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ECOLOGICAL SUSTAINABILITY AND POST COAL MINING IMPACT ASSESSMENT ON MAIGANGA COMMUNITY AND ENVIRONS

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ABSTRACT

Mining of natural resources of any kind leaves behind human footprints where little is done to restore the mined area back to its previous status. In this study we examined literature on the socio-cultural and environmental impacts of over a decade of coal mining in Maiganga. We searched databases to retrieve articles/publications on the implication of mining in Maiganga. We administered structured questionnaires to 160 respondents in five communities within the Maiganga Coalmine and environs. Our goal was to facilitate an unbiased conclusion on the level of compliance and sustainable practices of the coal mining company in Maiganga. Independent conclusions from retrieved journal articles revealed that 53.7% of coalmining focused studies conducted in Maiganga were neutral, 26.8% positive and 19.5 % negative. Similarly, respondents differed in their rating of the company's compliance; with (50%, 35% and 15%) of communities being of the opinions that the coal company has done fairly well, poorly, and absolutely nothing respectively. Further comparative analysis revealed that respondents from Piyau, Maiganga and Tudun Kuka were more of the opinion that the company has done fairly well with regards to CSR with 60%, 56.7%, and 56.3% respectively. Our findings suggest that the negative impact of mining at Maiganga is somewhat overrated; also, the effort by the company to improve health care services seems underappreciated; only 10.6% of respondents utilize the clinic established by the company. Despite ongoing efforts to reclaim mined areas and other eco-friendly interventions; we enjoin the company to periodically engage the community to determine areas for future interventions. Periodic post-mining EIA will help determine if the identified environmental impacts are stable, decreasing or increasing.

Key Words: Maiganga, Environment, Mining, Sustainability, Biodiversity

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INTRODUCTION

Historically, humans have explored the once vast natural resources for food, medicine and energy generation. These basic needs have risen along with human population increase with a resultant escalation in the negative impacts of human resource exploration on the environment (Seto*et al*., 2012). For instance, the use of technology and heavy equipment during mining and natural resource extraction leaves behind a distorted landscape, loss of natural habitats and massive depletion in biodiversity (Czech *et al*., 2000; Groffman et al., 2017).

Coal is the most abundant fossil fuel on earth (Ramani, 2013). It contributes more than one third (39%) of total electricity production all over the world (Brown, 2002). It is seared to produce heat or liquefied to produce gas and diesel fuel. Coal therefore is a major raw material for energy production.Energy of any kind is an indispensable resource, a basic requirement in our everyday lives and a crucial vehicle that drives economic growth and productivity(Abbasi and Abbasi, 2010).

Past studies had captured the significant contributions of coal to the growing economic, industrial and energy sectors of many developed and developing nations (Bhangare *et al*., 2014; Lauer *et al.*, 2015). Nonetheless, the environmental impacts and human health challenges associated with coal extraction and utilization cannot be overlooked or traded in exchange for the pecuniary benefits it offers (Maina *et al*., 2016). In recent times, whenever coal is mentioned in most public conversations (see COP 26 - Glasgow 2021), the demerits of coal mining seem to resonate more than the industrial and economic benefits especially with the proliferation of green alternatives to energy demand/supply (Kaygusuz 2012). These grim views have driven public perception of mining and extractive industries as enemies of the environment (Abdulsalam *et al*, 2016). According to Nitasha and Sanjiv (2015), post-mined sites are wastelands, and structurally damaged landscapes. Similarly, Maina *et al*., (2016) are of the opinion that post mined sites are ecologically unproductive and biologically barren. This is perhaps the reason for public condemnation (Abdulsalam *et al,* 2016) and ceaseless litigations (Adamu 2014).

Despite the seeming indications of unsustainable practices that have typified most extractive industries (Mishra 2004) and the fact that mining of any kind will always leave behind negative human footprints; there are signs that things could be less grim and negatively impactful, especially if miners adopt a safer and more eco-friendly approach (Oruonye *et al*., 2016).

Over the years, there have been gradual improvements in the way and manner in which the extraction and mining processes are done. The adoption of safety protocols, adherence to environmental regulations and laws, as well as sustainable practices to restore degraded landscapes (see Lafarge sustainability report 2020) have greatly reduced the negative impact of extractive industries. In fact, there are a horde of measures that have proven to alleviate the negative consequences of mining. These measures include but not limited to; progressive land reclamation, artificial wetland establishment to treat effluent discharge and acid mine drainage, and provision of alternative livelihood support systems. These measures when applied accordingly substantially reduce the negative impacts of mining to acceptable and less debilitating levels.

In addition, industries and mining companies are expected to conduct EIAs to determine the potential effect of their activities on the health of the people and the environment. These EIAs are ultimately tailored to mitigate or proffer remedial actions were possible or to out-rightlydis continue any further actions where the impact is deemed catastrophic.

Based on the forgoing, natural resource managers expect companies as part of their corporate social responsibility (CSR) to adopt the one health approach of maintaining and protecting the health of the environment, biodiversity and humans. This is why studies of this nature focus on the three components vis-a-vis environment, human health/wellbeing as well as biodiversity of the affected area. In this current study, we searched data bases for materials and information from researches carried out since inception of mining in Maiganga to develop a repository of information on what has been empirically done with regards to the effects of mining in the study area. We also evaluated the environmental reclamation actions of the company, the level of safety compliance, and corporate social responsibility obligations tailored to mitigate the impact of coal mining on the three components of health of the environment, people and biodiversity.

While some reports and studies (Oruonye *et al*., 2016; Lafarge Sustainability Report 2021), indicate some measure of sustainable practices in Maiganga coal mine; it has nonetheless become imperative to holistically review what has been done in the past and critically examine their respective conclusions. This holistic approach will support empirically driven, and fact-based conclusion on the overall impact of the mining activities of the company. These actions were evaluated based on their inherent capacity to sustainably mitigate the negative impacts of mining activities in Maiganga and other surrounding communities.

MATERIALS AND METHODS

Study Area

Maiganga village is located in Akko Local Government Area of Gombe state. The village is located 8km off Gombe – Yola Road; west of Kumo town between Latitude 09^{o} 18', and 11^{o} 59'E. The total area originally occupied by the community covers an area of about 48.16 Km^2 (Maina*et al.* 2016). However, as at 25th September, 2021, the Active Mine area is currently about (16.5 Ha.).Similarly, all areas with trees are about 31.32 hectare, while area filled with top soil is about 3.18 hectare (Lafarge Sustainability report, 2021).

The study area is typically distinct as dry savannah, predominated by grasses, shrubs and thorn-scrub interspersed by few trees; example *Pakia biglobosa*, *Tamarindus indica*, *Balanites aegyptiaca*, *Butyrospermum paradoxa*, *Afzelia africana* and *Adansonia digitata* (Abdulsalam *et al.,* 2016). It lies within the tropical continental type of climate characterized by well-marked wet and dry season. Rainfall ranges between 850 to 1000mm^3 and the rainy season last between 5 to 6 months (Oruonye *et al.,* 2016). It is also home to some extant vertebrates such as **s**quirrels, bats, giant monitor lizards, venomous snakes and small rodents. The coal mine is characterized by two ponds and an engineered wetland which is designed as the third phase of the water treatment process for eventual discharge or use for irrigation agriculture by the host communities. The sedimentation pond periodically feeds the artificial wetland where water plants like *Typhadom ingensis* and Common reed *Phragmites australis* have been planted to rid the water of any remaining traces of heavy metals after sedimentation.

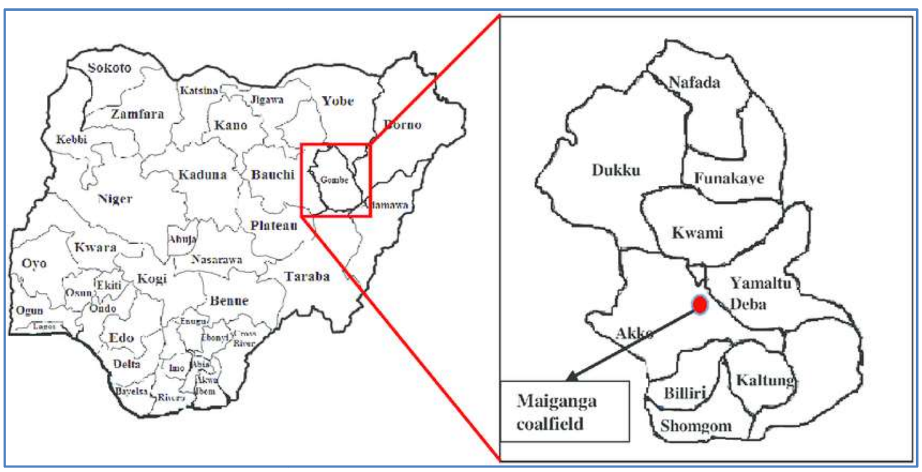


Figure 1A: Map of Akko LGA showing Maiganga coal mine field. (Source Koko *et al*., 2016)

Figure 1B. Differentiation and Graphical Description of the Maiganga Coal Mine as at September 25th, 2021. (Source: Koko *et al*., 2016)

Data Collection:
We conducted a search of research databases (Research gate, Scopus, Google scholar) to generate articles and reports on Maiganga coal mining activities and complemented this with empirical data from field assessment of the mine. In addition, we conducted interviews with key company players, community heads and administered 160 questionnaires to residents of the host communities.

Field Assessment: To validate some of the views and conclusions drawn from various researchers and the respondents, we inspected the facility, the mine sites, reclaimed landscapes, and wetlands. We used the checklist derived from a related study (Nsor *et al*., 2022), to determine the state of health of the environment using bird species as indicators. Pictures and field observations guided our conclusions of the level of sustainable mining practices and environmental safety measures taken by the company in the course of their mining activities in Maiganga.

Data Analysis: Descriptive statistics was used to analyse the data to determine frequencies and percentages. We used tables, figures and photographs where applicable to buttress our findings and conclusions. Microsoft Excel and IBM SPSS version 25.0 was used for analysis.

RESULTS

Our findings indicate that research started in 2011(Figure 2a), a year after the establishment and commencement of coal mining in Maiganga. The greatest number of researches were conducted in 2017 (Figure 2a). Results and conclusions drawn from previous researches were categorized as positive (where conclusions spell out positive outcomes), or negative (where findings are otherwise). Similarly results from studies that focused on subjects other than health and environmental wellbeing were categorized as neutral (Figure 2b).

There were more positive than negative outcomes from researches that focused on the subject of water quality, air pollution, and human health. Conversely, the subject of environmental safety had slightly more negative conclusions than positive ones; however, on the subject of agriculture and livelihood options, all the two researches identified, drew negative conclusions regarding the impact and implication of coal mining in the study area (Figure 3).

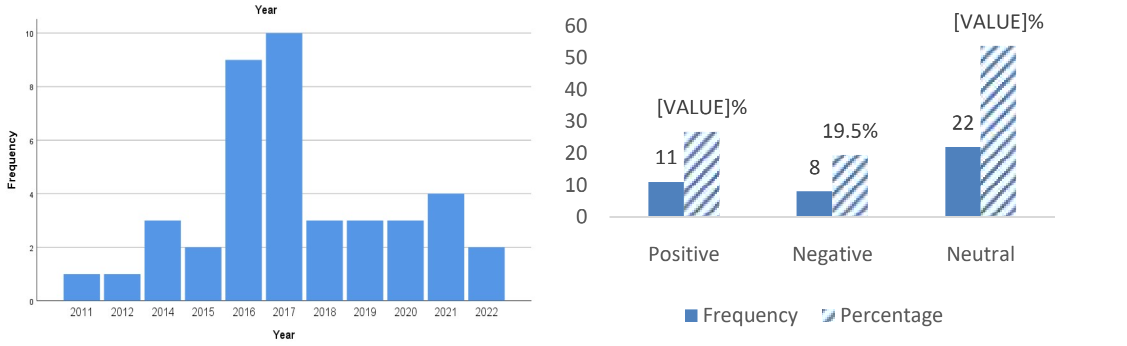


Figure 2 (a) Publication history and frequency since inception

(b) Category of remarks and conclusions from emperical studies of independent researchers

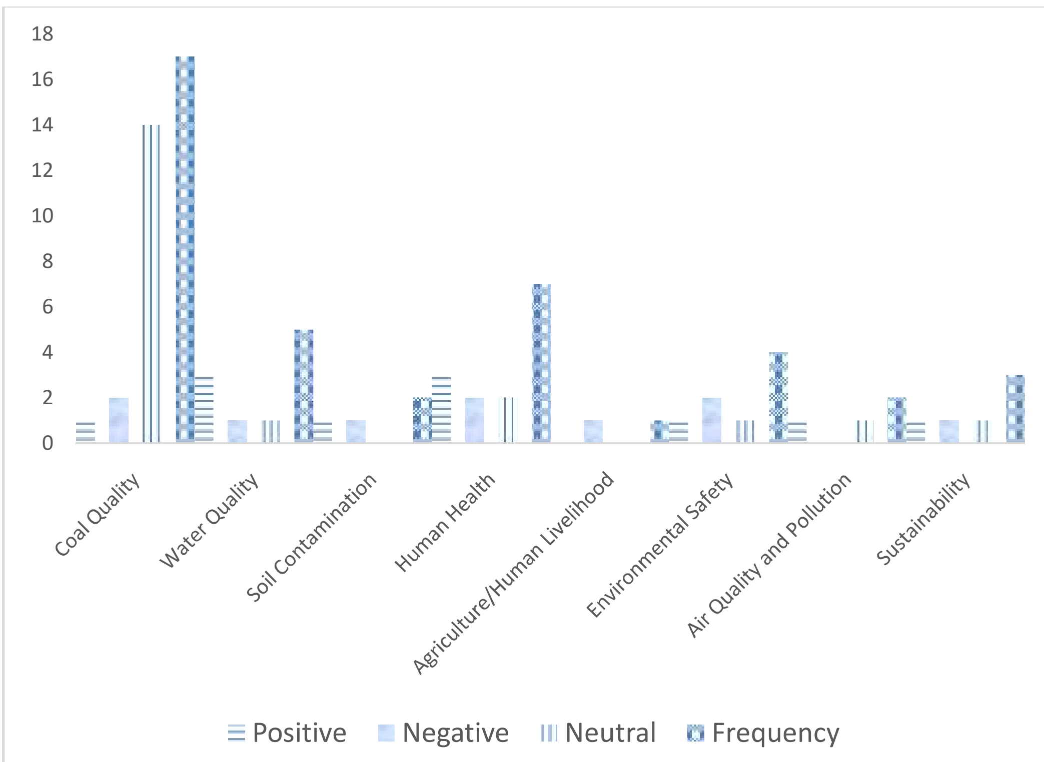


Figure 3: Research focal areas and distribution of respective outcomes

Respondents were more in Maiganga than the rest of the surrounding communities (Figure 4). Also worthy of note is the age distribution of respondents, where the highest population was within the age of 20-30 (Figure 5). As is typical of most rural settlements, farming was the commonest occupation across the various communities. Interestingly, all respondents (100%) confirmed that they farm to survive despite a few of them working as company staff, civil servants or engaged in one business or the other (Figure 6).

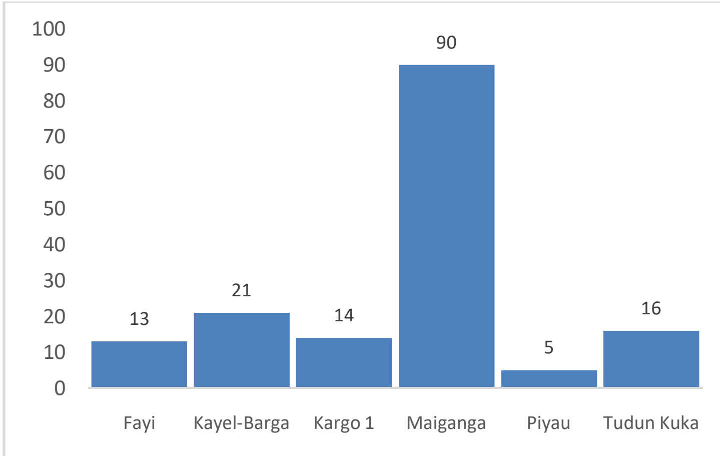
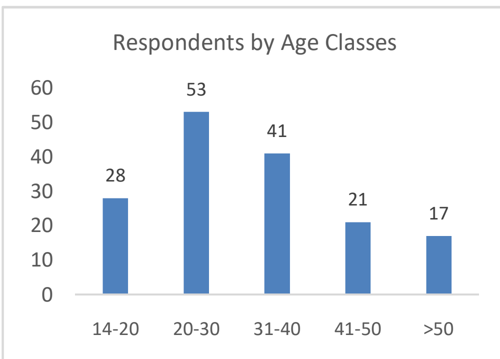


Figure 4: Distribution of respondents across surrounding communities



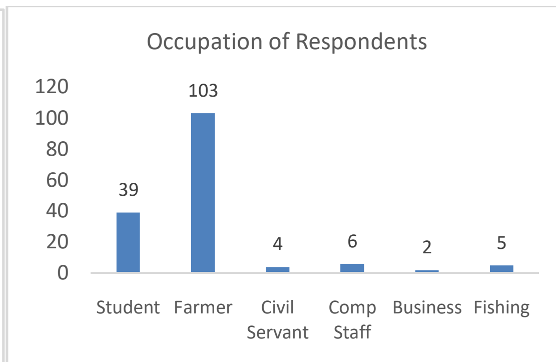


Figure 5. Respondents across Age groups **Figure 6. Occupational distribution of respondents**

Sustainable practices and Cooperate Social Responsibility (CSR) of the Company

Results indicate that 50 % of the respondents are of the view that the company has done fairly well, while 35% and 15% of the respondents are of the opinion that the company has done poorly and absolutely nothing respectively (Table 1). Further comparative analysis revealed that respondents from Piyau, Maiganga and Tudun Kuka were more of the view that the company has done fairly well as indicated by 60%, 56.7%, and 56.3% of respondents respectively (Table 2).

With regards to the quality of water and its availability, 96.9 % of respondents alluded to lack of clean drinking water. Similarly, 73.7 % of respondents were found to be dependent on hand-dug well water. On the effectiveness of the amenities available for health care, we inquired their health care destinations and we found that 84.4 % of respondents prefer Kumo General Hospital to the facility provided by the company in Maiganga. Only 10.6 % depend on the clinic in Maiganga.

Agriculture and Fisheries

Our field observations and questionnaires revealed that the most dominant crop cultivated in the area is maize (*Zea mays*), while other common crops were found to be millet (*Pennisetum glaucum*), rice (*Orizasativa*), sorghum (*Sorghum bicolor*) and Soya beans (*Glycine max*) (Table 5). A few respondents also indicated fishing as their main occupation, although they confirmed ownership of farms to complement their fishing venture (Figure 6).

Table 1. Respondents' views on provision of basic amenities (Water), healthcare and general wellbeing in Study area

S/No	Particulars	Respondents	Percentage
Sources of Portable Water			
1	Stream	9	5.6
2	Stream/well	24	15
3	Tank	6	3.8
4	Water Discharged from Company	2	1.3
5	Well	118	73.7
6	Well/Tank	1	0.6
Clean Water			
1	Yes	5	3.1
2	No	155	96.9
Health Care Destination			
1	Gombe	8	5.0
2	Kumo	135	84.4
3	Maiganga	17	10.6
Relocation			
1	Yes	152	95
2	No	8	5
Compensation			
1	Yes	68	42.5
2	No	92	57.5
Effects of Relocation			
1	Farmland/Ancestral Home	132	82.5
2	Farmland	2	14.4
3	Non	5	3.1
Corporate Social Responsibility (Promises Kept)			
1	Absolutely Not	24	15
2	Fairly Good	80	50
3	Poorly	56	35

Health and General Wellbeing: Results indicate that disease prevalence varied amongst the various communities. For instance, Malaria and Typhoid fever were reported as common diseases even before mining commenced across all communities studied

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Table 2: Respondents' views on CSR and other indices in Maiganga and across the various settlements/communities around Maiganga (Values in brackets are percentages while open values are counts and frequencies)

S/N	Parameters	Remarks	Fayi	Kaibuga	Kargo	Maiganga	Piyau	Tudun Kuka
1	CSR/Prom	Fairly	3(23.1)	9(42.9)	6(40)	51(56.7)	3(60)	9(56.3)
		Poorly	8(61.5)	12(57.1)	2(13.3)	24(26.7)	2(40)	7(43.7)
		ABN	2(15.4)	0	7(46.7)	15(16.6)	0	0
2	Relocation	Yes	12(92.3)	20(95.2)	15(100)	85(94.4)	5(100)	15(93.8)
		No	1(7.7)	1(4.8)	0	5(5.6)	0	1(6.2)
3	Compensation	Yes	7(53.8)	9(42.9)	8(53.3)	37(41.1)	4(80)	3(18.7)
		No	6(46.2)	12(57.1)	7(46.7)	53(58.9)	1(20)	13(81.3)
4	Clean Water	Yes	0	0	2(13.3)	2(2.2)	0	1(6.2)
		No	13(100)	21(100)	13(86.7)	88(97.8)	5(100)	15(93.8)
5	Health Care Destinations	Maiganga	2(15.4)	0	1(6.7)	10(11.1)	0	4(25)
		Kumo	10(76.9)	20(95.2)	13(86.7)	77(85.6)	5(100)	10(62.5)
		Gombe	1(7.7)	1(4.8)	1(6.7)	3(3.3)	0	2(12.5)
6	Source of Water	Well	13(100)	18(85.7)	15(100)	58(64)	5(100)	9(56.2)
		Stream	0	1(4.8)	0	7(7.8)	0	1(6.3)
		Stream/Well	0	2(9.5)	0	16(17.8)	0	6(37.5)
		WDC	0	0	0	2(2.2)	0	0
		Tank	0	0	0	7(7.8)	0	0
7	Sex	Male	12(92.3)	18(85.7)	9(60)	55(61.1)	2(40)	10(62.5)
		Female	1(7.7)	3(14.3)	6(40)	35(38.9)	3(60)	6(37.5)
8	Livelihood Effects	Home/ farmland	12(92.3)	19(90.5)	14(93.3)	68(75.6)	5(100)	14(87.5)
		Farm	1(7.7)	1(4.8)	1(6.7)	18(20)	0	1(6.25)
		Non	0	0	0	0	0	0

Table 3: Disease Prevalence before and after the commencement of miningin Maiganga(values in brackets are post mining disease prevalence, while openvalues are pre-mining).

S/No.	ParticularsDiseases	Location					
		Fayi	Kaibuga	Kargo 1	Maiganga	Piyau	TudunKuka
1	Appendix	0	0	0	0(1)	0	0
2	Asthma	0	0(1)	0	0	0	0
3	Blindness	0	0	0	1(1)	0	0
4	Cancer	0	0(1)	0	0(2)	0	0
5	Catarrh	0	1(1)	0	1(0)	1(0)	0
6	Cough	0	0(2)	0(1)	0(21)	0	0
7	HBP	0	0(1)	0	0(1)	0	1(0)
8	Liver Issues	1(3)	0(3)	0	1(4)	0(1)	0(10)
9	Malaria	8(0)	14(1)	11(4)	78(0)	4(0)	11(0)
10	Nil	2(8)	4(7)	2(6)	4(43)	0(4)	0(6)
11	Respiratory Diseases	0	0(3)	0	0(1)	0	0
12	Skin Infection	0	0	0	0(1)	0	0
13	Toilet Infection	0	0	0	0(8)	0	0
14	Typhoid	5(1)	15(7)	3(5)	36(27)	4(0)	11(0)
15	Ulcer	6(1)	5(5)	4(7)	20(12)	5(0)	12(0)
Total New Health Challenges*		0	6	1	7	1	1
	N respondents	13	21	14	90	5	16
Mechanism of Spread							
1	Water borne	0	0	0	0	0	0
2	Air-borne	0	3	1	2	0	0
3	Food poison (soil/water)	0	1	0	1	1	1
4	Unknown/ Genetic	0	2	0	4	0	0

*Key: 0 values indicate absence, all values are counts. * = total new health challenges are derived from entries with 0 values outside bracket (no disease) and values greater than 0 in bracket (disease presence).*

Table 4: A summary of CSR fulfilment, benefits and contributions of the Coal Mining Company to the host community, state and diaspora

S/No.	Particulars	Actions/Benefits
1	Healthcare	i). Establishment of a health care facility Clinic in Maiganga
2	Education	i). Establishment of a primary school facility in Maiganga
3	Access Roads	i). Construction of 8-kilometre asphalt road trip
4	Environment	i). Reclamation of mined area ii). Establishment of fruit tree plantation iii). Establishment of exotic and native tree plantation iv). Construction of Artificial wetland for waste water treatment
5	Employment	i). Provision of jobs for over 150 youths (source: Questionnaire)
6	Agriculture	i). Provision of extension services, multipurpose cooperative group and agro-based training ii). Incentives (fertilizers, cultivars, improved seeds and grants)
7	Eco-tourism	i). The facility is open to the public for educational purposes and ecotourism
8	Biodiversity	i). The site now supports water birds of global importance that were previously absent, and a major avian diversity hot-spot in Gombe.
9	Research	i). The facility has attracted researchers from all over the world so far, over 41 insightful researches have been conducted with a a global spread and diversity of research interest (Figure 3)

Table 5: Variety of Crops Cultivated in the study Area

S/No.	Crops	Fr	%
1	Mz,R,S, Gn	1	0.6
2	Mz,S	1	0.6
3	Mz,S,Mi	1	0.6
4	Mz,W,R	1	0.6
5	SB,Mz,Mi	1	0.6
6	Mz,SB,S,Mi	2	1.3
7	SB,Mz,R,Mi	2	1.3
8	SB,Mz,R,S	3	1.9
9	SB,Mz,R	5	3.1
10	Mz	7	4.4
11	Mz,R	16	10
12	Mz,R,S,Mi	17	9.6
13	Mz,R,S	43	26.9
14	Mi,R,Mz	60	37.5
	Total	**160**	**100**

Key: *Mz = Maize, Miy = Millet, R=Rice, Gn= Groundnut, S= Sorghum, W= Wheat, SB= Soybean*

DISCUSSION

The current study sought for empirical clarity on the ecological and socio-cultural implications of the more than a decade of mining of coal at Maiganga. The results derived from evaluating primary and secondary data obtained from questionnaires, company reports and research repositories have proved very insightful. Over 41 publications in peer-reviewed journals were evaluated; the inference drawn from these independent researches allude to the fact that the general perception of the negative impact of mining activities may be somewhat overrated. This assertion is based on critical review of related studies that looked at the negative impacts of coal mining. For instance, most studies with pejorative captions, eventually reveal that some of the post mining pollutants of soil, water and air, are often below harmful thresholds and within environmentally safe limits (Onsachi *et al.*, 2016; Koko *et al*., 2016; Ademu *et al*., 2020). More so, studies have shown that the anthropogenic footprints observed by most of the researches captured in this study (Appendix 4) can be erased and the distorted landscapes and ecological systems restored to their former or near pristine states. This is possible through the adoption of nature-based solutions and progressive reclamation measures (Oruonye *et al*., 2016). So far, the company has adopted bio-depuration, a nature-based solution that leverages on the heavy metal absorption capabilities of two species of water plants; Typha*Typhadom ingensis* and Common reed *Phragmites australis*. The idea behind this measure is to ensure that the water released from the wetland into farmlands for irrigation agriculture as well as other sundry uses, is devoid of lethal doses of heavy metals. This environmental remediation technique is not only effective but very eco-friendly.

Furthermore, of the 41 researches retrieved from web-based repositories, that examined the mining activities in Maiganga; Nineteen 19 studies (46.3%) focused on direct impact of mining on human and environmental wellbeing. Interestingly, of the 19 studies, 11 studies came to a positive conclusion with regards to sustainability and One-health focus. On the contrary, 8 studies had negative conclusions drawing attention to the impact of mining activities on the health of the residents as well as its implication on water and soil quality of the study area. While we may think that public outcry over the negative implication of mining may be disparagingly overrated, we should as a matter of fact take heed irrespective of the ratio of positive inferences relative to the negative ones. In our opinion, one cogent study highlighting negative implications is enough concern especially if the results call for urgent actions, or if the identified pollutant has the potential to toxically bio-magnify in the course of time. Analysis of available literature indicate that the bulk of the research numbering 22, (53.7 %) were focused on either coal quality (13 studies), or potentials for hydrocarbon deposits (2 studies) or some hypothesis testing or the other (3studies) (Figure 3). However, there were studies that had both negative and positive findings with suggestions that could help eliminate the identified negative impacts. In the same vein, some studies were neither concerned with environmental sustainability or health of humans and biodiversity (Figure3). This study has brought to the fore the state of affairs at Maiganga with regards to the health risk of people, biodiversity and the environment. More so, it has highlighted areas that may require more research attention and urgent actions. Furthermore, the over a decade long presence of the Mining company in Maiganga, has placed the once relatively unknown locality on the global map, as can be seen fromour harmonized research repository (Appendix 1). It is this spread and robustness that underpins our interpretations and conclusions

Sustainable mining, Environmental Safety: Implication for Agriculture and biodiversity

While we know from our evaluation of respondent's views and analysis of available evidence from empirical works of previous studies that the soil may be contaminated with heavy metals as a result of poor draining of acid mine and other pollutants (Adamu *et al*., 2017; Ademu*etal.,* 2020; Ezemokwe *et al*., 2021); studies have shown that, soil contamination could be from a host of sources other than the coal mine. For instance, past studies highlighted the significance of some agricultural practices to the health of ecosystem. They opined that most harmful heavy metals and other pollutants of soil and water are inadvertently fixed or introduced through agricultural practices; specifically the use of fertilizers, glyphosate-based herbicides and pesticides could fix heavy metals such as lead, arsenic, chromium and nickel (Wuana and Okieimen, 2011). In this study 100% of respondents affirmed that they use fertilizers. The use of fertilizers is almost ubiquitous in Nigeria, but more profound and somewhat obligatoryin the northern region because the arid and semi-arid savannah that typifies this region seems to be nutrient depleted due to leaching, wind and water erosion as well as other ecological factors (Maiangwa and Ogungbile, 2008). These fertilizers and other agro-chemicals accumulate over the years become more impactful through bio-magnification eventually contributing meaningfully to the overall pollution of the soil and water. In the end, the toxins enter the food chain disrupting both ecological networks of interacting organisms and health of humans who are at the top of the food chain.

Regrettably, there seem to be a dearth of alternatives of replenishing lost nutrients from depleted soils and combating pests. This leaves farmers with little or no alternatives other than dependence on inorganic fertilizers and pesticides especially for large scale farming. While we urge mining industries to embrace sustainable and environmentally friendly practices (Maina *et al*., 2016; Abdulsalam *et al*., 2016), we hope that relevant government agencies and MDAs will join forces to create awareness amongst farmers nationwide to adopt eco-friendly alternatives to fertilizers. This will go a long way in reversing the ugly trend of over-dependence on agro-chemicals. Fortunately, at Maiganga, there is an ongoing partnership between the Mining Company and ABU-Zaria owned Agricultural extension service providers. Under these schemes, farmers in Maiganga and environs are provided grants, seedlings and new technical skills to farm sustainably and ultimately to boost productivity.

Similarly, in Maiganga, the first purposeful artificial wetland is under establishment. When completed, it will boost agriculture, support biodiversity, especially water birds and improve the overall health and wellbeing of the host community. So far there is evidence of biodiversity boost, with over 120 bird species recorded in a recent avian diversity survey (Nsor *et al*., 2021). The authors recorded 19 wetland bird species, of these, 9 species were of global importance as they are listed among the 250 AEWA (African-Eurasian Wetland Agreement) priority species.

One-Health approach through environmental restoration

The health of the environment guarantees the health of humans and biological diversity. If well harnessed, this one-health approach simplifies the task of providing and achieving health for all. So far results suggest that the most common threats to the health of the host communities is Malaria and typhoid (Table 3), which are common endemic health challenges of sub-Saharan Africa. The fact that only a few respondents mentioned ailments that are most likely to be introduced by the presence and activities of the company, suggest that, perhaps the residents are not exposed to new health challenges as a result of coal mining as is often touted by some researchers and pundits. Interestingly four out of the seven allegedly new diseases exclusive to Maiganga seem to be unrelated to Mining or post mining effects (Table 3). Fourteen health challenges or diseases were mentioned by the 160 respondents. Of this number, six diseases were mentioned by only one respondent across the six communities. This is statistically and empirically weak to necessitate any claim of prevalence. There is also a strong possibility that the cause of these six diseases may be completely unrelated to coal mining in the study area. Further medical and epidemiological investigations are needed. Furthermore, results indicate that despite the provision of a health care facility; the facility (clinic) seem to be highly under-utilized. Further investigations identified lack of manpower, equipment and drugs as the reason why most residents prefer the general hospital in Kumo to the clinic at Maiganga (table 1).

So far, the project has planted over 70,000 plants on 15 hectares of land. In addition to ecological restoration, the project has also established economic fruit plantations such as mangoes, cashew, and oranges etc. These fruits are seasonally harvested by the residents of the host community periodically. In addition, the trees are contributing to the overall rehabilitated areas of the Maiganga coal mine site. It is apparent that this project will make huge contributions towards the targeted reduction of the global carbon footprint by 2030.The entire project when completed may go a long way in sustaining the peace within the general area. The abundance of treated water through the artificial wetland project of the company for communities' use all year round will eliminate sometimes aggressive competition for limited resources of which water and land are paramount.

CONCLUSION

This study has categorically shed light on the controversies that have dominated public perceptions on key issues of health, compensation, environmental degradation and other contending issues. Our conclusions are anchored on empirically driven scholastic findings and what we found through our field assessments during this study. In the light of this, we are confident that although our opinions may be subjective, our postulations are based on facts and empirical data and can be validated at any time.

While we know that there are still issues of grave concerns, and apparent negative impacts predicated on the activities of the company, we must also critically examine the remedial actions that are currently in place and those unfolding. Nonetheless, hope for an environmentally friendly and sustainable extractive industry is not lost. However, despite the afore-mentioned measures, the activities of mining companies need to be periodically monitored. Independent assessors and researchers ought to lean in and x-ray the processes and aftermath of the activities of extractive industries. Government as the main regulator ought to take proactive steps, enact good legislation and demand accountability and sustainable practices from the key industry players. It is only through these decisive actions can the environment be rescued and the debilitating effects of mining mitigated.

Recommendations

1. More effort should be geared towards planting more trees within, around and along the various roads that leads to the active mine. These trees apart from carbon sequestration will serve as bio-filters to absorb and reduce particulate discharge to the host communities.
2. The company should continue engaging all stake-holders in dispute resolution processes and constantly organize town-hall meetings to proactively resolve contending issues before they escalate, to maintain community peace and harmony.
3. The government should as a matter of urgency partner with the company by taking over the clinic and school so as to deploy personnel to man these facilities.
4. The host-communities should be encouraged to participate in ongoing nature-based agro-ecological projects that will solve some of their identified problems of excessive use of fertilizers and agro-chemicals etc.
5. We recommend periodic post-mining EIA to determine if the identified impacts are stable, decreasing or on the increasing; with that, we can comparatively analyse the present situation with what it was before mining and what it will look like in the years to come.

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List of Appendices

Appendix 1. Data Base of Researches conducted since inception of mining at Maiganga in 2010

S/No.	Research Topic/Authors	Author	Year	Focus	Remark
1.	Assessment of air quality within Maiganga coal mining area in Akko Local Government Area, Gombe State, Nigeria	AdemuTankoOgah, Obaje Daniel Opaluwa 2, Mohammed Alkali andKumo Lass	2020	Air quality, Environmental safety and sustainable practice	Positive/Negative
2.	An Assessment of Some Selected Heavy Metals in soils around Maiganga Coal Mine and its Environs, Gombe State, Nigeria.	Babayo, A. U, Santuraki, A.H,Adebayo Kabir	2018	Soil Analysis	Negative/Positive
3.	Impact of Coal Mining on the Environment in Mainganga Community of Akko Local Government, Gombe State, Nigeria.	Maina Benjamin, Kachalla Aliyudaand Comfort C. Amin Dawa	2016	Environmental safety and health	Negative
4.	Quantification andRadiologicalRiskEstimation DuetothePresenceof Natural RadionuclidesinMaigangaCoal,Nigeria	MatthewTikpangiKolo, et al	2016	Human health and environmental safety	Positive
5.	The Maiganga Coal Mine Drainage and Its Effects on Water Quality, North Eastern Nigeria	Onsachi, J.M., Dibal, H. U, Daku, S.S.	2016	Water Quality	Positive
6.	Implication of Mining to Health in Maiganga Coal Mine, Gombe State, Nigeria	Amosu C.O. et al.	2021	Human Health	Negative
7.	Health Risk Assessment of Heavy Metals in Soil Samples around Maiganga Coal Mine site and Kumo Town in Akko Local Government, Area of Gombe State	Rabiu, J. A.. et al	2019	Human Health	
8.	Some Heavy Metals in Soil and Maize of Maiganga Coal Mine, Gombe-Nigeria.	Adamu, SaniJauro	2015	Agriculture and Human Health	Neutral
9.	Sustainable Mining Practices in Nigeria: A Case Study of Maiganga Coal Mining in Gombe State	E. D. Oruonye, M. Iliya and Y. M. Ahmed	2016	Sustainable Practices and Environmental safety	Positive
10.	Estimation of some selected Heavy Metals in the Soil of Maiganga Coal Mine and Environs, Maiganga Coal Mine and Environs, Gombe-Nigeria	Adamu, S. J. et al	2017	Heavy metals and soil analysis	Positive
11.	An Assessment of Copper (Cu) Concentration in Filtered and Unfiltered Water From Coal Mine and Residential Areas of Maiganga Coal Mining Environment, Gombe-Nigeria.	Adamu S.J. et al.	2017	Water quality and presence of heavy metals	Positive
12.	Assessment of air quality within Maiganga coal mining area in Akko Local Government Area, Gombe State, Nigeria	Obaje et al	2020	Air quality and Environmental Health	Neutral
13.	Effect of Coal Mining on Agricultural Land of Maiganga Coal Mining Area, Gombe-Nigeria	Adamu S.J et al	2015	Agriculture and human livelihood	Negative

14.	Comparison of Some Heavy Metals Pollution in the Soils of Kayel-Baga and Wuro-Sarki Villages around Maiganga Coal Mine, Gombe-Nigeria.	Adamu S.J et al	2017	Soil Quality and Heavy metal analysis	Positive
15.	Radionuclide concentrations and excess lifetime cancer risk due to gamma radioactivity in tailing enriched soil around Maiganga coal mine, Northeast Nigeria	Kolo et al	2017	Radioactivity	Positive
16.	Assessment of Some Heavy Metal Concentration in the Water of Maiganga Coal Mining Area, Gombe-Nigeria	Adamu, S.J, et al	2014	Water Analysis and heavy metal presence.	Positive
17.	Impacts of Some Heavy Metals on the Population of Micro-Organisms in the Soil of Maiganga Coal Mining Area, Gombe-Nigeria	Adamu S.J. et al	2014	Heavy metals and soil microbes	Negative
18.	Source rock characteristics, depositional setting and hydrocarbon generation potential of Cretaceous coals and organic rich mudstones from Maiganga and Yaya-Ngari, Gombe Formation, Gongola Sub-basin, Northern Benue Trough, NE Nigeria	Habeeb et al	2017	Hydrocarbon generation and coal quality of Maiganga	Neutral
19.	Effects of Coal Mining on Ground water Quality of Maiganga, Akko ocal Government Area, Gombe State	Ezemokwe et al	2021	Ground water Pollution	Negative
20.	The Investigation of Sink - Float Nature of Maiganga Coal	Nuhu, Steven Kuba	2017	Coal Quality	Neutral
21.	Physicochemical, Thermokinetic and Rank Classification of GarinMaiganga Coal.	B. B. Nyakuma	2017	Thermo-kinetic and Physicochemical properties of Maiganga Coal	Positive
22.	The Maiganga Coal Deposit: Bituminous, Sub-Bituminous or Lignite?	Chibuisi Samuel Ikwuagwu andMaduabuchi Uche Uzoegbu	2017	Coal Quality	Low Quality
23.	Physicochemical Characterization and Thermal Decomposition of Garin Maiganga Coal.	Nyakuma, B.B and Jauro, A	2016	Coal Quality	Low Quality
24.	Rock-Eval pyrolysis and organic petrographic analysis of the Maastrichtian coals and shales at Gombe, Gongola Basin, North-eastern Nigeria	Yusuf AyoolaJimohandOlusola J. Ojo	2016	Hydrocarbons	Neutral
25.	Inorganic Geochemical Evaluation of Maastrichtian Coal at Gombe, Gongola Basin, Nigeria: Implications for Resource Potential and Paleo environments	Ayoola Y. Jimoh*, Olusola J. Ojo	2021	Coal Quality	Neutral

26.	Experimental Study of Destructive Distillation of Maiganga Coal: Analysis of Products' Yield and Composition	Mohammed, H.I. et al	2019	Petrochemical properties of Maiganga Coal	Neutral
27.	Radiological Implications of Coal-Mining Activities in Maiganga Coalfield of North-Eastern Nigeria	Kolo et al	2017	Radioactivity	Positive
28.	Characterization of some Nigerian coal for effective power generation and industrial utility	J.N Benedict et a.l	2022	Coal Quality and energy potential	Neutral
29.	Assessment of Underground Water Contamination Due to Early Coal Mining Activities in Nigeria	TijjaniGarba et al	2014	Water Quality and human health	Neutral
30.	An Assessment of the Socio-economic Impact of Maiganga Resettlement Scheme, Akko LGA, Gombe State, Nigeria	Abdulsalam, M. et al.	2016	Socio-economic Impacts of Coal Mining	Negative
31.	Assessment of Coal Mining in Maiganga	Adamu Ahmad	2017	Environmental Degradation	Negative
32.	Evaluation of Radioactivity and Heavy Metal Concentration in soils around a Coal Fired Cement Factory in North-East Nigeria: Implication for Human Health and Environment	Kolo et al	2018	Human Health and environmental Safety	Neutral
33.	Physical and Plastic Properties of three Nigerian Coals	Chuckwu, C.J. et al	2012	Coal Quality	Neutral
34.	Proximate and Ultimate Characteristics of some Nigerian Coal Deposits in Benue Trough and Anambra Basin	Mohammed L.M. etal	2018	Coal Quality	Neutral
35.	Rare earth elements study of Cretaceous coals from Benue Trough basin, Nigeria: Modes of occurrence for greater sustainability of mining	Akinyemi, S.A., et al	2021	Coal Quality	Neutral
36.	Production of Formed Coke from Nigerian Coals	Jauro A. and C. J. Chukwu	2011	Coal quality	Neutral
37.	Characterzation and Ash Chemistry of Selected Nigerian Coals for Solid Fuel Combustion	Mohammed, U. G.	2016	Coal Quality and Properties	Neutral
38.	Elemental Characterization of some Nigeria Coal deposits: Implication for the origin of the coals	Onoduku U.S. et al.	2019	Coal Quality and features	Neutral
39.	Ultimate Analysis of some Nigerian coal: Ranking and Suitable Application	Solomon Akila Ryemshak et al	2016	Coal Ranking, quality analysis and classification	Neutral
40.	Nigerian Cretaceous Coal Deposits and Their Petroleum Source Rock Characteristics	N. G. Obaje, et al	2020	Coal Availability	Neutral
41.	Avifaunal Assemblage of a Post –Coal Mining Artificial Wetland and Reclaimed Woodland in Maiganga, Gombe State	Nsor et al.	2022	Environmental Sustainability/Biodiversity	Positive