



Review

Impacts of Mining on the Environment in West African Sahel: A Review

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Abstract: Mining activities have led to the depletion of over 577.15 km² of forest area in the West African Sahel zone. These have destroyed the habitats of mammals, including elephants and giraffes, as well as economic trees and grass species, and polluted ground and surface water. In addition, mining activities are responsible for degrading more than 1,000 acres of farmland. Even though mining is destroying the environment, it has accounted for exports of €211,468,13, €247,034,485 and €275,720,817 in Burkina Faso, Niger, and Mali, respectively, between 2014 and 2015. It is also a lever of sustainable environmental management, as in Senegal, by providing mining social funds for mining communities and employing over 450,000 people in Niger. Furthermore, mining companies promote land restoration activities in the West African Sahel, such as China National Petroleum Corporation (CNPC) promoting tree plantations in Niger. Nevertheless, the mining in the region will continue to serve as the breeding ground for criminal gangs and terrorist groups unless a radical approach stabilises the insecurity. The degradation of farmlands and forest reserves or protected areas requires re-evaluation and full enforcement of the existing laws and regulations to achieve sustainable mining for the needed development in the West African Sahel region.

Keywords: sustainable mining, biodiversity loss, environment, West African Sahel

1. Introduction

Globally, nations' wealth and economic growth potentials are significantly derived from natural resources [1]. The contributions of natural resources to the economies of developing countries are enormous, ranging from sources of employment to revenue generation. Specifically, mineral extraction is booming but can cause irreversible environmental damage. Mining operations have consequential ecological impacts since they are a destructive industry [2]. Gold mining in over 70 countries using mercury is a global pollution issue, with more than 10 to 19 million people involved in small-scale artisanal mining [3]. It has posed serious health, security, social, economic, and environmental challenges [4]. The ecological consequences emanating from mining have significant implications for animals and their biodiversity. About 44% of the extensive mineral mines in Africa are in reserved areas or a distance of 10 km, compared to 25% in Asia and South America [5, 6]. Past conflicts and civil disturbances in accessing mineral resources are evident in Angola, Liberia, and Sierra Leone [6], as reflected by the government's inadequate capacity to implement mining-development control effectively. In West Africa, large-scale and small-scale mining impacts on the environment vary [7]. The authors

further revealed that the vegetation in the ecosystem, water, landscape, and soil, among other environmental resources, are depleted due to illegal mining (called *galamsey* in Ghana). Surface erosion, water pollution, farmland depletion, public health, soil erosion, and rapid deforestation are challenges associated with mining due to the high requirements of human labour and tract [8]. In the central Sahel (Mali, Niger, Burkina Faso and Chad), the preferential government allocation of mining permits has been described as opaque [9]. Although mining reforms in Nigeria in the form of privatisation yielded positive results, accruing revenue of N400 billion in 11 years (from 2007 to 2018) with over 1,424 licences issued as of 2017, sustainable development for communities is still lacking [10]. The West African Sahel is endowed with vast mineral potential. Some researchers examining the weaknesses of mining laws raise questions about environmental management and protection and the inadequate power of mining-affected districts in the region to sanction defaulters. The environmental consequences deteriorate if these illegalities are not controlled and sustainable practices are not enforced. Hence, the protection of the environment and best mining practices are required. Despite the vast mineral deposits and mining quantum in the Sahel zone of West Africa, there is a scarcity of information on the mining impacts on the environment in the region. Several studies have been conducted on environmental risks emanating from mining operations, but only a few have researched their impacts on the environment in the context of the West African Sahel. Despite that, there have been records of illegal mining activities in the region, negatively affecting the environment's health. This paper, however, reviewed literature on the impacts of mining on the environment in nine countries such as Burkina Faso, The Gambia, Guinea, Guinea Bissau, Mali, Mauritania, Niger, Nigeria, and Senegal in the Sahel zone of West Africa. This review seeks to close the gaps in information scarcity about the impacts of mining on the environment by considering the economic, social and ecological aspects and their interactions. In addition, best mining practices could be implemented to ensure sustainable environmental management and sustainability.

1.1 Impacts of mining on human health

From this review, it appears that the environment involves economic, social, and ecological interactions with man for its survival. The environment is home to living organisms, including humans. The abode of living organisms is influenced by man's positive and negative mining activities in the quest for wealth and the development of economies. For instance, the outbreaks of lead poisoning from the mine in the 2010 tragedy in northwestern Zamfara State, Nigeria, killed about 400 children and affected thousands [11]. Mining centres serve as breeding grounds for the spread of diseases such as malaria, human immunodeficiency virus (HIV) infection and acquired immunodeficiency syndrome (AIDS), typhoid fever, skin disorders, and asthma [1, 12, 13]. In Burkina Faso, research proved that using mercury and cyanide as chemicals in artisanal and industrial gold mining directly affects the health of the population, livestock, and the ecosystem in the area [14]. Furthermore, mining exploitation and mineral resources are linked to banditry and other worrisome insecurity in the Sahel zone. In particular, more than 3,600 people were held captive in North-West Nigeria from 2011 to 2019 [15], including a massacre of 6,319 children and women. Illegal mining is also responsible for the provision of funds to rebel groups in the Sahel region and the proliferation of small arms. In Mali, Niger, and Burkina Faso, approximately 100,000 children are involved in gold mining [16], raising issues of child prostitution, violence, harsh labour, and fundamental human rights abuses. For example, Kansole et al.'s survey [17] revealed that the artisanal exploitation of granite quarries near Ouagadougou potentially affects people's lives and causes air pollution (environment).

1.2 Impacts of mining on agricultural lands

Mining canker has gargantuan effects on various land uses at the Bukuru mining site in Nigeria. With a total land area of 1,574.13 km² undergoing degradation, mining production has caused a significant change in the arable farming land size from 779.64 km² to 549.74 km² and 673.04 km² from 1975 to 1986 and 2005, respectively [18]. These indicated that the allocated area for agricultural production had shrunk gradually and slightly increase and could subject the place to food insecurity, hunger, malnutrition, resource conflict, and the disbenefits of the ecosystem. The loss of vegetation cover and landscapes is unprecedented and consequential evidence of mining. For example, mining has destroyed over 1,000 acres of agricultural land in the Baryte mines [19]. In addition, the area's cultivable land for growing food crops has been polluted and degraded, with no strategic restoration and reclamation plans in the district.

1.3 Key impacts of animal biodiversity

The Lefa Gold Mine in Guinea has endangered and extinct mammals, including two species of the Suidae family, two in the Felidae family, and three in the Bovidae [13]. Heavy mining reduced the forest area in the Bukuru mining district in Nigeria from 420.52 km² in 1975 to 399.56 km² by 1986 [18], with a further reduction of 156.63 km² as green cover in 2005 after nearly 20 years. The associated mining risks are deforestation, land degradation, noise pollution, health hazards, animal traps from open pits, dust, land contamination (soil and water), and other environmental impacts [20]. The Société de Raffinage de Zinder (SORAZ) mine is responsible for producing dust, waste, noise, and gas flares in the Zinder region of Niger, thereby affecting the survival of biodiversity. In addition, the oil pipeline construction in Niger has fragmented natural vegetation with the death, of many local trees and the destruction of agroforests and gardens. Mining of baryte in the Azara district of Nasarawa state has affected economic trees such as mango (*Mangifera indica*), dorawa (*Parkia biglobosa*), and kirya (*Prosopis africana*), as well as grass species, including spear grasses [19].

1.4 Positive impacts of sustainable mining

Mining industries have the financial power to build resilient local economies, create jobs, and provide adequate infrastructure to drive sustainable economic growth and development. The West African Sahel has unique climatic and geographical characteristics, along with resource-driven economies. In Nigeria, the mining production sector employed over 1,254,200 people in rural communities in 2013, with a total output of 60.54 million tonnes from 1,710 quarries [18]. In Niger, uranium, an export commodity, contributes immensely to the gross domestic product (GDP). The mining sector's contribution to Mali's GDP was 18.6% of overall revenues in 2014 [21]. The sustainability of mining can help restore degraded lands and ecosystems to improve natural regeneration. Mali, Burkina Faso, and Niger benefit more than 60 million people from gold mining in the Liptako-Gourma region [16]. The author further stipulated that in 2015, the mining sector, specifically gold, contributed to a total revenue generation of 180,861 million CFA francs in Mali and 162,044 million CFA francs in Niger in 2014. Mining is an alternative source of employment and an essential tool for controlling emigration in the face of climate change. Gold is a significant export earner in Burkina Faso after toppling cotton in 2009 [16]. However, prioritising the private sector's needs to address the disadvantages of local mining communities is a clear gap in mining codes in Senegal [22]. In Mali, the central and local governments are gravely concerned about the environment, human health and water quality of unsustainable gold mining in the region of Sikasso [2].

2. Methodology

The review of the relevant literature was conducted using the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

2.1 Review of literature

The data was mainly found in web searches using Scopus, Google Scholar, Google Search, ResearchGate, Mendeley, and ScienceDirect. These are powerful tools for finding specific literature and allow users to search various documents, including articles, books, grey literature such as conference proceedings, and reports on various subjects.

Some keywords were first used in French, and then translated into English to obtain the maximum number of documents on the subject. Reading the summary and conclusion ensured that each document provided new information. Various critical themes of the topic were identified to assist in the review: mining, impact, environment, degradation, and management. Research on the environmental impacts of mining was filtered from 2011 to 2022. Figure 1 illustrates published studies on mining and the environment over the years.

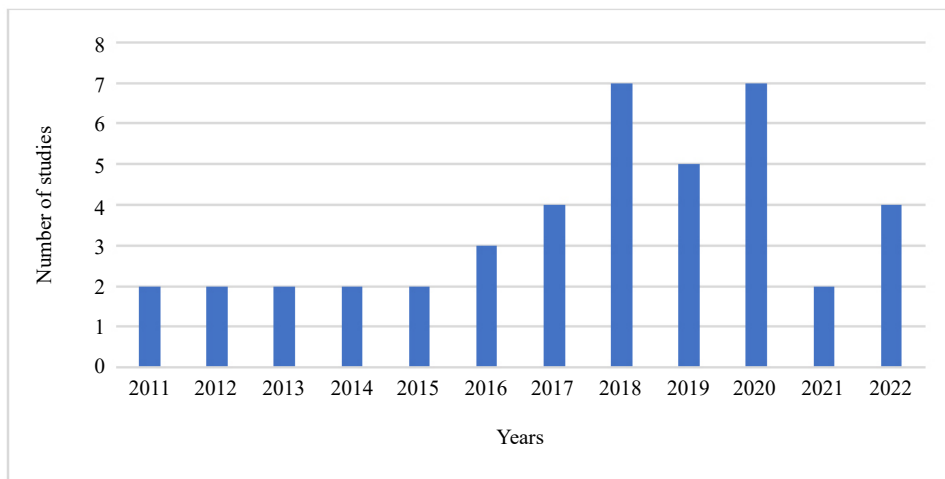


Figure 1. Number of studies selected according to publication year

2.2 Screening process and publication selection

The next step was to review the title and summary of the articles to decide which to include or exclude from the study. A total of 40 publications qualified for the next step, which included an analysis of the full texts.

To review the full text of the selected articles, the focus is on mining in West Africa, specifically in the Sahel. From here, it is possible to identify the various forms of mining, pressures, and impacts, both positive and negative, on the environment and society. The policies or measures to mitigate impacts were also reviewed. Finally, the bibliographic list of articles was analysed using the Mendeley software.

2.3 Study area: West African Sahel

The West African Sahel region is a semi-arid area that runs from the Atlantic Ocean eastward to Chad, separating the Sahara Desert to the north and the Sudanian Savana to the south. The region is one of the world's poorest and most environmentally degraded. As a result, it is considered one of the world's most vulnerable regions to climate change, as temperature increases are projected to be 1.5 times higher than in the rest of the world. Warming across the region is expected to continue, with the Sahel being the warmest and most significant. Climate vulnerability is compounded by the region's high dependence on rainfed agriculture and its natural resources to support food security and livelihoods, rapid population growth, and chronic humanitarian crises due to recurrent drought, flooding, food insecurity, epidemics, and violent conflict. The Sahel in West Africa covers nine countries, including Mauritania, Senegal, Gambia, Guinea-Bissau, Guinea, Mali, Burkina Faso, Niger, and Nigeria; it has a total area of 5.4 million km² and a population of almost 60 million [23]. Figure 2 shows the map of West African Sahelian countries.

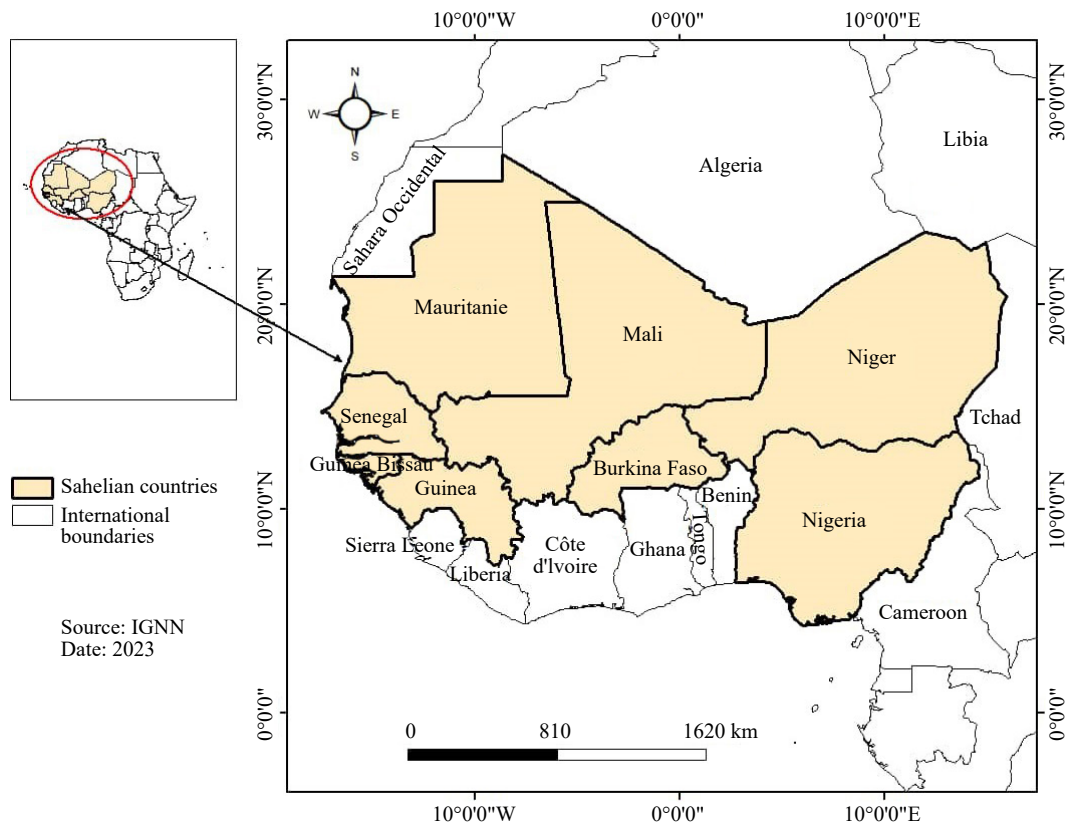


Figure 2. The map of the West African Sahel region

Table 1. Mineral potentials of the West African Sahel

Source	Country	Mineral potentials
[16, 23]	Nigeria	Gold, lead, tin, zinc, limestone, coal, marble, barite, lead, copper, talc, silica sand, granite, gemstones, ball clays, feldspar, kyanite, dolomite, mica, quartzite, asbestos, graphite, manganese, iron, rocks, galena, wolframite, monazite, xenotime, zircon, thorite, molybdenite, laterite, chromium, cobalt, kaolin, brine, and diamond
[25]	Niger	Uranium, gold, coal, copper, limestone, tin, gypsum, phosphate, silver, manages, vanadium, chrome, nickel, lithium, lead, zinc, molybdenum, salt, titanium, wolframite, Colombo-tantalite, bentonite, and natron
[26]	Senegal	Gold, rutile, ilmenite, zircon, leucosene, petroleum, natural gas, iron, sable titaniferous copper, lithium, chromium, alumina phosphate, ceramic clays, limestone, heavy minerals (ilmenite, zircon), extra siliceous sand (glass sand), manganese, diatonic earth, sand, and rock salt
[27]	Burkina Faso	Gold, zinc, manganese, granite, copper, bauxite, calcarine, phosphate, diamonds, iron, vanadium, nickel, copper, antimony, lead, zinc, aluminium, phosphate, limestone, sand, kaolin, clay, ornamental stone, uranium, and shale
	The Gambia	Rutile, ilmenite, zircon, bauxite, phosphate, and petroleum
[28]	Guinea	Bauxite, iron, gold, diamond, uranium, gold, diamond, uranium, petroleum, nickel, copper, cobalt, chromium, manganese, limestone, granite, dolerite, and marble
[29]	Mali	Gold, diamond, lithium, bauxite, iron ore, kaolin, lead, cadmium, zinc, phosphate, limestone, salt, manganese, marble, gypsum, uranium, lignite, and bituminous shale
[30]	Mauritania	Iron, copper, gold, uranium, gypsum, phosphate, petrol, and natural gas

Despite being environmentally vulnerable and politically sensitive, the West African Sahel is one of the wealthiest zones regarding mineral potential on the earth's surface. The region is experiencing a mining boom. This boom attracts substantial economic growth and development [24]. However, it carries significant risks for African societies and the

environment. Mining resource exploitation poses potential environmental threats orchestrated by the rapid escalation of large- and small-scale mining. Mining is not a new phenomenon, but due to the problems of climate change, its impact on the environment is beginning to be severely felt at all levels, especially in the Sahelian zones of West Africa. The table below presents the different mineral resources of the West African Sahelian zone. Table 1 represents mineral resource deposits found in the West African Sahel region.

3. Results

In the West African Sahelian countries, mining is often used for economic and social development. It also lays the foundation for building and driving the resiliency of rural communities by providing social services and infrastructure. Despite positive impacts, conflicts and environmental problems are the externalities associated with mining due to poor exploitation, greed and political corruption. This paper presents the findings of the study zone’s mining effects on the environment in tables and figures for critical analysis to generate reasonable implications. The environmental externalities are profiled, including agricultural land reduction, water resource depletion, human health, forest degradation, the creation of jobs, land reclamation, afforestation and reforestation, and sound policies on sustainable mining. Table 2 summarises the impacts of mining on the region’s local economies and biological diversity.

Table 2. Economical, social and ecological impacts of mining in the West African Sahel

Source	Country	Economical, social and ecological impacts
[18]	Nigeria	More than \$50 billion is lost annually due to illegal mining activities. In addition, over 400 fatalities were recorded in 2005, with 5,000 abandoned mine ponds now serving as death traps.
[23, 31]	Senegal	The country invested \$5 billion from 2000 to 2013 in the mining industry. Despite massive investments, the sector accounts for about 20% of exports. The provision of mining social funds for social programmes in mining communities within 3 to 5% of annual profit is also a mirage. In addition, the environmental impact assessment report, approval, and ecological management plan prohibit mining in protected areas, but such enforcement has not been fully realised.
[16]	Mali	Despite employing approximately 400,000 people, 40,000 illegal miners are expelled, criminal gangs and terrorists exploit minerals, and Jama’ a ul-Islam groups exploit minerals. The mining zones are characterised by abductions and money laundering. In addition, chemicals such as cyanide have killed livestock and poisoned groundwater through dredging in the Niger, Falémé, and Bagoué Rivers.
[15]	Niger	The sector accounts for 450,000 labourers employed in the countries. However, Islamic State of the Greater Sahara terrorists and other anti-mine operating groups have made the industries unfavourable for investments. In addition, there is evidence of cyanide processing killing livestock and poisoning groundwater along the border of Burkina Faso and Mali.
[15]	Burkina Faso	Over 1 million active labourers are employed in the mining sector of the country. However, the upsurge of Ansarul Islam terrorist groups and criminal gangs has eroded the fortune gained, mainly in the Liptako-Gourma region.

3.1 Impacts of mining on animals, plants and microorganisms

Due to forest degradation and deforestation, mining is affecting protected areas, Ramsar sites, and pastoralists. Biocontamination of water resources due to chemicals, heavy metals, and production dust, particularly gas flaring in Niger (SORAZ). Table 3 further demonstrates this.

Table 3. Land use, land cover and percentage change from 1975 to 2005 in Bukuru Plateau, Nigeria [18]

Land cover	Area in 1975 (km ²)	Area in 1986 (km ²)	Area in 2005 (km ²)	Percentage change					
				1975 to 1986	1986 to 2005	1975 to 2005	1975 to 1986	1986 to 2005	1975 to 2005
Arable land	779.64	549.47	673.04	-29.52	22.49	-13.67	-230.17	123.57	-106.6
Waterbodies	31.52	59.09	88.59	87.47	49.92	181.06	27.57	29.5	57.07
Degraded area	213.72	368.22	398.8	72.29	8.30	86.6	154.5	30.58	185.08
Built-up area	99.35	168.41	228.69	69.51	35.79	130.19	69.06	60.28	129.34
Hills or rocks	29.38	29.38	29.38	0	0	0	0	0	0
Forest	420.52	399.56	155.63	-4.98	-61.05	-62.99	-20.96	-243.93	-264.89
Total	1,574.13	1,574.13	1,574.13						

3.2 Positive impacts and sustainable mining

Mining could also serve as sustainable environmental management in the context of land reclamation and restoration activities. In addition, it has the potential to build resilience in local communities in the context of green job creation, the building of schools, and the provision of potable water. Table 4 presents positive externalities in the context of uranium exportation in Niger. The production of uranium contributes to the GDP of Niger through foreign exchange. However, there was a decline in the uranium production output from 4,277 tonnes in 2013 to 3,485 tonnes in 2017. This decline in production is primarily attributed to the insecurity in the area. There has been a fluctuation in the exportation of uranium in the Société du Patrimoine des Mines du Niger (SOPAMIN) industry.

Table 4. Production and exportation of uranium in Niger [32]

	Unit	2013	2014	2015	2016	2017
Production*	Tonne	4,277	4,156	4,116	3,478	3,485
Exportation**	Tonne	4,382	4,099	4,334	2,924	3,564
	Million CFA francs	302,788	240,529	240,762	177,680	169,556
The average price of exportation	CFA francs/kg	73,000	58,833	51,253	63,850	50,364

Note: * = excluding the sale of SOPAMIN and ** = including the sale of SOPAMIN

Gold is a precious mineral mined in the Sahel region. Table 5 covers mineral production in the various industries in the area. Table 6 indicates gold production and exportation in Burkina Faso, Mali and Niger. These countries represent the heart of the West African Sahel. The fluctuation in the production and exportation of gold is linked to terrorism in the area.

Table 5. Production of mineral products [32]

	Unit	2013	2014	2015	2016	2017
Gold	kg	1,150.71	731.68	1,220.28	999.12	913.66
Gold from gold planning	kg	73.25	63.91	346.19	277.34	91.56
Gold industry or Société des Mines de Liptako (SML)	kg	1,077.46	667.77	874.09	721.78	822.1

Table 6. Production and exportation of gold in the selected countries

Source	Production	Gold Export	Tax per kg	Countries
[16]	20 to 25 tonnes per year	€211,468,130 in 2015	€686, €305	Burkina Faso
[16]	10 tonnes per year	€247,034,485 in 2014	€183, €533.50	Niger
[16]	30 to 50 tonnes per year	€275,720,817 in 2015	€709	Mali

3.3 Role of environmental policies for sustainable mining in the West African Sahel

For sustainable mining to be realised, it requires effective laws, regulations and policies to be in place. Table 7 demonstrates the constructive approaches governments have adopted in revising existing mining regulations to reflect current realities. These reforms involved the right to buy, own, process, and trade to ensure the entire operation's control [16].

Table 7. Laws and codes for sustainable mining

Source	Laws and regulations			Mining policies	Countries
	Old code	Weaknesses	New code		
[33]	Minerals and Mining Act, No. 34 of 1999	Unclear roadmaps for environmental sustainability and dispute resolution strategies	Minerals and Mining Act, 2007 A 479	National Minerals and Metals Policy, 2008	Nigeria
[22, 31]	2003 Mining Code, Act No. 2003-36, dated 24 November 2003	The distinction between a mining concession and a mining permit needs to be clarified. No special funds for mining communities' development and environmental protection	Mining Code, Act No. 27/2016 of 30 October 2016 gazetted on 8 November 2016 (law no. 2016-32).	Plan Sénégal Emergent (PSE) with seven mining projects from 2014 to 2035, Mining Sector Development Policy Letter (2017 to 2023)	Senegal
[4, 16, 21]	Law n° 2012-015 of 27 February 2012, on the Mining Code	Unfavourable for investments and tax burdens	Ordinance n° 2019-022/P-RM of 27 September 2019	National Mining and Oil Sector Development Policy for 2018 to 2022, adopted in June 2018	Mali
[16]	Mining Ordinance 93-16 of 2 March 1993 related to the Mining Law	Inadequacies in semi-mechanised artisanal mining and residue handling	Artisanal Mining Reforms Act of 2017 with a unique dealer card to ensure complete control of production and marketing processes	National Mining Policy for 2020 to 2035	Niger
[16]	Law No. 023/AN of 8 May 2003	Inefficient distribution of mining proceeds or revenues	Act 028-2017 operating decree no. 2017-433 of 9 June 2017 on marketing 2015 (Law n° 036-2015/CNT of 26 June 2015).	Mining Sector Policy for 2014 to 2025, adopted in May 2013	Burkina Faso

Mining in the Amajim area has serious environmental issues (see Figure 3) regarding farmlands' destruction, waterbodies' pollution and the breeding of waterborne diseases. All these have unspoken implications for the health of youth, women, and children. In addition, aquatic and terrestrial animals are also affected due to contamination and the destruction of vegetative cover.



Figure 3. Artisanal mining at Amajim, Nigeria [10]

Mining impacts on the environment cannot be neglected due to heavy metals and machines affecting biodiversity (Figure 4). The land and vegetation that serves as the living organisms' abodes have been degraded in the Ameka. For example, water bodies have been polluted and rendered uninhabitable for amphibians. Moreover, using toxic chemicals such as mercury is dangerous to human survival due to the mobility of rivers and streams to adjoining ones.



Figure 4. Degradation of land, vegetation and breeding of disease vectors from mining at Ameka, Nigeria [10]

Figure 5 represents an excavator clearing farmlands in the Djado District and plateau in the Agadez Region of Niger. Mining has destroyed farmlands and endangered animal species.



Figure 5. An excavator clearing farmlands for mining in the Djado District of Northern Niger [34]

Figure 6 indicates degrading mining land in the Djado District in the Niger Republic by leaving empty potholes. Unfortunately, these are also traps for livestock and humans, especially hunters in the area.



Figure 6. Land degradation emanating from the empty gold field in the Djado District of Northern Niger [34]

The restoration plan that the China National Petroleum Corporation (CNPC) in Niger is implementing includes the observations shown in Figures 7 and 8. The initiatives seek to reclaim the vegetation and land destroyed due to mining in the area. The implications of this plan include building local communities' resilience, creating jobs, and providing potable drinking water as part of the positive externalities of mining projects in the Sahel region.



Figure 7. *Terminalia mantaly* planted by the CNPC in Niger



Figure 8. Protection of natural tree regeneration by the CNPC in Niger

4. Discussion

This paper reviews the impacts of mining on the environment in eight countries in the West African Sahel. We discovered that unsustainable mining had destroyed arable land, waterbodies, built-up areas, and protected forests in the region. Tables 3 and 4 indicate that unsustainable mining practices have more significant environmental consequences. Furthermore, the mining zones serve as breeding grounds for water pollution, criminal gangs, and terrorist groups such as Boko Haram, Jama'a ul-Islam, and Ansarul Islam in the Sahel, particularly in the Liktako-Group Region. On the other hand, Tables 3, 4, and 5 present positive externalities of mining. The sector is vital to the growth of the Sahel's economies in terms of job creation, trading and foreign exchange earnings from gold and uranium production. However, based on the results, its negativity has outweighed its benefits. The region has become a "college" of terrorism, abduction, money laundering and other illicit mining activities.

There are different views on the social, environmental, and economic balance that mining could bring to a country. Boidin and Simen [35] outline that the Senegalese authorities, wishing to use the natural resources at their disposal better, have deployed powerful means to attract as many investors as possible. The aims are to promote institutional capacity building, minimise the risks inherent in any mining operation (destruction of the ecosystem, displacement of populations, etc.), and increase the impact of this exploitation on the activities of the enterprises operating to ensure local development. This implies a better distribution of operating revenues and strict compliance with environmental standards in line with a sustainable development perspective. However, there is a lack of clarity between the public actors and the realities the population perceives. Civil society and the population complain about the adverse effects of mining on their health and the environment. Indeed, civil society, spiritual guides and customary leaders are negatively impacted by mining. Moreover, weak institutions and inadequate enforcement of regulations for multinational companies operating in the mining sector in Senegal degrade natural resources and community rights. In particular, the practices of certain companies in the phase-out of the mining code requirements are incriminated. According to Drechsel et al. [36], presenting industrial mining in Burkina Faso through the report "Mines Make Us Poor" on page 17, "*Since the mine was set up, the lives of the people along the river have changed in many ways, as the population of the former small village of Taparko has increased considerably with the opening of the mine, with people from all over Burkina Faso and foreign countries, especially from neighbouring countries, came looking for work*". In addition, Stephens [37] stated on page 82 of his report on employability by the local workforce that, "*According to the Initiative pour la transparence dans les industries extractive au Burkina Faso (ITIE) and Société des minière de taparko (SOMITA) employed a total of 766 people in 2016, 727 from Burkina Faso and 39 from foreign countries*".

Nevertheless, despite this growing increase in the local labour force, the hopes of recruiting the local population have yet to be realised since most workers were recruited outside the mining villages. This sometimes provokes anger among the regional and local labour forces. The authors describe these "*As the land of the mining concession was once used for agriculture, many residents, most of whom were peasants, lost their source of income. In addition to employment, conflicts between the public and mine management have emerged due to the dangers and damage caused by mining activities, such as dynamite explosions and the proximity of the mine site to the village*" [36].

Moreover, in the review of multidisciplinary economic and social sciences studies presenting the case of Mali, the study report by Sidibe [38] stated that "*mining is undeniably disrupting the villagers' way of life, customs and symbolic values. The occupation of their lands and their displacement, the influx of foreign workers and the transition from a local subsistence economy to an economy with greater monetary flows can affect people's cohesion and social order. When training measures and positive discrimination in recruitment are not taken upstream of the farm, the local labour force is often confined to subordinate jobs or extra work*".

This could, therefore, have a significant impact on workplaces. It can also create tension and conflict between indigenous and non-native workers. The latter develop little or no sense of belonging to the host community. The so-called "flying" workforce emphasises this phenomenon in remote areas, by the principle of rotational work with shuttle service.

Mining is also the basis of conflict creation and insecurity in certain Mali, Burkina Faso and Niger regions. The inadequate creation of jobs combined with the influx of labour from other parts of the region has complicated the situation. In addition, the youth have lost interest in agriculture, meaning mining sites experience unemployment problems and crime development [39]. Water resources are also not spared from the impacts of mining operations. Discharges and leaks of effluents containing toxic chemicals such as arsenic, mercury, or mine waste led to water quality

degradation [40]. A study by Gibb and O'Leary [41] demonstrates the consequences of artisanal gold mining on resident communities and those living in the riparian zones of rivers draining through gold-mining areas. The ill effects were due to mercury-contaminated water and fish consumption.

Heavy metals and chemicals pose much concern to the public, given their toxic effects on humans and other organisms. Some of these metals include arsenic, zinc, cadmium and mercury, whose concentrations in water, air, soil, sediments and food chains have been significantly increased through anthropogenic activities. As a result, these pollutants heavily impacted drinking water, aquatic organisms and water used for agricultural production. Despite the destructive impacts of mining on the environment, it can be done sustainably. The Sahelian countries of West Africa have considerable mineral potential. These minerals are sources of financing and investment for several foreign countries that want to benefit from their various natural resources.

5. Conclusion

Mineral extraction contributes significantly to the economies of the West African Sahelian countries. However, urgent attention is needed due to the implications of mining on the environment, particularly the health of miners and the population. Mining activities have contributed to the loss of biodiversity, the degradation of farmlands, and the pollution of water bodies. Biologically, some Ramsar sites along the Niger River in the Liptako region are negatively affected by biocontamination, dust and noise production coupled with over 40,000 illicit mining activities. The study concluded that mining activities had negatively impacted the environment.

Therefore, there is a need to minimise the effects of unsustainable mining practices on living organisms, protected areas, water resources and other non-living components. In addition, there is a need to enforce existing regulations to ensure proper land reclamation and restoration through sustainable mining.

We would like to recommend a comprehensive study on the impacts of mining on public health. Such information will help monitor, regulate and evaluate existing mining laws' weaknesses to inform sustainable mining. In addition, these strategies will contribute to public health protection and the conservation of endangered animals, vegetation and microorganism species.

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Conflict of interest

All authors declare no conflicts of interest in this paper.

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