

Mercury Problems and Presidential Artisanal Gold Mining Development Initiative (PAGMI): Challenges, Opportunities and Future Directions of the Mining industry in Nigeria

Auwal M. Musa^{*1,3*}, Sani Muazu^{** 3} and Bashar Y. Sani^{**2}

Abstract

Artisanal and Small-Scale Mining (ASM) describes informal mining activities using low technology or minimal machinery. The use of low-tech and minimal machinery characterises the ASM industry in Nigeria. ASM sector in Nigeria, however, remains a potential source of employment, a source of revenue for the Government, and contributes to the growth of the nation's economy. The Government has made several efforts to revamp the industry thus far; however, the sector still has some weaknesses and challenges. This paper discusses the various reforms in the mining industry that have been made in the sector. It discusses the health, environmental, and gender impacts of the activities of ASM, the safer mining technologies, standardisations related to mining technology, characteristics, and challenges of current mining systems. It also addresses mercury exposure prevention using a formalisation approach, among other things. The formalisation policy takes care of two significant constraints: environmental consciousness through monitoring the Presidential Artisanal Gold Mining Development Initiative (PAGMI) activities and the necessity to improve the sector to attract more investors. The industry has opportunities to generate countless job opportunities for Nigerian youth, thus contributing to poverty alleviation.

Keywords: Presidential Artisanal Gold Mining Development Initiative (PAGMI), mercury poisoning, environmental impact, sustainable growth, Nigeria

Introduction

Every nation is endowed with some sort of minerals, including Nigeria. The act of extracting these mineral resources is known as mining. Mining activities vary and are carried out by diverse people, both individuals and mining companies. In Nigeria, artisanal and Small-Scale miners carry out most of the mining activities using simple and basic technology. Artisanal and Small-Scale Mining (hereafter referred to as ASM) is a phrase used to describe informal mining activities using low technology or minimal machinery¹ Mining can be done on a large scale or a small scale. The focus of this paper is on artisanal and small-scale mining, which has been described as poverty-driven by several researchers, including^{2,3, 4}.

*Institute of Bio-Sensing Technology (IBST), University of the West of England, Bristol, BS16 1QY, U.K.
Corresponding author: auwal.musa@uwe.ac.uk

**State College of Basic & Remedial Studies (SCBRS), Department of Sciences, Chemistry Unit, Sokoto, Nigeria

***Allbridge Technology Development Foundation, Kano State, Nigeria.

¹ Idris-Nda, A. Waziri, N.M. Bida, A.D & Abdullahi, S. (2018). Socio-Economic Impacts of Artisanal and Small-Scale Mining in Parts of Niger State, Central Nigeria, *International Journal of Mining Science (IJMS)*, 4(3), pp.21-30.

² Adesugba, A. (2018). A study of the challenges of gemstones artisanal and small-scale mining in Nigeria. *Journal of Scientific Research and Studies*. 5(4), pp. 97-108

³ Reed, H.E. & Mberu, B. U. (2014). Capitalizing on Nigeria's demographic dividend: Reaping the benefits and diminishing the burdens. *Afr. Popul. Stud.* 27(2):1-12. *Sciences*, 19 (1): 88-106.

⁴ Maduaka, A.C. (2014). Contributions of solid mineral sectors to Nigeria's economic development (Masters Thesis, Eastern Mediterranean University). Retrieved from <http://irep.emu.edu.tr:8080/xmlui/handle/11129/1684?show=full>

Artisanal and Small-scale Mining is subsistence in nature. Most miners or individuals who engage in this scale of mining are usually only interested in catering for themselves and family. In other words, artisanal mining is generally carried out on a small scale on shallow mineral resources where the miners use rudimentary techniques to access the ore. As revealed,⁵ about 13 million people are employed in the ASM industry, while up to a 100 million people depend on ASM for their livelihood worldwide; while in Nigeria, it has been established that⁶, 186 million people, 64% of the population of the country are living in the rural area – where ASM is generally expected and thus, if handled properly, ASM will be a source of job for many locals. This will go a long way to alleviate Nigeria's unemployment rate and lead to economic growth. Unfortunately, this sector has been neglected for attention to the petroleum (oil and gas) sector. Therefore, the abandonment of the mining sector – leaves the industry in the hands of ASM, which mines with crude equipment leading to low output in terms of quality and quantity. Besides, the activities of artisanal and small-scale miners are brutal and dangerous to the health of those involved; the health of the community, environmental degradation, and many other risks cannot be ignored.

However, the mining sector remains a potential source of employment, a source of revenue for the Government, and contributes to the growth of the nation's economy. To this effect, the Nigerian Government recently had been deliberating on increasing its budget allocation to the mining sector; as a result, instead, the Government had proposed to increase the original \$1 billion budget for the mining sector in 2016 to a \$25 billion budget comes 2026. Based on this interest, it is imperative to have an overview of the sector to determine if such a budget is justifiable or otherwise, hence the need for this study. Therefore, this paper presents an overview of the ASM industry in Nigeria, the health, environmental, and gender impacts of the activities of ASM; the safer mining technologies, standardizations related to mining technology, characteristics, and challenges of current mining systems, as well as addressing mercury and lead exposure using formalization approach, among other things.

Historical Background of Mining in Nigeria

The mining sector was once a significant source of export in Nigeria before discovering oil and gas. This implies that minerals contributed substantially to foreign exchange earnings in Nigeria and considerable employment opportunities for the people⁷ before the Government's attention drifted to the oil and gas sector. Idris-Nda, Waziri, Bida, and Abdullahi⁸ added that the aftermath of the Nigerian civil war of 1967-1970 added to the loss of interest in the mining industry in favour of the oil and gas sector to the extent that solid minerals contributed only a paltry 1% to the country's GDP. Ignoring the solid mineral sector leaves it in the hands of Artisanal and Small-Scale miners. As a result, the past decades have witnessed a significant number of individuals and households who depend on ASM for their daily living; and this trend

⁵ Bodenheimer, M. (2014): Certifying improvement, improving certification: An analysis based on the artisanal and small-scale mining sector, Working Paper Sustainability and Innovation, No. S9/2014, Fraunhofer ISI, Karlsruhe, <http://nbn-resolving.de/urn:nbn:de:0011-n-3070075>

⁶ Reed, H.E. & Mberu, B. U. (2014). Capitalizing on Nigeria's demographic dividend: Reaping the benefits and diminishing the burdens. *Afr. Popul. Stud.* 27(2):1-12.- *Sciences*, 19 (1): 88-106.

⁷ Idris-Nda, A., Ajenifuja, G.O. & Jimada, M.A. (2015). Effects of Artisanal and Small-Scale Gold Mining and Granite Quarrying on Women Miners in Parts of Minna, North Central Nigeria. *Nigerian Mining Journal*, 13 (1),76-84.

⁸ Idris-Nda, A. Waziri, N.M. Bida, A.D & Abdullahi, S. (2018). Socio-Economic Impacts of Artisanal and Small-Scale Mining in Parts of Niger State, Central Nigeria, *International Journal of Mining Science (IJMS)*, 4(3), pp.21-30.

is likely to continue to grow in the face of high mineral prices, population growth, poverty, and climate change. The higher the country's poverty rate, the higher the number of people engaged in ASM activities, making it extremely difficult to eradicate ASM activities in Nigeria completely. The better option is to invest in ASM by acquiring modern technologies that will reduce environmental degradation and ensure larger output in terms of quantity and quality. This way, it will transform from small-scale to large-scale mining.

Some of the commodities/solid's minerals include:

Tin/Columbite: Tin and Columbite are found in large quantities in Jos Plateau, constituting about 90% of the cassiterite mineral produced in Nigeria. In 1904, nearly 1.36 tonnes were made, reaching their peak in 1943 with 15,842 tonnes. However, the drift of attention to the oil and gas sector led to the decline in production, which dropped to 2,760 metric tons in 2000, then 180 metric tons in 2010 and then 200 metric tons in 2017 as a result of the activities of artisanal mining⁹. According to Mallo, the sub-basalt sub-stratum of the untapped reserve of tin/columbite is about 3500 tonnes. In 1961, Jos Makeri Smelting Company used to smelt high-grade alluvial tin concentrates; however, as the decline of interest in tin grew further, the Company could no longer hold its ground and thus merged with other companies resulting in Consolidated Tin Mining Company of Nigeria Ltd (CTMN Ltd). As the technical capacity of the sector declined further alongside falls in the price of tin in 1985 witnessed by the primary market - the London Metal Exchange, the industry collapsed altogether, leaving its activities in the hands of ASM, whose subsistent miners are. About this time, lead and zinc were also mined in Plateau and Enugu, Nigeria, respectively.

Coal: Coal is one of the solid minerals in Nigeria and is used mainly for domestic purposes. Prior Civil war - in mid1960, the production was between 500,000t/yr and 1 Mt/yr¹⁰ for domestic use and export to generate foreign exchange. However, the sector declined drastically between the 70s and the 80s, and it was not until 2000 that there were a noticeable increase of 12000metric tons and 450000 metric tons in 2010; and 750,000 in 2017. This development is due to the fall in oil price, prompting the Federal Government to redirect its attention to solid minerals.

Gold: Gold is another essential mineral that every country emphasises, including Nigeria. In Nigeria, the production of gold in 2006 was 52 kilograms; this increased to 600 kilograms in 2010, and there is an expectation that it will follow an upward trend. For example, the Nigerian gold company – Topical Mines Ltd liaised with the CGA Mining Ltd of Australia to work on the Segilola project in 2008, a project that was discovered about 120 kilometres northeast of Lagos. Similarly, Savannah Gold Ltd of the United Kingdom also found gold in north-western Nigeria in 2010. Other goldmines abound.

Bitumen: About 16 core holes were drilled between October 2002 and July 2005 in Nigeria in different locations, which indicated the prominence of bituminous deposits and high Tar sands.

Iron and Steel: The Government is significantly involved in iron and steel, and the National Iron Ore Mining Company situated at Itakpe in Kogi State is wholly owned by Government. The Company specifically explore, exploit, process, and supply iron ore concentrate. By 2000, about 9000metric tons of iron had been produced in Nigeria, while the production increased to 18000 metric tons in 2010. The anticipation is that the trend will follow an upward movement. Likewise, steel production had been on the increased overtime; from 100,000 metric tons in 2005 to 410,000 metric tons in 2010.

⁹ Mallo S. J. (2012). The re-emerging mining industry in Nigeria: Issues for appropriate manpower training. *Continental Journal of Sustainable Development*. 3(2):15-25.

¹⁰ Bodenheimer, 2014, op. cit note 5

Aluminium and Bauxite: Another essential industrial mineral is the Nigerian aluminium production which has been on the rise. In 2008, the production was 10,600 metric tons; and has increased to 21,200 metric tons in 2010, and about 96,000 metric tons in 2017.

Overview of the System

Nigeria as a country is endowed with uncountable natural resources, among which are crude oil, iron ore, gas, tin, gold, columbite, lead-zinc, tantalite, wolfram, limestone, clay, kaolin, shale, radio-active minerals, marble, barytes, coal, cassiterite, lignite, natural gas, petroleum, natural and hydro-electric power¹¹. These mineral resources are spread unevenly across the 36 states within the country. For instance, above 3 billion metric tonnes of iron ore deposits are found in Enugu, Lagos, Niger and Kogi. Benue State has huge rock salt, Abakaliki and some part of Ebonyi State.

Talc deposit is said to have about 40 million tonnes deposits in Niger, Osun, Ogun, Kogi and the Kaduna States; about 7.5 million tonnes of baryte is seen in Taraba and Bauchi States. Over 700 million bentonites are spread out across several states in Nigeria and are yet to exploit. About 42 billion tonnes of bitumen deposits are also located in Nigeria¹². There are also deposits of limestone in Ogun State, gold in Oyo, Kaduna, Edo, Zamfara, Sokoto states, etc. as well as liquid minerals such as crude petroleum and natural gas are primarily deposited in Delta, Rivers, Akwa-Ibom, Edo, Imo, Bayelsa, and Abia States. The litany can go on and on, among others. While some are exploited in a reasonable amount, others remain untouched. If properly utilized, Nigeria will be among the wealthiest country in the world. However, the annual Nigeria Extractive Industries Transparency Initiative (NEITI) Solid Minerals Audit Report revealed that the total revenue of the solid mineral in 2013 was N33.86 billion, while in 2014, it rose to N55.82 billion by 0.11% of GDP, while in 2015, there was still an upward growth of N69.2 billion resulting to a growth rate of 0.33%. In 2016 there was a 0.55% increase in solid minerals production.¹³

Following the economic recession witnessed in Nigeria lately due to the fall in the price of oil and gas in the international market, Nigeria is presently diversifying her foreign exchange products, thus redirecting the attention to the agriculture and mining sectors. This is evident in the amount of capital injected into the sectors. For instance, the country's GDP went from US\$2 billion in 2016 to about US\$27 billion in 2025. Furthermore, at the tail end of 2016, the Government approved a US\$30 billion intervention fund from the Natural Resources Development Fund (NRDF) to open up the mining sector to multinational companies for exploration and research. Furthermore, in an attempt to open up the mining sector, Sovereign Investment Authority advised the Nigerian Government to source capital from the capital market, of which the country is currently negotiating a floating US\$600million mining fund with the Nigeria Stock Exchange.

Similarly, a US\$150 million was secured from the World Bank to promote the Mineral Sector Support for Economic diversification program. All these efforts are meant to improve the

¹¹ Jack, J. T.C.B, Nkwocha, I. B. & Odubo, T. R. (2016). Natural resource exploitation and socioeconomic development in Nigeria (1981-2015). *Sustainable Human Development Review*, Vol. 8 Nos. 1-4, pp77-104

¹² David, O.O, Noah, O.A & Agbalajobi, S.A (2016). An empirical analysis of the mining sector's contribution to economic development in Nigeria. *Khaza Journal of Humanities Social*

¹³ Banwo, O. & Ighodalo, O. (2018). Solid minerals; Harnessing Nigeria's viable alternative resource to crude oil. <https://www.vanguardngr.com/2018/02/nigeria-makes-n7-3tr-oil-2017-cbn/>

mining sector. As a result, as of December 2016, 2,395 companies and individuals were licensed to operate in the upstream subsector¹⁴ (KPMG, 2017).

Health, Environmental, and Gender Impacts of ASM Activities

Health Impact

One of the significant challenges of ASM is its implication for health. According to Banwo and Ighodalo, many health problems are connected with artisanal and small-scale mining, which significantly affect the lives of the miners and the health of the entire community where that occurs. Usually, the underground mines are exposed to high noise, dust, vibration, and inadequate ventilation, leading to breathing-related problems, silico-tuberculosis (silicosis), headaches, bronchial damage, and permanent ear damage. In addition, the more exposed the miners are to the activities of ASM, the more frequent they are with over-exertion, and the longer the working hours the miners spend in the mine, the higher the chances that they suffer from "irritability, sleeping disorders and appetite loss".

The mining sector also has hygiene issues. It is usually carried out in rural areas where the community sometimes suffers inadequate sanitation services and waterborne diseases like dysentery, malaria, and typhoid fever. Moreover, apart from hygiene cases, there are cases of chemicals being released into the air. For instance, while extracting gold from its ore, some the substances such as mercury, nitric acid, and sodium cyanide are bound to be released into the air, and their damaging impacts on health cannot be overemphasized as they can even lead to death.

Bodenheimer¹⁵ pointed out that the worst of these chemicals that impact life negatively is mercury; mercury vapour that is also released during mercury-gold amalgam, when inhaled, has a damaging effect on the lungs. When inhaled, it becomes soluble as methyl mercury, causing colic, vomiting and gastroenteritis, kidneys, and urinary tract; acute enteritis; and finally, ulceration of the gums combined with extreme sensitivity to light.¹⁶

The crude equipment adopted by ASM activities also seriously affects the miners' lives and health conditions. These miners lack safety equipment as the majority of them wear shorts, trainers and, sometimes, a shirt or even shirtless in hot weather with no attention to some protective gear such as helmets, earplugs, masks, or gloves. This implies that these workers have direct contact with chemical residues that significantly impact their health.

It is important to note that most of the ASM are not frequently supervised, which makes it easier for the owners to neglect the security and safety of their workers. Some miners do so illegally and, as such, abide by no rules. There is also the problem of poor equipment and structures, which increase the rate of accidents from gas explosions, cave-ins, natural disasters such as landslides, earthquakes, flooding, and fire outbreak, among others, are common in ASM activities and thus endanger the health and lives of the miners. The reasons why ASM activities experience lots of health-related issues are attributed to certain factors such as inadequate resources, lack of regulation and supervision in the sector, poor sense of safety, inadequate training, and illiteracy, among others.

¹⁴ KPMG (2017). *Nigerian Mining Sector Brief, Third Edition*, February

¹⁵ Bodenheimer, M. (2014): Certifying improvement, improving certification: An analysis based on the artisanal and small-scale mining sector, Working Paper Sustainability and Innovation, No. S9/2014, Fraunhofer ISI, Karlsruhe, <http://nbn-resolving.de/urn:nbn:de:0011-n-3070075>

¹⁶ New Jersey Department of Health and Senior Services, 2010.

Tschakert and Singha¹⁷ pointed out that prostitution and HIV/AIDS rates are high in many ASM communities. Most ASM activities are carried out in a rural environment where there is a lack of access to public healthcare. In addition to poor living conditions, the possibility of disease spreading is also straightforward. Some women working in artisanal mining communities suffer from menstrual cycle disorder, neurologic and kidney failure, and miscarriage in the early stage of pregnancy.¹⁸

Environmental Impacts

Another possible challenge of ASM activities is their impact on the environment. While some of the activities of ASM pose risks to human health, the environment is not spared as the immediate locations of the mines suffer a great deal of air and water pollution. For example, according to Spiegel,¹⁹ in mining gold, the immediate environment suffers from toxic methylmercury in the food chain where mercury is released into the waters and air, endangering the life of fishes and other animals.²⁰

Apart from mercury pollution, there is also other air pollution resulting from ore roasting; quantities of sulphurous gases are emitted into the air polluting the environment and making the environment unsafe. ASM activities also lead to land degradation as incomplete mine closure could lead to 'pot-holed' landscapes. These potholes could collect waters which sometimes serve as breeding grounds for mosquito, malaria-infested parasites. Again, the activities of ASM could lead to acid mine drainage (AMD), which is the outcome of oxidation of discarded tailings, which causes an acidic solution that is toxic to aquatic life and some plants. Erosion and deforestation are other environmental degradation experienced by the activities of artisanal and small-scale mining in Nigeria.

Gender Impacts

The artisanal and small-scale mining (ASM) comprises tens of millions of male and female workers. According to Stocklin-Weinberg²¹ more than 40 million people globally work directly in the ASM sector. In addition, in more than 70 countries, about 300 million people are indirectly dependent on the ASM sector. Of these workers, about 30–50% are women worldwide; however, the earnings vary significantly between males and females. For instance, Eshun²² (2016) and Lahiri-Dutt²³ revealed that women only earn one-quarter of what men make in the ASM sector.

¹⁷Contaminated Identities: Mercury and Maginalization in Ghana's Artisanal Mining Sector. November 2007. Goeforum 38(6):1304-1321 DOI:10.1016/j.jgeoforum.2007.05.002

¹⁸ Gibb, H. and O'Leary, K. G. (2014) Mercury Exposure and Health Impacts among Individuals in the Artisanal and Small-Scale Gold Mining Community: A Comprehensive Review. *Environmental Health Perspectives*, 122, 667-672. <https://doi.org/10.1289/ehp.1307864>

¹⁹ Spiegel, S. J., 2009. Resource policies and small-scale gold mining in Zimbabwe. *Resources Policy*, 34(1-2), pp.39-44.

²⁰ Bodenheimer, 2014, op. cit

²¹ Stocklin-Weinberg, R., Veiga, M.M, & Marshall, B.G. (2019). Training artisanal miners: A proposed framework with performance evaluation indicators, *Science of The Total Environment*, Volume 660, Retrieved from <https://doi.org/10.1016/j.scitotenv.2019.01.113>.

²² Eshun, M. M. (2016) Not Just Counting Their Numbers, But Making Women Artisanal Miners Count. Retrieved from <https://africaupclose.wilsoncenter.org/not-just-counting-their-numbers-but-making-women-artisanal-miners-count/>

²³ Lahiri-Dutt, K. & Others (2018). *Between the plough and the pick*. Informal, Artisanal and Small-Scale Mining in the contemporary world. Australian National Press.

Nevertheless, despite the variations in earnings, both males and females are well represented in the sector. Similarly, studies such as Arcos²⁴ and Buss²⁵ revealed that the opportunities and privileges available for workers in the ASM differ significantly between males and females. In comparison, women take on non-digging jobs, including rock crushing, sluicing, washing, panning, sieving, transporting and creating ancillary businesses, such as selling food and goods around mining sites.

From the preceding, women are considered "a cheap and readily available reservoir of labour, but one that needed special protections". This is why there are laws meant to protect women and children from mining sites for fear that chemicals may affect them. For instance, the 2012 Washington Declaration Diagnostic Framework, launched with support from USAID, includes a commitment to strengthening women's rights which provides for protecting women against violence, and the establishment of a trust fund to support interventions for women in mining communities as well as reduce gender disparities²⁶. In addition, World Bank²⁷ pointed out that women are the most active in the ASM sector in Africa. However, studies such as Jaillon and de Brier²⁸ show that only 28% of women are workers at gold mining sites, while Ndongo and Dejong²⁹ show that only 3% of women are workers at the diamond mining sites.

Furthermore, Arcos³⁰ show that women in the mining industry are assigned secondary roles only. This evidence indicates that women's roles in the ASM sector vary from country to country, site to site, and the type of mineral involved. Also, the number of women involved in mining activities depends on the location or proximity of the mine to their homes. Nevertheless, the facts above show that although both males and female workers in the mining sector, both sexes receive differential treatment in terms of the nature of tasks and the remuneration.

Overview of Safer Mining Technologies

Standardizations related to Mining Technology

To a large extent, the scale and nature of technology adopted in the mining activities bring about a difference between ASC mining and large-scale mining. Technology brings about mass production. Mining in the heart is technology-dependent and, as such, uses some form of

²⁴ Arcos, A., & Rivera Guzmán, E. (2018). Brechas de género en la minería. La minería artesanal y de pequeña escala colombiana desde una perspectiva de género. Envigado (Antioquia): Alianza por la Minería Responsable. Retrieved from https://www.responsiblemines.org/wp-content/uploads/2019/02/digital-brechas-de-g%C3%89nero_m21_c13-compressed.pdf

²⁵ Buss D., Rutherford B., Hinton J., Stewart J., Lebert J., Eva Côté G., Sebina-Zziwa A., Kibombo R., & Kisekka F. (2017). Gender and Artisanal and Small-Scale Mining in Central and East Africa: Barriers and Benefits, GrOW Working Paper Series, 2017-02 – Research Contribution Paper. Retrieved from https://impacttransform.org/wp-content/uploads/2017/10/GrOW-Working-Paper_2017.pdf

²⁶ GIZ & Levin Sources. (2019). Gender Safeguards for the Kimberly Process: Global Policy Dimension. Retrieved from https://www.bmz.de/rue/includes/downloads/Gender_KimberlyProcess_LocalPD_gb.pdf

²⁷ World Bank. (2019). 2019 State of the Artisanal and Small-Scale Mining Sector. Washington, D.C.: World Bank. <https://delvedatabase.org/resources/state-of-the-artisanal-and-small-scale-mining-sector>.

²⁸ Jaillon, A., de Brier, G. (2019). Cartographie des sites miniers artisanaux dans l'ouest de la Centrafrique, IPIS, for USAID. Retrieved from <https://land-links.org/wp-content/uploads/2020/04/AMPR-IPIS-ASM-Mapping-in-Western-CAR-English-Final.pdf>.

²⁹ Ndongo, B. & De Jong, T. (2019). *Baseline Knowledge-Attitudes-Practices (KAP) Survey of Artisanal Miners in the Central African Republic*. Washington, DC: USAID Artisanal Mining and Property Rights Task Order under the Strengthening Tenure and Resource Rights II (STARR II) IDIQ.

³⁰ Arcos, A., & Rivera Guzmán, E. (2018). Brechas de género en la minería. La minería artesanal y de pequeña escala colombiana desde una perspectiva de género. Envigado (Antioquia): Alianza por la Minería Responsable. Retrieved from https://www.responsiblemines.org/wp-content/uploads/2019/02/digital-brechas-de-g%C3%89nero_m21_c13-compressed.pdf

technologies right from Palaeolithic humans several hundred years ago, known as the Stone Age, man used crude instruments (bone, wood, stone, rock, etc.) to mine. As pointed out Olumuyiwa, early miners used simple ground control methods, ventilation, haulage, hoisting, lighting, and rock breakage.³¹ The advent of the Bronze and Iron Ages led to the discovery of smelting to reduce ore into pure metals or alloys, leading to the revolutionary techniques in the history of mining using fire-setting where a fire is used to heat the rock to expand. Then cold water is used to douse the stone resulting in the breakage - a scientific method invented by Alfred Nobel in 1867.

The industry continues to witness improvement, especially since the Industrial Revolution close to the eighteenth century. As the demand for minerals soared, an individual became more innovative and inventive and thus produced new technologies to increase production at a much lesser time and stress. Dynamite was discovered in the nineteenth century, while explosives became the most prominent technology used in the twentieth century. The continuous development of more mechanized instruments for mining brings about the industry's metamorphosis – from its peasant origin to a more commercial enterprise. The beauty of modern technologies in mining is that the contemporary technologies consider the need to address, environmental and energy conservation, declining deposit grade, and the safety of the miners.

In Nigeria, therefore, most technologies are not well developed compared with those of advanced countries; however, currently, most of the mining activities are carried out using chemicals/explosives, especially in ASM. Nigerian ASM lacks advanced technologies, which makes the industry unsafe. However, in some larger companies, Burke³² identified the following diverse technologies: explosives such as ammonium-nitrate and aluminized-slurry explosives are adopted. Others are the millisecond delays in blast ignition. Other technologies are the rock bolts, multi-drill hydraulic jumbos, load-haul-dump units, safety couplers on mine cars, longwall mining, airborne respirable dust control, and the global positioning system (GPS) in surface-mine operations. In plants, there are radiometric density gauges, closed-circuit television, hydro cyclones, wedge-bar screens, autogenous and semi-autogenous grinding mills, wrap-around drives, high-intensity magnetic separators, spirals and Reichert cones, high-tension separators, continuous assay systems, high-pressure roll grinding, computerized modelling, and process control, and many more innovations. However, only a handful of these technologies exist in the Nigerian mining industry.

Characteristics and Challenges of current mining Systems

The mining sector in Nigeria is characterised by certain pitfalls that impair its growth and development. Hafizullah³³ highlighted some of these challenges to include: low metal prices, depleted alluvial reserves, which are common in tin and columbite, inefficient State-owned

³¹ Olumuyiwa, I. O., Fred, A. O. and George, M. O., 2012. Groundwater: Characteristics, Qualities, Pollutions and Treatments: An Overview. *International Journal of Water Resources and Environmental Engineering*, 4 (6), pp.162-170.

³² Boakye, B., Cascadden, M., Kuschminder, J., Szoke-Burke, S. and Werker, E., 2018. Implementing the Ahafo Benefit Agreements: Seeking Meaningful Community Participation at Newmont's Ahafo Goldmine in Ghana. Available at SSRN 3661951.

³³ Hafizullah, A. A, Musa, B. G., Abdullateef, O. I., Victor, I. V., Mukhtar, H., H., Musa. S. D, Ismaila, V. H., Maimunatu, H., Dlama, K.V., Nasiru, A. M. & Yuxiang, Z, (2017). Solid Mineral Deposits of Nigeria: Potentials, Challenges and Prospects. <https://www.researchgate.net/publication/322153237>
<http://neiti.org.ng/sites/default/files/documents/uploads/neitiact.pdf>.

corporations, unfavourable mining code, opaque and inefficient license administration system, the prevalence of illegal mining, lack of adequate and reliable geoscience data, poor management of the state enterprise, excessive dependence on petroleum resources; policy instability, lack of credit and financing, and information on minerals mined. In another study, Shenpam, Araen, and Ali³⁴ also listed some of the overall challenges in the mining sector to involve inadequate reliable data that would convince individuals and organizations that these solid minerals are available in large quantities to the extent that the considerable investment in the business would not be futile. Other challenges include high exchange rate; inadequate capital investment in the solid mineral sector; inadequately qualified human resources; poor access to road and transport networks, erratic power supply and high energy costs is, a challenge to reliable mineral processing in the state; lack of modern technology to process the solid minerals into finished or semi-finished products is a challenge in the State; Policy issues and weak institutional capacities have encouraged the thriving of illegal miners and have reduced the ability of the Mining Corporation to fulfil its statutory obligations of diversifying the economy of Nigeria as a nation³⁵.

Addressing Mercury and Lead Exposure: A Formalization Approach

Mercury and lead are by-products of gold mining. Both, and both elements cause severe environmental pollution when not properly maintained³⁶. According to Spiegel, mercury and lead pollution exceed the combined emissions of coal combustion, cement production, Chlor-alkali plant operation, and large-scale industrial mining and metallurgy. Acknowledging the danger of mercury emission and the high health risks associated with the chemical substances such as mercury and lead as a result of the operations of ASM, Nigeria has signed and ratified the Minamata Convention on Mercury treaty meant to protect human health and the environment from the adverse effects of mercury exposure. Collaborating with the United Nations Industrial Development Organization (UNIDO) and the World Health Organization (WHO), Nigeria proposed to prepare a NAP for managing mercury in the ASGM sector. The NAP project began in March 2016 and had an estimated completion date of December 2019. The purpose was to create a safer mining programme and enable the environment to upturn productivity in the artisanal mining sector. This leads to the introduction of ASGM formalization. Formalization aims to reduce mercury and extension and reduce other social and environmental problems associated with the ASGM community³⁷.

Formalization is defined as:

the integration of artisanal mining activities into Nigeria's legal, economic, and institutional framework. In other words, —[a] well-designed formalization process generates the enabling conditions for accountability within the sector to be integrated into the formal economy ultimately. The idea is that by bringing

³⁴ Shenpam, G. D., Araen, A. S. Ali, A. Y. (2017), Challenges of Harnessing and Development of Solid Mineral Resources in Taraba State, Nigeria. *Journal of Resources Development and Management* Vol.35, pp 27-36

³⁵ Shenpam, G. D., Araen, A. S. Ali, A. Y. (2017), Challenges of Harnessing and Development of Solid Mineral Resources in Taraba State, Nigeria. *Journal of Resources Development and Management* Vol.35, pp 27-36

³⁶ Spiegel, S. J. Agrawal, S., Mikha, D., Vitamerry, K. Le Billon, P., Veiga, M., Konolius, K., & Paul, B. (2018). *Ecol. Econ.* 144, 1 –11.

³⁷ United Nations Environment Programme, UNEP (2012). Chemicals Branch, *Analysis of Formalization Approaches in the Artisanal and Small-Scale Gold Mining Sector Based on Experiences in Ecuador, Mongolia, Peru, Tanzania, and Uganda* (2012), http://www.unep.org/chemicalsandwaste/Portals/9/Mercury/Documents/ASGM/Formalization_ARM/Formalization%20Document%20Final%20June%202012.pdf.

artisanal miners under a legal framework that includes secure tenure, a valid license, and access to credit, among other things, they will have more significant support, incentives, and resources to improve their operations, develop safer mining practices, obtain greater profits, and potentially scale up their operations to the level of small and medium-scale mining. While formalization alone will not automatically solve all of the environmental and social problems facing the ASGM sector in Nigeria, it is likely the single best long-term approach for addressing the mercury and leads issues associated with artisanal mining in Zamfara elsewhere (Maconachie & Hilson, 2011; 302).

The formalization will reduce illegal mining to a considerable extent, but only if the process of licensing is made simple. It is impossible to eradicate illegal mining; it is beneficial to focus attention on making formalization easier for the miners to ensure compliance – the more complex the process, the more likely the illegal miners' activities increase³⁸. Furthermore, making a strict policy is likely to alienate communities and families who might want to hide away yet are still engaged in illegal mining.

The formalization approach addresses the more structural factors, such as rural poverty and the lack of viable alternative livelihoods, underpinning the artisanal and small-scale mining sector. Given the overall structure of artisanal operations in Nigeria, a fresh, integrated, and holistic approach must be adopted to formalize the sector and address its critical needs. The formalization approach must integrate organizational, social, labour, environmental, economic, health and safety, commercial, gender, and technical considerations. All these factors are essential for the reformation of the ASGM sector. However, improved financing is critical to a complete formalization and legal framework in the ASGM sector. Thus, formalization should also include sources of income and investments and or investors to invest in the industry. The core institutional, legal, and financial factors that need to be integrated with the formalization as elicited from the UNEP formalization report are presented in the figure below:

³⁸ Maconachie, R. & Hilson, G. (2011). *Safeguarding Livelihoods or Exacerbating Poverty? Artisanal Mining and Formalization in West Africa*, NATURAL RESOURCES FORUM, 35, 293-303.

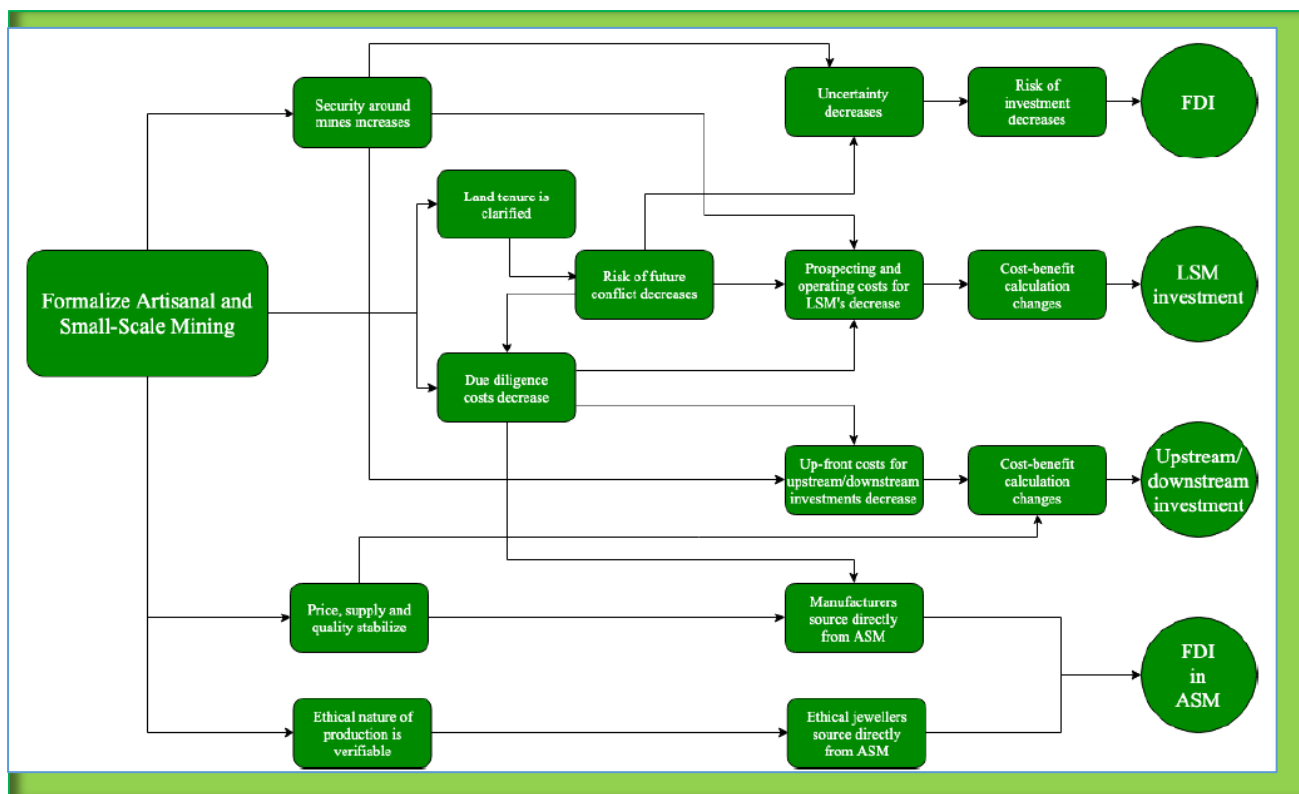


Figure 1: Path from formalizing mining to investment (source: Capstone team, 2019)

The Legal, Policy, and Institutional Framework Governing ASGM in Nigeria

One way to ensure sanity in ASGM is to enact laws to guide their action. Thus, in ASGM, two legal government agencies are responsible for overseeing the legal framework to guide mining activities. The Federal Ministry of Mines and Steel Development (MMSD) and the Federal Ministry of Environment (FMENV). It is the MMSD that administers the 2007 Minerals and Mining Act and its regulations and the actor that ensures the respect for information, policy, and regulatory oversight of the country's solid minerals sector. MMSD has the responsibility of formulating policy; providing information and knowledge to enhance investment in the industry; regulating operations; and generating appropriate revenue for the Government. Apart from the 2007 Mineral and Mining Act, MMSD also enacted the 2011 Minerals and Mining Regulations. In addition, MMSD has four technical departments with diverse responsibilities. These departments are: (1) the Mining Cadastre Office; (2) the Mines Inspectorate Department; (3) the Mines Environmental Compliance Department; and (4) the Artisanal and Small-Scale Mining Department.

The Mining Cadastre Office (MCO) has the responsibility of receiving and disposing of applications for the transfer, renewal, modification, or relinquishment of mineral titles or extension of areas as well as maintaining a chronological record of all applications for mineral titles. The Mines Inspectorate supervises the entire survey, exploration, and mining operations. It enforces the health and safety regulations at mining sites and conducts inspections and investigations necessary to ensure compliance with applicable laws. The Mines Environmental Compliance Department ensures that all plans, studies, and reports required from holders of mineral titles follow their environmental obligations. This department is also in charge of monitoring and enforcing compliance by holders of mineral titles with all applicable environmental requirements and responsibilities and carrying out periodic environmental audits to ascertain that mineral title holders are meeting all regulations and obligations. Finally, the Artisanal and Small-Scale Mining (ASM) Department oversees the ASM section activities.

This department is in charge of ensuring the formalization of the ASM sector and providing extension services to artisanal and small-scale miners. In addition, it supports ASM miners in exploration, exploitation, mineral processing, and entrepreneurial training. It is the role of this department to ensure that ASM is in harmony between the miners and the community and ensure that small miners and large-scale co-exist in harmony. It is responsible for liaison with other governments and multi-lateral organizations on behalf of ASM. Such organisations include the World Bank, UNEP, as well as Department for International Development.

On the other hand, FMENV is responsible for administering the National Environmental Standards and Regulation Enforcement Agency (NESREA) Act. Established in 1999, FMENV has the mandate to monitor and enforces laws meant to protect the environment; enact regulations intended to control water quality, air quality, effluent limitation, atmospheric protection, noise control, ozone protection, as well as controlling as well as the removal of hazardous substances in the air, land and sea; as well as cooperating with Federal and State Ministries, Local Government, statutory bodies, and research agencies on matters that relate with environmental protection and resource conservation.

MMSD has a basic legal framework for mining, including the 2007 Minerals and Mining Act and the 2011 Minerals and Mining Regulations; the three policy documents – the 2008 National Minerals and Metals Policy, the 2009 Vision 2020 National Technical Working Group on Minerals and Metals Development Report, and the 2012 Road Map for the Development of the Solid Minerals and Metals Sector, are all essential in controlling and monitoring the activities in the mining sector, precisely, the ASGM in varying degree.

The mining sector in Nigeria has undergone a series of reforms to improve the industry. As part of its development plan, the Government instituted the Solid Minerals Development Fund (SMDF) – a fund meant to assist in developing the mining sector as created in the 2007 Minerals and Mining act (the 2007 Act). The 2007 Act tasks the SMDF to ensure the development of both human and capacity of the sectors, including funding geoscientific data gathering, storage, and retrieval; equipping mining institutions to perform their statutory functions; funding extension services to artisanal and small-scale mining (ASM) operators; and provide mining infrastructure³⁹.

Among these are the New Minerals and Mining Act of 2007 that gives the Government total ownership of the mining sector, 100% private sector ownership of mining but through adequate licensing, the strengthening of geoscience data generation, the private sector liberal and transparent access to mining rights and the removal of discretionary powers of government officials in mining title grant, the competition for mining titles/rights on "first-come, first-served basis. Other practices include security of tenure of mining rights, the use of time limits for granting titles, the provision of the principle of "use it or lose it" in mining rights administration, the introduction of mineral resources and environmental management committee in states to facilitate mining development are some of the frameworks that have been put in place in Nigeria to help develop the mining sector.

Summary of the legal framework

³⁹ Nigeria Extractive Industries Transparency Initiative Act[NEITI Act] (2007), Nigerian Minerals and Mining Act 2007, Pub. L. No. 20 (2007) §34

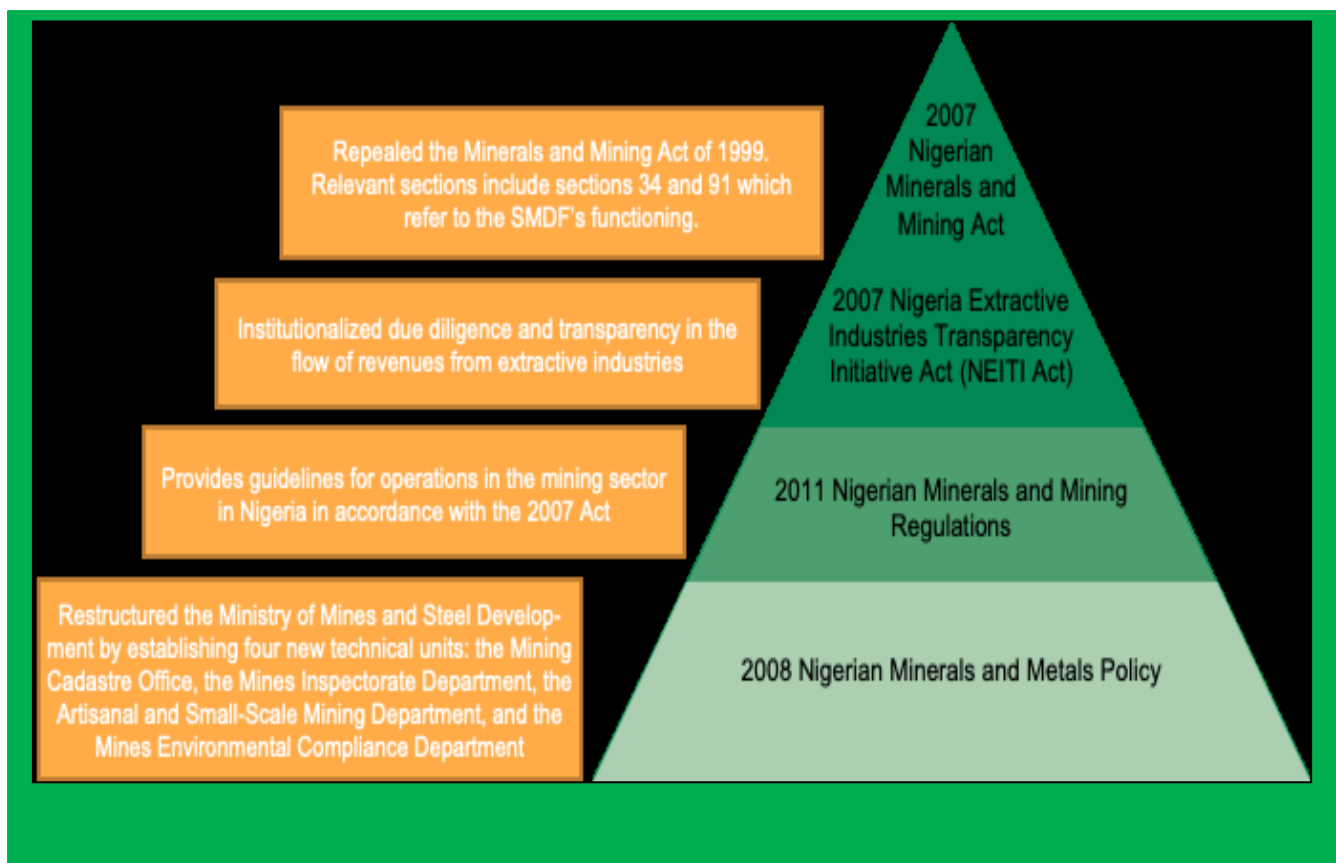


Figure 2: Legal framework for mining in Nigeria (source: Capstone team, 2019)

Opportunities and Future Directions of mining in the Global Market.

Although Nigeria is endowed with numerous mineral resources, only about 0.18% of it contributes to the nation's GDP⁴⁰. However, the mining industry has great potential for growth if the number of artisanal miners embraces restructuring through a formalization approach. Furthermore, the economic shocks and price fluctuation in the oil and gas sector have paved the way for the Nigerian Government to invest in the mining sector to have various means of exports. This will reduce the tendency of Nigerians over-dependent on oil and gas by embracing the diversity offered by the mining industry. As a result, the government has proposed new programs for formalizing artisanal gold miners. This is essential because ASM offers about 100,000 to 150,000 people jobs, directly and indirectly, supporting another 500,000 individuals. However, these individuals do not contribute to the nation's GDP for lack of formalisation. In addition, ASM is illegal and thus does not contribute to income taxes; they also lack access to financing and government labour protections.

Another opportunity for growth is the introduction of the Presidential Artisanal Gold Mining Development Initiative (PAGMI) meant to improve the sector. The initiative is intended to strengthen the industry. If improved, the miners' earnings are anticipated to increase by 5% as a result of an increase in productivity, adoption of a more mechanized method of mining operations, more excellent recovery rates, and access to improved geological data. Government involvement in mining will reduce the effect of mercury or lead in the air during production, improving the health of the local communities. PAGMI is hoped to promote safer mining

⁴⁰ Esdaile, L.J. & Chalker, J. M. (2018). The mercury problem in artisanal and small-scale gold mining. *Chem. Eur. J.* 24, 1 – 13 1

practices and help control the use of mercury and cyanide in mining activities. By formalizing more artisanal miners, the Government anticipates receiving higher taxes and royalties on mining activities. The Government estimates that only 0.008% of gold is being processed through official channels (NEITI Act, 2007). If the PAGMI achieves its medium-term target of formalizing 30-50% of the sector, the income tax benefit to the Government could increase by \$30-51 million, with royalties accounting for an additional \$9-16 million.



Figure 3. Presidential Artisanal Gold Mining Development Initiative (PAGMI)

The various reforms in the mining industry offer many opportunities to the sector as it can now attract investment from both private and public features. For instance, the Minerals and Mining Act of 2007 proposed several reformations in the sector, mainly by providing raw materials to domestic markets/industries such as bentonite and barite to the oil industry; marble, phosphate, and kaolin to the fertilizer industry; the supply of iron ore, marble, coal, refractory clay and magnesite to Ajaokuta Steel Complex; the supply of bauxite to the Delta Aluminum complex; and the supply of solid minerals to mineral consuming industries like ceramic, textiles, soap, glass, detergent, and building industry etc. Supplying products to the domestic market is a massive opportunity for ASM as that will go a long way to reduce the pressure from the foreign exchange and discourage the importation of these available raw materials into the country. The sector has opportunities to generate countless job opportunities for Nigerian youth, thus contributing to poverty alleviation. In addition, given the high rate of population growth, access to new markets is another opportunity for expansion for the mining industry.

Again, the expansion of trade has also led to the rapid growth of mining activity to generate foreign exchange earnings. In addition, mined products could be exported to foreign countries, thus increasing revenue from the sector. The reformation in the industry serves as an essential tool to attract investors and other investment incentives in the mining sector. The introduction of new modernized and more advanced infrastructure and machines has improved productivity and increased the industry's efficiency. Nowadays, companies, even companies in the mining sectors, are also embracing the transition to green growth. This requires investment in

infrastructure, plant and equipment, technology, and training people. The mining industry must also learn to introduce equipment that will encourage recycling, to reduce environmental pollution.

Finally, the introduction of SMDF has provided the financial assistance needed by the sector. The Government instituted the Solid Minerals Development Fund (SMDF) – a fund meant to assist in developing the mining sector as created in the 2007 Minerals and Mining act (the 2007 Act). The 2007 Act tasks the SMDF to ensure the development of both human and non-human capacity of the sector, including funding geoscientific data gathering, storage, and retrieval; equipping mining institutions to perform their statutory functions; funding extension services to artisanal and small-scale mining (ASM) operators; and provide mining infrastructure.

Conclusion and Recommendations

Until recently, the country Nigeria had dedicated all its attention to the oil and gas sector as oil constitutes above 80% of the nation's GDP. However, Nigeria is technically in a sorry state of serious economic difficulties following the fall in oil prices due to high inflation and fluctuation in the foreign exchange market. The situation calls for diversification. Diversification offers a significant competitive and strategic option for Nigeria regarding her developmental challenges. According to Saberu⁴¹, diversification is of great advantage for Nigeria to maximally utilize her great resource base to rebuild the economy and enjoy the benefits of all the linkages, synergy, economies of scale, grow national technology, and foreign investment profile, build human capital, exploit new opportunities, lessen averagely operational costs, increase national competitiveness and boost the standard of living and confidence of the citizens for a national renaissance. One way to diversify Nigeria's economy is to invest in the Minerals and Mining sector. Artisanal and Small-scale mining occupies a primary quota and, if properly maintained, will considerably contribute to the development of Nigerian economic growth and development.

The current economic challenges is a wake-up call to Nigeria and thus calls for the need to reposition the mining sector. Currently, the Government is dedicated to providing an enabling environment using a series of reforms beginning with formulating a national policy on solid minerals development. The formalisation policy takes care of two major constraints: environmental consciousness through monitoring the activities of ASM and the need to improve the sector to attract more investors. Other reformation includes the review of the Mineral Act of 1946, which was passed into law as the Minerals and Mining Act 1999, which gives the private sector the right to lead mining operations with the Government as administrator/regulator. There is the Mineral and Mining Act, 2007 which has increased the sector's competitiveness. The Government also has other agencies to oversee the operations in the mining sector, such as the Nigerian Geological Survey Agency (NGSA), with the responsibility to generate, manage and transfer geological data meant to improve the development of solid minerals in Nigeria. Reliable information is one of the critical success factors in the mining sector, thus making NGSA extremely important.

Privatization of the Sector is also a way to improve the sector. Consequently, the mining sector, which was once owned 100% by the Government now has about 21 subsidiaries, 22 Associated Companies (four of them with foreign holdings: Niger Uranium (30%); Guinea Uranium

⁴¹ Suberu O. J., Ajala O. A., Akande M. O., Olure-Bank Adeyinka (2015). Diversification of the Nigerian Economy towards a Sustainable Growth and Economic Development. *International Journal of Economics, Finance and Management Sciences*. Vol. 3, No. 2, pp. 107-114. DOI: 10.11648/j.ijefm.20150302.15

(25%); Guinea Bauxite(13%); Niger Phosphate(10%)) and over 60 Mining Titles that have been slated for privatisation.

Beyond the policies, there are other transformation agendas by the Government meant to ensure compliance in which the goal is to achieve best practices in the mining sector. The Government has made several efforts to revamp the industry thus far; however, the mining sector in Nigeria still has some weaknesses and challenges. Among these are the dearth of proven mineral reserves, the smuggling of minerals out of the country, inadequate infrastructure and Slow effort by the Government to provide the requisite enabling environment, the uncompetitive legal and regulatory structure, illegal mining and economic capital flight through the unlawful sales of minerals commodities, the lack of mineral production and processing capacity, the lack of a target time-bound strategic plan, the inadequacy of reliable geological data for investors, and the looming conflicts between the Federal and the States Governments on who has the rights on minerals in its domain, and unfavourable domestic fiscal policies.⁴²

Despite the limitations, the industry has a great chance to grow, mainly if it supplies its essential materials to our domestic industries; creates jobs to alleviate poverty, provides raw materials such as fertilizers to improve the agricultural sector, generates energy from solid minerals, if the downstream sector is developed and gain access to new markets that will enhance its price. Also, trade expansion is another opportunity for growth for the industry; investment initiatives in the sector and modernization and increased efficiency are all opportunities for the industry to grow. These opportunities abound, but it is worth noting that there are also some threats confronting the mining sector in Nigeria, particularly the Artisanal and small-scale mining. These threats include inadequate capital, the poverty status of the mining community, corruption in the country, the state of insecurity and damaging environmental practices, among others.

The following as measures to improve ASM are recommended:

- 1) The Government should establish a body to carry out regular environmental impact assessments (EIA) to monitor, explore, and develop a project related to mining and mining operation and closure. The goal is to promote green growth in the sector
- 2) There should be more partnership between the Government and private sector (PPP) to ensure sustainability
- 3) There should be a constant risk assessment of both the mine as well as mining activities to mitigate risks in the sector
- 4) There should be ready-made provision for response to emergencies at the local levels
- 5) There should be improvement mechanization and technology to ease the stress and improve the quality of the job.
- 6) The Government should ensure consistent and attractive fiscal and legal policy to guide and ensure the protection of miners and mining activities and constant review of these policies regular to suit current trends of the event in the sector.
- 7) There should be sanction for defaulters to serve as a deterrent to others
- 8) The Government and other investors should improve the funding in the sector to promote research and serious exploration work in the industry.

⁴² Lahiri-Dutt, K. (2012). Digging Women: Towards a New Agenda for Feminist Critiques of Mining. *Gender. Place and Culture*. 193-212. Retrieved from https://www.researchgate.net/publication/233355834_Digging_Women_Towards_a_New_Agenda_for_Feminist_Critiques_of_Mining/citation/download

- 9) Registration and licensing process should less cumbersome and made to be smoothly to take less time to complete and as long as the applicants abide by the laws and policies. related to the mining sector.