination and most (~90%) disagree environmental risks due to forest fires. Most (~95%) also disagree the negative impact of exposure to high temperature or lack of primary health (~68%) or collapse of mining pits (~80%) (Table 7).

The economic effect of mining was looked upon not as a good additional source of income was by 41%, also most (~73%) disagree that mining as excellent alternative to pastoralists, or add burden to the area (~54%) or improve development to the area (~72%). on the other hand many (~63%) agreed the negative impact of mining activity on pastoralism (Table 8).

Herders would seek means in order to improve their animal production which could be look for veterinary assistance (~88%), move to other areas with better pasture (~72%), or send their animals attended by shepherd (~77%), almost all would turn to private sector to treat animals' illness, almost all would demand compensation from gold mine owners or claim compensation from the government. Many (~98%) would turn to sell part or all their animals (Table 9).

Table 6. Respondents' opinion about the risk effects of mining on pasture status and animal lives.

Items		Disagree	Agree
Pasture contamination with mercury and its poisoning	N	57	326
	%	14.8%	85.2%
The appearance of new symptoms of diseases on the animal or the return of diseases that have disappeared	N	352	31
	%	91.8%	8.2%
The appearance of blisters or rashes on the animal and animal osteoporosis	N	333	50
	%	86.9%	13.1%

Items		Disagree	Agree
Fracture animal legs or death of as a result of falling into mining pits	N	339	44
	%	88.5%	11.5%
Animal death due to mining activity	N	226	157
	%	59%	41%

Table 7. Respondent' opinion about risk mining activity to human health.

Items		Disagree	Agree
Exposure to heavy metals, chemical and mining residues pollutants	N	113	270
	%	29.5%	70.5%
Contamination of food and water	N	339	44
	%	88.5%	11.5%
environmental risks due to forest burning	N	345	38
	%	90.2%	9.8%
Exposure to high temperatures	N	364	19
	%	95.1%	4.9%
Lack of primary health care services	N	264	119
	%	68.9%	31.1%
collapse of mining pits	N	308	75
	%	80.3%	19.7%

Table 8. Respondent' opinion economic effects of mining.

Items		Disagree	Agree	Don't Know
Good additional income source	N	157	126	100
	%	41%	32.8%	26.2%
An excellent alternative to pastoralism	N	283	0	100
	%	73.8%	0.0%	26.2%
Add a burden to the area	N	207	78	100
	%	54.1%	19.7%	26.2%
Worked on the development of the region	N	277	6	100
	%	72.1%	1.6%	26.2%
Negatively impacted on pastoralism	N	44	245	94
	%	11.5%	63.9%	24.6%

Table 9. Respondent' response to avoid the effects of mining on their animals.

Items		Disagree	Agree
Go to the veterinary service site	N	339	44
	%	88.5%	11.5%
Move to another area with better pasture within the state	N	276	107
	%	72.1%	27.9%
move to another area outside the state where there is a better pasture	N	188	195
	%	49.2%	50.8%
Send the herd with a shepherd to another area and turn to another job	N	295	88
	%	77%	23%
Turn to the private sector to treat the animal in case of illness	N	383	0
	%	100%	0.0%
Turn to the gold mine owners to claim compensation.	N	383	0
	%	100%	0.0%
Turn to the local government or state to claim compensation	N	383	0
	%	100%	0.0%
Selling part or all animals	N	377	6
	%	98.4%	1.6%

4. Discussion

4.1. Impact on Vegetation Cover

In this study deterioration of rangelands were confirmed by Remote Sensing data where the maps showed a decrease in land cover vegetation cover and wet land decreases calculated as 772.391536 km and 726.324499 for vegetation and wet land respectively which could be related to the wide spread activity of artisan mining. Similarly, it was found that mining activities are known for causing reductions in the grassland. The severe disturbance caused by mining disrupts the original morphology and stratum structure of open-pit mines, and hence biotic communities therein, particularly the local vegetation cover. Most of the respondents agreed that rangeland conditions were excellent before mining than after mining due to drilling activities, however, most also related rangelands degradation to various other factors as land tenure problems and expansion of agriculture leading to conflicts and change in the migration routes. Most of respondents agreed of the appearance unpalatable species and disappearance of palatable ones. Similarly it has been pointed out that recently, droughts in Butana region have been exacerbated by the introduction of rain fed agriculture and operations gold exploration and climate change led to higher pastoral load after the concentration of animals in specific areas, knowing that they come from seven different states as the only excavator in the east and central region of Sudan, the lack of pastoral land in the central and southern areas compared to agricultural land 6.3%, plays a large role in some of the harassment suffered by herders and animals, where they stay for 9 months without finding enough feeding, this forced them to enter the forbidden areas such as the Dindar barn, Ethiopian lands and agricultural projects [1]. Furthermore in this study pastoralists as forced to change migration routes suffered from new animal diseases due poisoning animals' theft and looting.

A study carried out to assess the impact of small-scale mining on land in the western part of Ghana revealed that mining removed vegetation and topsoil, and resulted in loss of farm land permanently. They further reported that surface mining alone accounted for about 58% of the region's deforestation, 45% loss of farmland (within mining concessions) and pervasive spillover effects often resulting from expansion of mining activities into reserved forests [2, 11]. In addition gold mining was shown to alter microbial communities, resulting in low soil fertility and productivity [6]. Similarly, it was shown that in western Australia that, areas occupied by mine workings are difficult to rehabilitate and pastures are lost permanently where livestock are regularly disturbed therefore they are temporarily lost as a pasture resource as long as mining activity continues [8].

4.2. Impact on Economic Aspects

Artisan and Small-Scale Mining (CASM) initiative elaborates on the economic and social effects of artisan and small-scale mining work as "… largely a poverty driven activity, typically practiced in the poorest and most remote rural areas of a country by a largely itinerant, poorly educated populace with little other employment alternatives" [13]. These characteristics illustrate the cycle of poverty that can exist in artisan and small-scale mining communities, particularly where inefficient mining and processing techniques yield a small quantity of product and low profit [3]. Further compounding this cycle are the health and environmental hazards associated with this type of work.

Traditional gold mining in Sudan absorbs about 5 million miners and other workers of accompanying jobs, while those affected by this activity are estimated at 11 million people. There are two types of workers, those who work individually and those who work under the umbrella of an investor, group of investors, or companies [11]. Artisan and small-scale gold mining activities are frequently linked to extensive environmental degradation and conditions of extreme poverty. Artisan and small-scale gold mining is largely a poverty-driven activity that constitutes an important source of livelihood for many rural communities [5]. A similar situation is reported in India indicating low earning of small-scale operations. However, in this study most of the respondents did not see that gold mining in area would improve the economic development, they expressed that they would not change their lifestyle and join in gold mining investment. They complaint that their income had been adversely affected by rangeland decrease due mining, they have to purchase crop residues and concentrates to feed their animals. They also suffered from animals' losses due to diseases from poisoning or animal wastes due to accidental fall of animals in pits excavated for gold exploration. Similarly, it was shown that it was that animals can be poisoned directly by mine products and residuals [4]. It was also stated by [9] that the removal of vegetation through mining can compromise animals' ability to survive.

It could be concluded that mining activities have social, economical and environmental impacts on pastures and animals' food scarcity and health. Environmental legislation should be enforced for natural resource protection and to prevent, air, water and soil pollution.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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