African Journal of Social Sciences Education Vol. 2 (2), 2023, pp.87-122
(ISSN: 2821-8809)

Small-Scale Mining, Environment and Livelihoods: Perspectives from Mining Communities in Ghana

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ABSTRACT

The environment and livelihoods have come under severe strain in mineral-rich areas with the emergence of mechanised small-scale mining equipment, which generates more than five-fold increase in gold production. This article discusses the impact of mechanised small-scale mining on the environment and livelihoods of peasant farmers within broader climate change processes in Ghana. Methods used include community-level qualitative interviews, field observations, analysis of satellite imagery spanning the period 1987-2016, and published data on climate change processes affecting Ghana. The findings show water loss of more than seventy per cent, severely degraded lands and forests, with detrimental effects on livelihoods in the areas studied. Though the study did not find direct evidence of the impact of climate change processes on the environment, corroborative reports from research indicate about 1.6% rise in temperature across Ghana from 1960 to 2020, combined with extreme weather events such as torrential rains, excessive flooding and intensified evaporation from lands exposed through small-scale mining; these are very likely to have more adverse effects on the environment. The article concludes that the consequences of mechanised mining on the environment have been very detrimental in the face of domestic legislation and well-established environmental protection conventions and principles. The paper recommends a return to the observance of sound ecological principles and ideals by the State, and respect for the country's legislation, to ensure sustainable livelihoods for people living in mineral-rich areas.

Keywords: Environment; small-scale mining; peasant farmers; livelihood; Ghana.

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INTRODUCTION

Artisanal small-scale mining (ASM) has been undertaken in many parts of Africa for centuries, and it is estimated to employ some 8 million small-scale miners, indirectly supporting about 45 million people on the continent (Weng et al., 2018, p76; Benkenstein, 2012; Jonsson and Bryceson, 2009). ASM has been practised in Ghana for hundreds of years with rudimentary tools: pick axe, shovel and bowl. All that was required was no objection from a landowner. Thus, it has been a livelihood activity for many people in mining areas, and the State neglected the sector and paid more attention to large-scale mining corporations (Crawford et al., 2015). However, significant transformations have occurred within the ASM sector from the onset of the 2008 global financial crisis, mainly a shift to gold as a haven for investors driving up the price of gold and the involvement of miners from Shanglin County in the Guangxi Zhuang Autonomous Region of China (Botchwey et al., 2018). This period saw a transformation of a primary, rudimentary mining activity into a highly mechanised venture that increased gold production by at least seven-fold. The contribution of ASM to total gold production in Ghana increased from 11% to 41.4% in 2018 (Ghana Chamber of Mines, 2019, p11), when all small-scale gold mining activities were banned from April 2017 to December 2018. Mechanised mining led to significant economic gains for Chinese mining investors and a few Ghanaians but negatively affected many in rural communities (Crawford and Botchwey, 2016). Such mechanised artisanal small-scale mining activities involved mercury use, excavators and pumping machines, which heavily impact water resources and land (Crawford and Botchwey, 2017). The intensified small-scale mining activities include clearing the vegetation cover of lands and using heavy equipment to excavate lands which lie alongside or within water bodies to gain access to the gold underneath. This overturns fertile soil components and increases water bodies' exposure to evaporation, leading to water resource loss. With rising temperatures through climate change processes, more water is lost through increased evaporation; lands become less suitable for agriculture, and peasant livelihoods become more precarious. Thus, climate change is likely to extend the damaging impact of small-scale mining on the environment.

Intensified illegal small-scale mining has persisted in Ghana despite the enactment of laws to stem this tide, including the Minerals Commission Act of 1993 (Act 450), the Minerals and Mining Act of 2006 (Act 703); the Minerals and Mining (Amendment) Act of 2015 (Act 900); the Minerals and Mining (Amendment) Act of 2019 (Act 995); and the Minerals and Mining (Minerals Operations, Tracking of Earth Moving and Mining Equipment) Regulations of 2020 (Legislative Instrument 2404).

Climate change, which concerns observable variations in climate properties over time, has been linked to changes in temperature, rainfall and other weather conditions that occur through natural processes such as changes in the solar cycle or volcanic eruptions or through human activities that alter the composition of the atmosphere (IPCC[3], 2018, annex 1; UNFCC[4], article 1). Research on the effects of climate change has shown that it can impact land and water bodies on which humans depend for food, water, dwellings and other life-support services provided by the ecosystem (Shukla et al., 2019). The report of the Inter-governmental Panel on Climate Change (IPCC) revealed that rising global temperatures have led to the warming of lands up to 1.53 degrees Celsius from 2006 to 2015, which in turn has led to land degradation and reduction in forests by some 3% globally; this has affected the livelihood of some 3.2 billion people living primarily in developing countries (IPCC, 2019, p53).

In Ghana, research on climate change has shown an increase of 1 degree Celsius in the past 40 years from 1960 to 2000. It is projected to rise by 0.6 degrees Celsius in 2020, 2.0 degrees Celsius by 2050 and 3.9 degrees Celsius by 2080 (Environmental Protection Agency (EPA), 2000; Ministry of Environment, Science Technology and Innovation, 2013). Over the same 40-year period, changes that have been observed include a reduction in rainfall, less predictable weather patterns and an increase in extreme weather events such as torrential rains, storms and excessive flooding; these have been accompanied by a rising sea level of 2.1 mm per year, which is expected to reach 5.8cm by 2020, 16.5cm by 2050 and 34.5cm by 2080 (Ministry of Environment, Science Technology and Innovation, 2013, pp1-3). These sea-level changes will likely affect about 25% of Ghana's population living along the coast. A further 7% reduction in crop yield is forecasted over the next 20 years. This will undoubtedly impact 70% of the population depending on agriculture for sustenance in crop farming, animal husbandry and fisheries (EPA/UNDP/UNEP, 2010). Recent efforts to combat climate change in Ghana have been reported in Ghana's Adaptation Plan Framework (EPA, 2018), which focused on involving the private sector in the planning and implementing adaptation strategies, gender-responsiveness and community-based approaches. Ghana's Adaptation Strategy and Action Plan for Infrastructure Sector -Water, Energy and Transport (EPA, 2020) also focused on managing water resources, greater use of green energy and transport to minimise ecological impact; and Ghana's Adaptation Communication to the UNFCCC (EPA, 2021) proposed adaptation strategies such as introducing more climate-resilient agriculture to ensure food security, sustainable forest management, protection of human health and livelihoods, and introduction of more effective early warning

3. Inter-governmental Panel on Climate Change

4. United Nations Framework Convention on Climate Change

systems.

Earlier studies on ASM in Ghana have focused on political involvement in illegal gold mining activities, inclusive of the major political parties who promise support to ASM operators while in opposition but organise crackdowns against them when in power to appease the public, despite profiting from the illicit activity (Ntewusu, 2018; Abdulai, 2017). The work of Andrews (2015) also focused on reasons why people continue to engage in illegal mining despite available procedures to regularise the activity; Andrews revealed that many illegal miners take to the activity as a last resort to eke out a living, while others do so out of a sense of entitlement to resources bequeathed to them on their ancestral land, believing that the State has no right to control access to such resources. Luning and Pijpers (2017) have also examined the recurrence of encroachment of mining concessions by illegal miners and the tensions and conflicts generated between mining companies and illegal miners, often requiring the intervention of the state security services. McQuilken and Hilson (2016) have also discussed attempts by successive governments to formalise the ASM sector in Ghana, which employs about one million people, with 60–80 per cent of them operating illegally.

Regarding the environment, two key studies stand out from the available literature: Hilson (2002) and Kusimi (2008). The work of Hilson (2002) looked at the environmental impact of small-scale gold mining before mechanisation occurred through Chinese involvement. The study noted the increased use of mercury to extract gold, increased land degradation, and the Minerals Commission's weak capacity to monitor ASM operators' activities. The study by Kusimi (2008) employed remote sensing to examine land use and land cover changes in forestry in the Wassa West District of the Western Region of Ghana from 1986 to 2002 and found that built-up areas, farms, and surface mining by large-scale mining corporations had significantly reduced forest cover in the study area. The critical focus of this study was to investigate the effects of mechanised mining on the environment and its impact on livelihoods within the broader context of climate change processes. The study was motivated in part by direct observation of small-scale mining practices in the study sites, media reports on the impact of ASM, such as severely polluted water bodies, and the shut-down of water treatment plants at Kyebi in the Eastern Region and Abessim near Sunyani in the Bono Region of Ghana because water quality had exceeded treatable threshold for domestic use (Citimfmonline.com, August 30 2016; Citimfmonline.com, February 27 2017). Water experts have warned that Ghana must import water by 2030 if nothing changes (Citifmonline.com, February 28 2017; Myjoyonline.com, March 22 2017). Only a little has been done to explore the interface between small-scale mining and climate change in Ghana. Therefore, this study systematically investigated the impact of mechanised artisanal mining on the environment and the livelihoods of people living in mining communities.

Environmental Principles and State Obligations

Globally, the environment does not have a parent, international hard law, which is comparable to the United Nations Charter (1945); thus, protection of the environment has been founded on soft law in the form of principles, except in situations where regional and national legislation enable legal enforcement of such principles in designated courts (Canuel, 2016). The most prominent international principles governing the environment include the Stockholm Declaration of the United Nations Conference on the Human Environment (1972), the Rio Declaration on Environment and Development (1992), the Convention on Biodiversity (1992), which seeks to conserve and promote sustainable use of genetic resources, the United Nations Framework Convention on Climate Change (1992) and related commitments, and the Paris Agreement on Climate Change signed in December 2015.

Before these, much of the existing legally enforceable environmental principles have been enacted into legislation by respective regional and national jurisdictions or pursued under related human rights provisions. The Stockholm Declaration (1972) enunciated the potential of human activity on the environment to bring development benefits and enhance the quality of life if undertaken wisely. However, it also warned that human intrusions into the environment could do incalculable harm to the environment and humans themselves and pointed to the dangers of pollution that affect water, air, the earth and living organisms, thereby disturbing the ecological balance. The Declaration included 26 fundamental environmental principles that have served as the foundation for subsequent ecological regulations and legislation.

The first principle of the Stockholm Declaration articulated the environmental rights of all persons, stating that 'man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being, and he bears a solemn responsibility to protect and improve the environment for present and future generations.' Here, the quality of the environment is closely tied to the quality of life, and the present generation is responsible for preserving and improving the environment for future generations. The second principle focuses on safeguarding the earth's natural resources, such as air, water, land, flora and fauna, and natural ecosystems, for the benefit of present and future generations through careful planning or management. These two fundamental principles are expected to underlie efforts to protect the environment, but adherence to these still needs to be improved in pursuing economic gains (Malin, Ryder and Lyra, 2019).

The Rio Declaration on Environment and Development (1992) went further to crystallise the principles articulated in the Stockholm Declaration. The fundamental principles introduced by the Rio Declaration, which are relevant to this study, include principle three (3), which states that the right to development must be fulfilled to equitably meet the developmental and environmental needs of present and future generations; principle fifteen (15), which states that to protect the environment, States shall widely apply the precautionary approach according to their capabilities, and where there are threats of serious or irreversible damage, lack of total scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. Principle sixteen (16) also states that national authorities should endeavour to promote the internalisation of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment (United Nations, 1992; UNCED, 1987).

Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC 1992), which deals with the ultimate objectives of the convention, states that it is focused on the stabilisation of greenhouse gas concentrations in the atmosphere; to ensure a sufficient time frame that allows ecosystems to adapt naturally to climate change; and to ensure that food production is not threatened and that economic development must proceed sustainably. The Kyoto Protocol further buttressed these objectives to the UNFCCC (1998), which states in article 10(b) that parties to the convention must formulate, implement and publish regularly all measures to contain and mitigate climate change and to facilitate adaption strategies to its impact. Article 2 of the Paris Agreement 2015 also stated that its main objective was to strengthen the global response to the threat of climate change in the context of sustainable development and to eradicate poverty by enhancing the ability of people experiencing poverty to adapt to climate change. These objectives were translated into several principles that state parties were urged to implement or observe.

These principles have been discussed in detail by Beder (2006) and summarised into six main themes, namely, the ecological sustainability principle, which concerns the carrying capacity of the ecosystem; the polluter pays principle, which refers to the liability to compensate for the harm caused to the environment and livelihoods of people; the precautionary principle which deals with preventative action and exercise of restraint from interfering with the climate when the scientific proof is unable to determine the impact of human activity on the environment. Others include the equity principle, which must ensure inter and intra-generational equity in all decisions and actions regarding the environment; the human rights principle, which must protect the right to live in and enjoy a healthy climate; and the public participation principle, which guarantees the rights of individuals, peoples and communities to know and be involved in decisions and activities that affect the environment in which they live or work (Maguire, 2012). The African Charter on Human and Peoples Rights (1981) protects the environment for the benefit of people. Article 24 of the Charter states that all people shall have the right to a generally satisfactory environment favourable to their development. Breaches of this provision are legally actionable in the domestic courts of States Parties and regional adjudicative bodies such as the African Court on Human and Peoples' Rights or the ECOWAS Court (Pigrau et al., 2013; Greyl and Minguet, 2014).

In Ghana, article 40 [d] of the Fourth Republican Constitution (1992) urges the State to respect and adhere to the principles and ideals of the United Nations, the African Union, the Economic Community of West African States, and any other international organisation of which Ghana is a member. The Environmental Protection Agency (EPA) of Ghana, established by Act 490 (1994), remains the central institution responsible for environmental protection. Section 2 (d) of Act 490 empowers the EPA to secure by itself or in collaboration with others the control and prevention of the discharge of waste into the environment and the protection and improvement of the quality of the domain. The EPA has also set conditions which must be complied with by persons engaged in small-scale mining as part of the licence acquisition process. The requirements are based on sections 2 and 12 of the Environmental Protection Agency Act of 1994 (Act 490) and part 1 of the Environmental Assessment Regulations 1999 (Legislative Instrument 1652). The EPA is empowered to suspend, cancel or revoke the permit issued where the provisions and conditions of the permit are not being satisfactorily complied with; or the continued operation of the small-scale gold and diamond mining and processing project poses a risk to the environment, public health and safety; or the operations by the permit holder have deteriorated below the required standard. Information on the permit conditions form indicates that before the commencement of small-scale mining operations, the license holders must meet the landowner's or land user's appropriate representatives and discuss the nature of the project and the likely environmental impacts and mitigation measures associated with the project. Small-scale mining permit holders must also undertake reclamation of lands after their operations, within three months after completion, or conduct concurrent reclamation and re-vegetate the land with indigenous economic trees such as acacia, cassia, oil palm, etc. Concerning water resources, permit holders are not allowed to discharge contaminated water with mercury on any toxic chemicals or water with high turbidity or pollutant into natural drainage; they are also obliged by the environmental permit conditions to observe a buffer zone with a minimum distance of 100 meters to any stream on the concession, and to rehabilitate their mining sites to a situation that is comparable to the pre-existing land use of the area before commencement of the mining operations, within three months after the end of the mining activity, and report to the EPA for verification (Botchwey, 2019)[5] .

With these as a backdrop, the questions posed by this study include the following: Do environmental practices in artisanal small-scale mining comply with the EPA regulations, and do they reflect observance of well-established environmental principles and conventions to which Ghana is a signatory? To what extent have land use changes occasioned by mining activities impacted the environment and livelihoods of community residents, who are mostly peasant farmers? And how do small-scale mining activities relate to broader climate change processes? The paper addresses these questions by examining the impact of mechanised artisanal mining on the environment and people's livelihoods in selected districts within Ghana's Central and Western regions.

METHODS

The methods used for the study include field visits to mining sites, observations, interviews, and land use land cover (LULC) analysis based on remote sensing data within a broader framework of case study design. Published climate change research and reports were analysed to ascertain relationships between small-scale mining activities and environmental changes. Initial visits were undertaken to the study sites to observe mechanised artisanal mining processes, which had moved from the pick axe, bowl and shovel methods to the deployment of heavy equipment, including excavators, pumping machines, wash-plants, and others mainly imported from China.

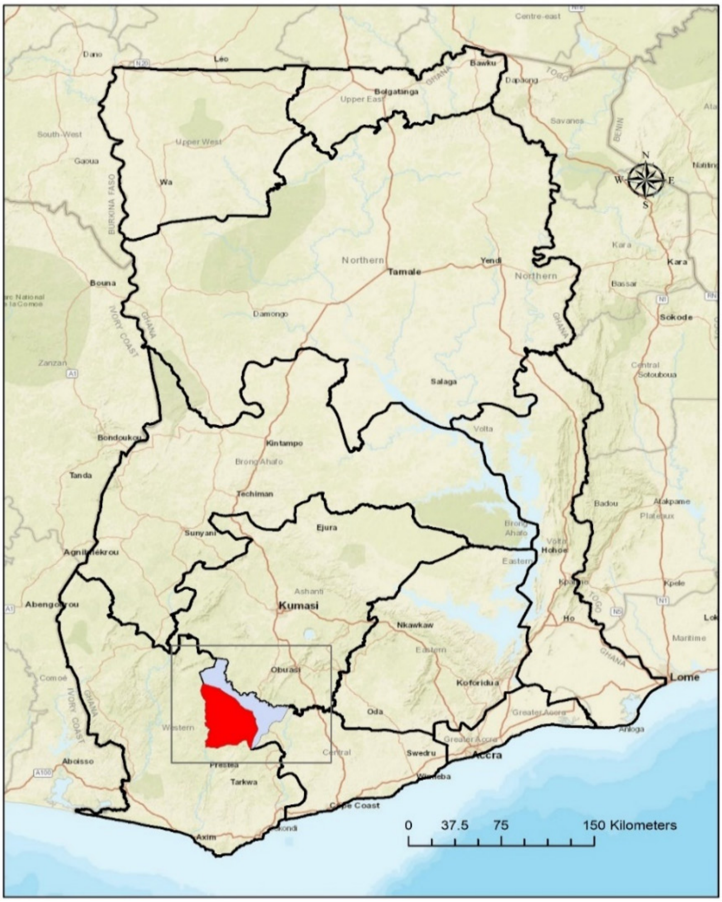
The study area spanned Upper Denkyira West and Upper Denkyira East[6]. In the Central Region, and Amenfi East in the Western Region of Ghana. The research covered mining communities along rivers Offin and Pra, down to the Daboase

5. Environmental Permit for Small-Scale Mining Operations, 2019

6. Two more districts have been created out of Upper Denkyira since 1987, namely Upper Denkyira East and Upper Denkyira West. However, we adopted the district designations in 1987 for analytical purposes since the best comparable satellite images with less cloud cover were obtained in 1987 and 2016

Water Treatment Plant, which supplies water to Sekondi–Takoradi Metropolis and surrounding districts. The study sites included Denkyira Fosu, Denkyira Kyekyewere, Denkyira Abora, Denkyira Dominase, Wasa Abreshia, Denkyira Breman, Denkyira Brofoyedu, Nyamebekyere, Wasa Dadieso, Wasa Gyapa, Wasa Ntwentwena, Wasa Nananko, Denkyira Pokukrom, Denkyira Nkotimso, Subin, and others.

Figure 1: Study Area, Upper Denkyira and Amenfi East Districts, Ghana (shown in box).



Source: Environmental Systems Research Institute (ESRI) World Street Maps, February 2020.

The second stage involved identifying land use land cover changes through remote sensing analysis of Landsat satellite imagery from two–time points, namely 1987 and 2016. These time points were chosen because they provided images with less cloud cover, which allowed better analysis. This was used to analyse land use and land cover changes in the study area and to explore linkages with accounts from interviews related to small–scale mining activities and evidence from direct field observations. The third stage involved the analysis of published data on climate change processes affecting Ghana to determine changes in temperature, rainfall and related extreme weather events, which also affect the study area. The fourth stage involved analysing semi–structured interviews and published research to examine the linkages between environmental changes, land use land cover analysis results, and climate change data. The data obtained from field observation visits include pictures of mechanised small–scale mining sites, grounds which have been excavated during mining activities, uncovered mine pits, polluted and extinct water bodies, and damaged lands which are no longer suitable for agriculture.

Land Use Land Cover Analysis

Land use/land cover (LULC) analysis involved obtaining satellite data from the US Geological Survey (USGS): Earth Explorer. Two time–points (1987 and 2016) atmospherically–corrected surface reflectance Landsat images were downloaded from the USGS website. Surface reflectance imagery was pre–processed to check for geometric and radiometric errors, and the downloaded data was verified for geometric corrections. The imagery covered a relatively more considerable extent beyond our case study locations, and the images were cropped using a boundary shapefile of the study districts. LULC analysis was done using the software ENVI 5.3. This study used 2016 as the baseline to assess LULC change, but ideally, 2018 would have been the best time to measure change. However, 2016 was used instead of 2018 because all the imagery in 2018 had over 50% cloud cover, which made it unsuitable to be used for any analysis without the clouds affecting the result. Cloud cover is a significant problem with satellite images within the tropics.

Notwithstanding this limitation, 2016 still accurately reflects LULC changes that may have happened in 2018. It is also essential to State that small–scale mining activities can only account for some of the land use changes observed in the period studied. However, evidence from field observations, qualitative interviews and other studies were used to triangulate the data. Table 1 below provides information on the images used in the two–time points.

Table 1: Satellite Data from 1987 and 2016

	1987 imagery	2016 imagery
Spacecraft identifier	Landsat 5	Landsat 8
Date of Acquisition	07/01/1987	17/01/2016
Spectral resolution	30m	30m
Number of Bands	7	11
Image Quality	9	9
Cloud Cover	0%	8.81%
Projection	UTM Zone 30N	UTM Zone 30N

Source: USGS: Earth Explorer, February 2020.

This study's land use/land cover classification was developed based on Anderson et al. (1976) classification system. However, this classification scheme was modified to suit the local context using a combination of first and second-level classification based on local area knowledge. The LULC were grouped into five central classification schemes: High-Density Forest (Forest Reserves), Low-Density Forest, Built Up, Water and Bare Soil (Barren Land). A maximum likelihood classification method was used in classifying the image into the various LULC classes. A maximum likelihood classification scheme is a supervised classification system in which the analyst specifies numerical descriptors of the land cover classes and provides training pixel samples to the algorithm. The maximum likelihood method algorithm then computes the probability that an unknown pixel will be in each class, and the pixel is assigned to the class with the highest probability (Jensen, 2016). In generating the LULC classes, training samples corresponding to each land cover class were generated. The training samples were checked for homogeneity to ensure they covered all the possible pixel values for that particular land cover class.

Furthermore, class statistics were used to examine the spectral characteristics of the training samples. Each of the training samples corresponding to each land cover class was observed based on different band combinations to ascertain whether the training samples were reflective of the land cover classes they were depicting. The samples were also checked for separability to ensure the land cover classes did not overlap. After implementing these quality control procedures, maximum likelihood classification was used to generate the LULC classes.

Climate Change Data Sources

Climate change data was obtained from published reports and research from the United Nations Environment Programme, Inter-governmental Panel on Climate Change, United Nations Framework Convention on Climate Change, Environmental Protection Agency of Ghana, scientific publications on climate change and other relevant reports. These were analysed to identify variations in temperature, rainfall, changes in sea level, frequency of extreme weather events and their impacts on the environment, especially land and water resources on which many depend for survival and sustenance in the study areas.

Semi-structured Interviews

Semi-structured qualitative interviews were conducted with sixty-two (62) participants who were purposively selected due to their roles in the small-scale mining industry or residence in mineral-rich areas, following data saturation principles. Interviewees were chosen mainly based on their knowledge or experience of small-scale mining activities, and they included small-scale miners, farmers affected by mining activities, community elders, community residents, and public officials who manage water resources in Ghana. They were aged between 18 to 86 years drawn from the following communities: Denkyira Fosu (5), Denkyira Kyekyewere (4), Denkyira Abora (8), Denkyira Dominase (4), Wasa Abreshia (3), Denkyira Breman (4), Denkyira Brofoyedu (2), Nyamebekyere (4), Wasa Dadieso (4), Wasa Gyapa (5), Wasa Ntwentwena (5), Wasa Nananko (5), Denkyira Pokukrom (6), Denkyira Nkotimso (1), and Daboase Water Treatment Plant Officials (2). In all, 25 females and 37 males participated in the study. Interviews and field visits were conducted in May and July 2018, with follow-ups in 2021 and 2022. Pictures of mining sites and water bodies taken during field observation visits were used to corroborate accounts from interviews and data from satellite imagery. The views and experiences of community residents, elders, farmers, active and former small-scale miners, and public officials were analysed thematically alongside published research and reports and information from observation visits.

RESULTS

Land Use /Land Cover Changes in Upper Denkyira District

The LULC area estimate was made for various land cover classes based on the developed classification system. Table 2 and Figure 2 below show the LULC distribution for Upper Denkyira District for the two-time points. In 1987, low-density forest was the highest land cover occupying an area of 95,500ha or about 82.05% of the total landscape. This was followed by a high-density forest of about 15,071ha (12.95%). The built-up area occupied a smaller portion of about 2.40% relative to water which occupied 2.61%. In 2016, low-density forests still occupied a larger area of about 83,145ha (71.19%), followed by high-density forests occupying an area of 8,382ha (7.18%). Barren land emerged and occupied an area of 7,065ha (6.05%), followed by built-up area and water. Analysis of the trend and rate of land use/land cover (LULC) change revealed that water experienced the most significant change. There was a reduction in water from 2.61% to 0.58%, representing a net loss of 77.78% from 1987. This was followed by high-density forest, which reduced from 12.95% to 7.18%, representing a net loss of 44.55% from 1987. Similarly, low-density forests experienced a marginal loss of 13.26%. However, not all land cover classes had a net loss. The built-up area substantially increased from 2.39% in 1987 to 15% of the total landscape in 2016. Bare soil/ Barren land also increased in area occupying 6.05%. Figure 3 below presents the percentage of LULC change for the period.

Table 2: Land Use/Land Cover Distribution for Upper Denkyira District

	LULC 1987		**LULC 2016**	
	Area(ha)	Percent (%)	Area(ha)	Percent (%)
High-Density Forest	15071.31	12.95	8382.24	7.18
Low-Density Forest	95500.08	82.05	83145.87	71.19
Built-Up	2782.98	2.40	17522.1	15.00
Water	3039.93	2.61	679.14	0.58
Bare Soil/Barren Land	-	-	7065.18	6.05
Total	**116394.3**	**100**	**116794.53**	**100**

Source: Based on Maximum Likelihood Classification.

Figure 2: Spatial Distribution of LULC Classes for Upper Denkyira

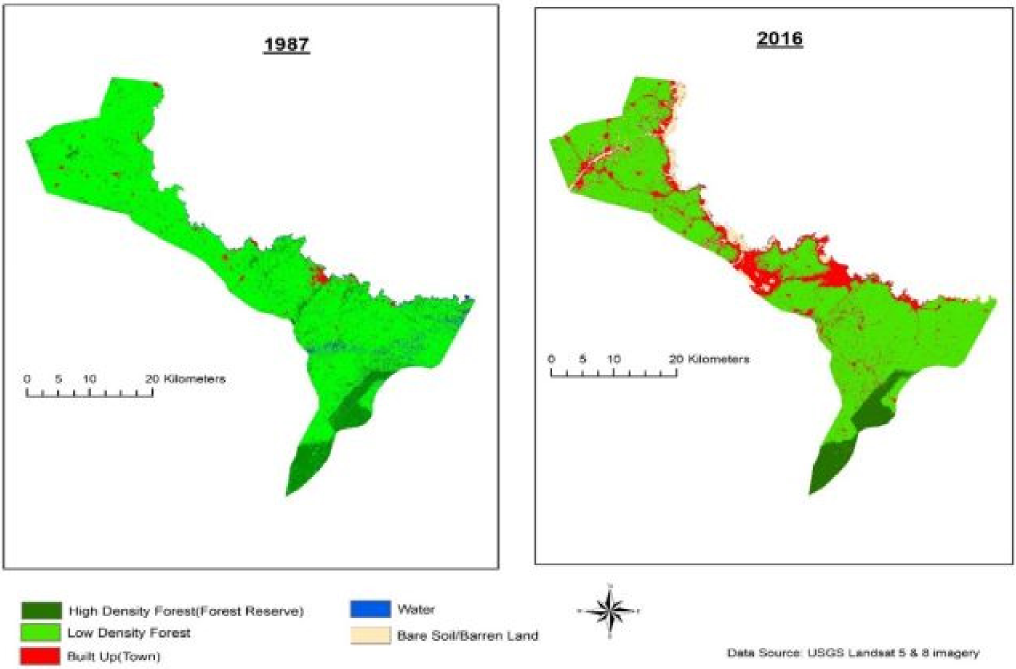
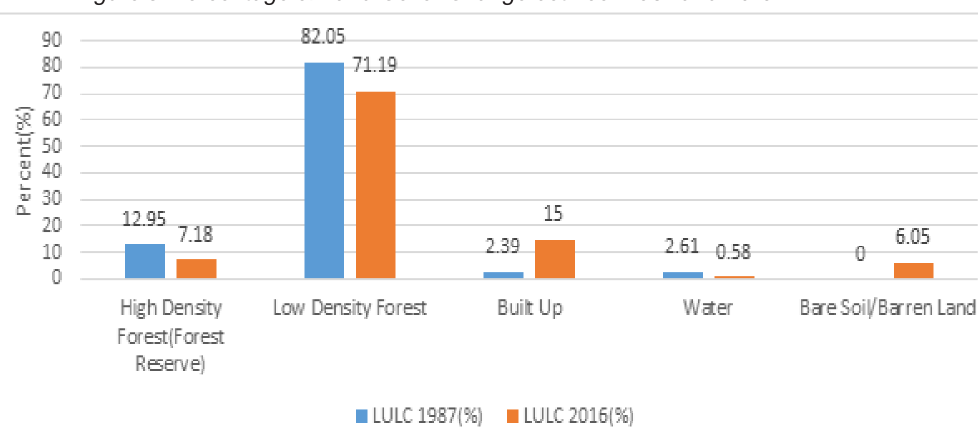


Figure 3: Percentage of Land Cover Change between 1987 and 2016



Source: Based on Maximum Likelihood Classification.

Land Use/Land Cover Changes in Amenfi East District

Analysis of the trend and rate of LULC change also revealed that from 1987 to 2016, water reduced from 2.15% to 0.41%, representing a net loss of 80.9%. There was also a reduction in high-density forest (net loss of 16%) and low-density forest (net loss of 10%), from 26.75% to 22.34% and 69.8% to 62.77%, respectively. On the contrary, the built-up area experienced a net gain from 1.29% in 1987 to 11.32% in 2016. Barren land also increased in size with a net gain of 3.15%. Figure 5 below presents the percentage of LULC change from 1987 to 2016, and Table 3 and Figure 4 below show the distribution of LULC for Amenfi East District between 1987 to 2016.

In 1987, low-density forests had the highest area occupying 120,481.38ha (69.8%), followed by high-density forests at 46,175.13ha (26.75%). Water occupied 2.15% of the landscape, and built-up had the lowest area, 1.29%. In 2016, low-density forests still occupied a relatively larger size of about 108,341.4ha (62.77%), followed by high-density forests (22.34%). Water occupied a smaller area of 0.41% of the total surface area.

Table 3: Land Use/Land Cover Distribution for Amenfi East District

	LULC 1987		**LULC 2016**	
	Area(ha)	Percent (%)	Area(ha)	Percent (%)
Water	3715.02	2.15	718.2	0.41
Built-Up	2227.23	1.29	19533.33	11.32
High Density	46175.13	26.75	8563.74	22.34
Low Density	120481.38	69.8	108341.4	62.77
Bare Soil			5442.12	3.15
Total	**172598.76**	**100**	**172598.8**	**100**

Source: Based on Maximum Likelihood Classification.

Figure 4: Spatial Distribution of LULC Classes for Amenfi East District

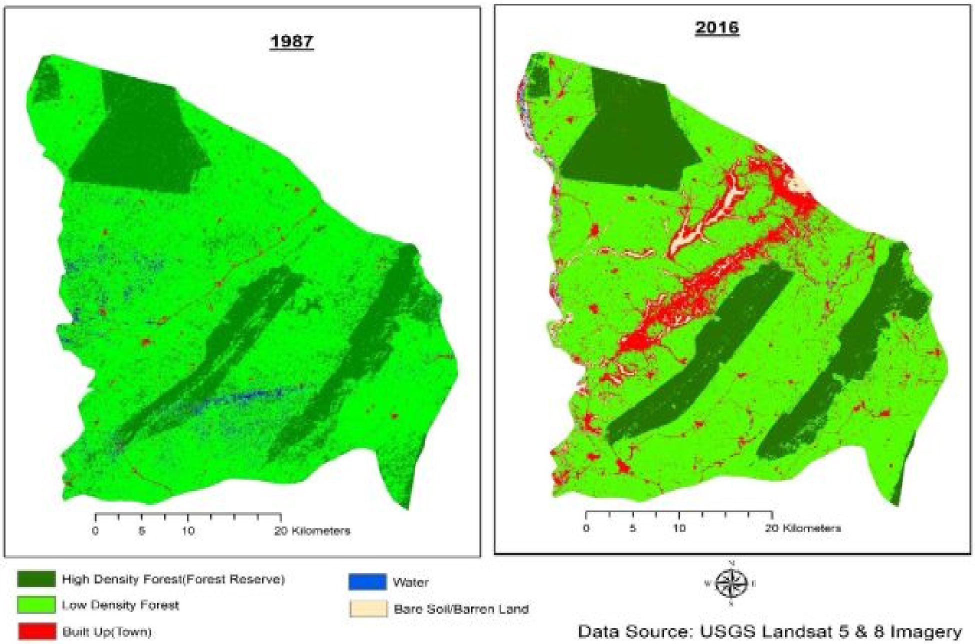
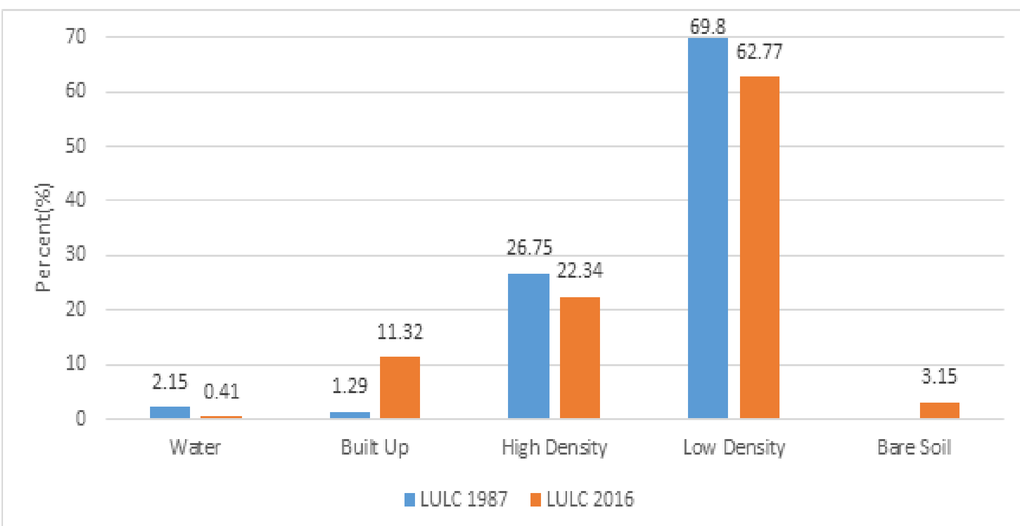


Figure 5: Percentage of Land Cover Change for Amenfi East District

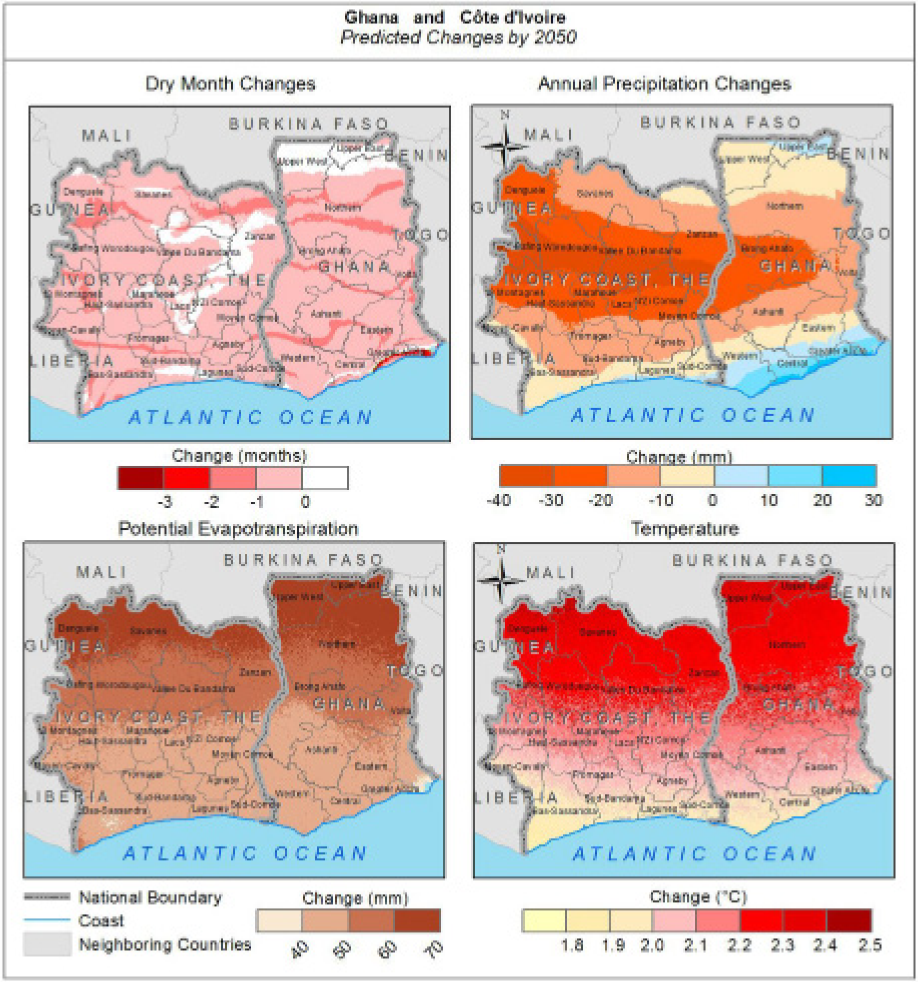


Source: Based on Maximum Likelihood Classification.

Climate Change Impact Analysis

Data from studies by Laderach et al. (2013), which covered forest regions in Cote d'Ivoire and Ghana (and the study area), projected that mean temperature has been rising and is expected to rise by 2.1 degrees Celsius by 2030. By 2050, these conditions are predicted to get worse, increasing the risk of drought in forest regions and making it more challenging to cultivate the major cash crop of Ghana and Cote d'Ivoire, cocoa. Research on temperature and precipitation by Stanturf et al. (2011) in Tarkwa, close to the study area, also projected that temperatures in the rainforest zone are expected to increase by 1.69 degrees Celsius in 2050 to 2.56 degrees Celsius in 2080 during the wet season. In the dry season, temperatures are predicted to rise by 1.76 degrees Celsius in 2050 and by 2.76 degrees Celsius by 2080. Precipitation will decrease from 45% to 31% during the wet season. Similar results have been reported by Asante and Amuakwa Mensah (2015), which projected increasing temperature, decreasing rainfall and accelerated desertification rate of 20,000 hectares per year in Ghana. The combination of rising temperatures, evapotranspiration, and decreasing precipitation with greater unpredictability, accompanied by frequent extreme weather events, is likely to adversely impact the suitability of land for agricultural purposes (See Figure 6: Predicted Changes in Precipitation, Evapotranspiration and Temperature by 2050). Published research reports on extreme weather events in the study area were unavailable. Still, a review of the frequency of such events in other parts of the country provides a sense of the situation (Table 4: Major Extreme Weather Events in Ghana since 1995).

Figure 6: Predicted Changes in Precipitation, Evapotranspiration and Temperature by 2050.



Source: Laderach et al. (2013).

Table 4: Major Extreme Weather Events in Ghana since 1995.

Year	Extreme Weather Event	Area Affected
1995	Flooding	Greater Accra and Western Region (Axim)
1997	Flooding	Greater Accra
1999	Flooding	Upper West, Upper East, Northern Region, Brong Ahafo Region, Volta Region
2001	Flooding	Greater Accra
2007	Flooding (300,000 people affected)	Upper West, Upper East, Northern Region
2010	Flooding (3,000 people affected; a collapsed bridge that cut off parts of Agona Swedru) –24 deaths recorded –1,000 homes destroyed –5 000 people evacuated in the Tema area.	Greater Accra; Eastern Region (Begoro area); Central Region (Agona Swedru)
2011	Flooding (10 hours of heavy rain) –14 deaths –43,000 people affected	Greater Accra; Eastern Region (Atiwa)
2013	Flooding	Greater Accra
2014	Flooding (10 hours of continuous heavy rain)	Greater Accra
2015	Flooding and fire (worst flooding incident after 2 hours of rain) –154 deaths –46,370 people affected	Greater Accra
2016	Flooding	Greater Accra
2017	Flooding	Northern Region (Tamale)
2018	Flooding –34 deaths (including 32 year old medical doctor)	Greater Accra
2019	Flooding (55 mins of rain) –5 deaths	Greater Accra

Source: Ministry of Environment, Science, Technology and Innovation (2013); BBC[7] News Pidgin, Ghana (2019).

[7]. https://www.bbc.com/pidgin/tori-48456992, date of access August 4, 2021.

Land Degradation and Mercury Use

In the interviews, respondents were asked to comment on how small–scale mining is undertaken around their communities. A respondent indicated that the miners usually excavate the banks of water bodies and use wash plants which discharge mud and waste material into the water and destroy the water bodies. As a result, the Offin River, a tributary of River Pra, has been heavily polluted by small–scale mining activities (Interview 1)[8] . The creation of mine pits on lands was mentioned as having a significant impact on the environment in many communities, and these have blocked access to the farms of the locals. Mine pits (Figure 7) are created from the excavation process but usually are left uncovered, filled up with water from streams which have been diverted or from rainfall. These pits, which were often close to communities, were notorious for breeding mosquitoes which infect residents with malaria (Interview 4)[9] . The problems associated with water, mine pits, land and farms were found to be interrelated, reinforcing each other.

8. Interview with woman, 50yrs, Denkyira Dominase, June 20 2018.
9. nterview with man, 32yrs, Wasa Dadieso, June 22 2018.

Figure 7: Uncovered Mine Pits at Denkyira Breman

Source: Authors, June 2018

Several instances were cited where both children and adults have fallen into the pits and died, mainly because they misjudged the depths and dangers they posed; at least four such deaths were reported from Denkyira Kyekyewere, Denkyira Fosu, Pokukrom and Wasa Gyapa. Many deaths caused by the uncovered pits were not officially declared but were mentioned in almost every community where illegal mining occurred during the research. In many instances, domestic animals fall into the pits and die, especially where the pits are close to the community, such as Pokukrom. (Interview 5[10] and interview 6[11] 1 2018). Using chemicals, mainly mercury and diesel, in mining was mentioned as causing severe problems. It was noted that almost all the fish in River Offin and smaller water bodies have died due to these chemicals used by the small-scale miners. The residue of the mercury which is used to extract the gold is washed unto the land and the water bodies, while much of the diesel used to power the machines, excavators, and other mechanised equipment involved in the mining operation frequently spills onto the land and water bodies due to poor handling (Interview 7[12]) . These chemicals pollute the air and the land as well, making it extremely difficult for plants to grow (Interview 8[13]) . Mercury was mentioned as affecting crops, with some respondents indicating that most plants do not survive on lands that have been polluted with mercury and diesel (Interview 9[14] 2 2018; interview 10[15] 3 2018).

Impact on Farms

As a result of mechanised small-scale mining, most of the lands close to the banks of rivers have been destroyed and are easily flooded when the rivers overflow or during heavy rainfall, and the mining activities have also damaged thousands of acres of cocoa and food crop farms (Interview 11[16] and interview 12[17] 2018). The most affected crop is cocoa because many acres have been cut down for small-scale mining. Some farmers sold their farms to the miners for cash, while others suffered dispossession due to a lack of tenure security to the land they were cultivating (Interview 13[18]) . As a consequence, some farmers indicated that the production levels of cocoa farms have reduced to about 40 per cent due to small-scale mining, and some farms were still being cleared to make way for mining activities at the time of data collection in 2018 (Interview 14[19]) . Several rural residents have relocated from their communities and farms to nearby villages because the water bodies they depend on for farming and domestic purposes have been utterly destroyed. In addition, several acres of fertile land have been cleared for mining, and most of these were left with uncovered pits by small-scale miners. These become death traps for farmers whenever it rains heavily. Many

10. Interviews with youth leaders and elders, Pokukrom, June 25 2018.
11. Interview with woman, 22yrs, Denkyira Breman, June 2
12. Interview with man, 24yrs, Denkyira Kyekyewere, June 15 2018
13. Interview with woman, 40yrs, Denkyira Dominase, June 20 2018.
14. Interviews with small-scale miners, 34yrs and 46yrs, Wasa Gyapa, June 2
15. Interview with elder, 64yrs, Wasa Nananko, June 2.
16. Interview with woman, 19yrs, Wasa Abreshia, June 22 2018.
17. Interview with a man, 49yrs, Denkyira Dominase, June 20
18. Interview with man, 40yrs, Brofoyedu, June 21 2018.
19 Interview with elder, 86yrs, Pokukrom, June 25 2018.

streams and water bodies have dried out because the forest cover protecting the water has been removed, streams have been excavated, and many water courses blocked. Many farms across water bodies have been abandoned because access to these has been blocked by large mine pits, which have collected water, making them impossible to cross (Interview 19[20] and Interview 20[21]) . In other instances, the land can no longer hold water for an extended period as it could in the past due to increased evapotranspiration resulting from comprehensive river banks and increased exposure to the direct impact of the sun. These changes have severely affected farming activities, especially in dry seasons (Interview 15[22] and Interview 16[23] 2 2018). Some lands have become so dry that they were described as 'deserts' by respondents (Interview 21[24]) Such lands have lost fertility, and nothing can be grown on them until they are restored, if at all possible; at the moment, they are not helpful for any farming activities (Interview 18[25]) . Several acres of cocoa farms, rice farms, palm plantations, plantain and cassava crops have been destroyed, creating food security problems in several communities (Interview 17[26]) .

Many farmers have resorted to walking long distances to find suitable land for farming or relocate to survive (Interview 22[27]) This is particularly so in the Nyamebekyere area, where it has become challenging to find suitable land to farm because of the destruction caused by small-scale mining, which has left many lands covered with deep, stagnant pools of water, making it very dangerous to walk to farms (Interview 23[28]) A significant increase in the cost of living has occurred because basic foodstuffs which people could grow on their farms have to be purchased, and water, which used to be readily available for domestic use and farming, is now scarce (Interview 24[29]) 2018.

Impact on Water Bodies

The impact of mining activities on water bodies has been monumental. According to an official of the Daboase Water Treatment Plant in the Western region, some small-scale miners directly dredge water bodies to find gold, especially

20. Interview with youth, 18yrs, Wasa Abreshia, June 20 2018.
21. Interview with elder, 69yrs, Wasa Ntwentwena, June 23 2018.
22. Interview with woman, 45yrs, Nkotimso, June 21 2018.
23. Interview with small-scale miner, 46yrs, Wasa Gyapa, June 2
24. Interview with man, 24yrs, Denkyira Abora, June 20 2018.
25. Interview with woman, 26yrs, Denkyira Breman, June 21 2018.
26. Interview with youth, 18yrs, Denkyira Abora, June 20 2018.
27. Interview with man, 59yrs, Wasa Nananko, 23 June 2018.
28. Interviews with men, 22yrs and 28yrs, Nyamebekyere, June 28 2018.
29. Interview with man, 20yrs, Denkyira Abora, June 20

in River Offin in the Denkyira-Fosu area. The official indicated that small-scale miners could dredge down to a depth of 50 feet to the bottom of the River and excavate other chemical components, which are carried downstream to the water treatment plant (Interview 2[30]) He stated that this severely worsens the turbidity of the water from 200ntu, which is the acceptable level for processing, to a high of 3,000-3,500ntu. This has affected the operations of the water treatment plant in many ways, such as a three-fold increase in the cost of treating water (Aluminum Sulphate, time, maintenance costs, power, etc.), a 50 per cent reduced volume of water available at the abstraction point for processing; and 50 per cent reduction in the water supply to consumers. The miners also divert water bodies to mining sites to wash gravels or create canals for wastewater from their plants to adjoining water bodies, leading to further reductions in water available to process for consumers (Interview 3[31])

The Offin River (Figure 8) has been polluted severely and cannot be used by people in communities such as Denkyira Kyekyewere for domestic activities. Interviews indicated that, previously, the people could drink the water and wash their clothes directly, but now they can no longer do these. They currently have to buy a sachet water for drinking (GHC 3-63[32] per day) and use borehole water for washing and other domestic activities. However, in some communities, the water is used for washing after treatment with Aluminum Sulphate (Interview 25[33]). Even borehole water has been affected by the pollution and, therefore, cannot be used for drinking or domestic purposes in some communities (Interview 26[34]) Obtaining clean water for watering crops, especially vegetables, and for spraying agrochemicals has become a significant problem due to the level of pollution water pollution by small-scale mining, and this situation becomes most severe in dry seasons (Interview 27[35]) . The practice of diverting waterways onto their mining sites and extending river banks has damaged many water bodies in communities, leading to frequent flooding of farmlands and blocking off paths to farms (Interview 28[36]) . In some instances, mining is undertaken in swamps, and the wastewater is diverted into nearby streams, thereby polluting them (Interview 29[37] and Interview 30[38] 2018).

30. Interview with the water treatment plant manager, Daboase, July 12, 2018.
31. Interview with elder, 64yrs, Denkyira Kyekyewere, June 15 2018.
32. USD 1 was equivalent to GHC 5.78 (Sept 2020)
33. Interview with woman, 25yrs, Denkyira Abora, June 20 2018.
34. Interview with woman, 38yrs, Wasa Nananko, June 23 2018.
35. Interview with woman, 22yrs, Denkyira Abora, June 20 2018.
36. Interview with elder, 69yrs, Wasa Ntwentwena, June 23 2018.
37. Interview with man, 54yrs, Wasa Dadieso, June 22 2018.
38. Interview with a man who personally lost farmland, 45yrs, Denkyira Dominase, June 20

Figure 8: Polluted River Offin at Nyamebekyere

Source: Authors, June 2018.

Many water bodies have become extinct due to mining activities or turned into mere ponds. For example, the Subin River at Kyekyewere no longer exists because of illegal mining (Interview 3). Table 5 below presents water bodies that have been heavily polluted (20 water bodies) or no longer live (25 water bodies) in the 12 communities covered by the study.

Table 5: Heavily Polluted and Extinct Water Bodies

#	Community	Heavily Polluted Water-bodies (Not suitable for domestic or agricultural purposes)	Extinct Water-bodies (No longer exists/ only mud remains)
1	Denkyira Abora	Offin, Fiamma	Donyame, Kotia, Kodowea
2	Denkyira Dominase		Ramumu, Bohumu, Aboma
3	Wasa Abreshia	Nsam, Akumaa, Kotobom, Sibre, Donkro	
4	Denkyira Breman	Asuofuo, Abokon	Asuo Yaa
5	Denkyira Brofoyedu	Asuofuo	
6	Denkyira Nkotimso	Foban	
	Wasa Dadieso	Eshire, Yaaya, Abramoa	
7	Wasa Adansi	Ankobra	
8	Wasa Gyapa	Eshire, Yaaya, Anikokoo	Kotonkron
9	Wasa Ntwentwena	Sutre, Anikyim	
10	Wasa Nananko		Boti, Waawaa, Nananko, Foofo, Prisi and Nsam
11	Pokukrom		Awiawia, Frumado, Bredi, Kwame Saman, Nsutuntun and Yubunu
12	Nyamebekyere	Total: 20	Abowie, Kwabrafo, Popo, Kyeretua Total: 25

Source: Authors, June 2018

Impact on Health

The impact of mining activities on the environment has led to severe health problems. Malaria has become nearly untreatable and endemic. This is because mosquitoes bred in mine pits have increased to unmanageable proportions, causing widespread malaria (Interview 31) . In an earlier study (Botchwey and Crawford, 2016), a medical doctor in Dunkwa-on-Offin confirmed this situation, stating that the Chinese miners bring along their version of drugs to treat themselves against malaria, which are more potent than the ones used by the Ghana Health Service

39. Interview with elder, 69yrs, Wasa Nkwekwena, June 23 2018.

(GHS). With time, the malaria parasites develop resistance to the drugs, rendering them ineffective and jeopardising the GHS medicines' efficacy. Thus, they have had to keep scrambling for alternative medication to treat malaria, putting pressure on their activities. Therefore, malaria is prevalent in the communities due to the high number of mosquitoes bred from the stagnant ponds. In addition, community residents along the Offin River have also been advised by health personnel not to eat any fish from the River due to the high level of pollution detected (Interview 32[40]) . It was also revealed that some community residents had been diagnosed with cancer-related to the chemicals which enter the water and food systems from the mining activities (Interview 33[41]) . Some of these were traced to the use of the polluted water for watering crops, spraying vegetables, and for domestic use at Abreshia (Interview 34[42] and Interview 35[43]). Other common health problems related to the use of unwholesome water that was mentioned include Buruli ulcer and bilharzia in the Pokukrom area. Indeed, small-scale mining activities were still happening in this area despite the ban at the time of data collection in June 2018 (Interview 36[44]) .

State Responses to Intensified Small-Scale Mining

In April 2017, the Government of Ghana banned all small-scale mining activities for six months, which was extended for 20 months but eventually lifted in December 2018. The argument of the Government was to sanitise the sector and stamp out the culture of impunity that had festered since 2008. The interview with the Daboase Water Treatment plant official indicated that the ban initially helped to bring the water turbidity level from 3,000ntu to about 700ntu. However, by July 2018, the turbidity level had increased to about 2,000ntu. The military crackdown by the State led to several arrests of small-scale miners involving Chinese and Ghanaians. However, small-scale mining continued from many indications but was more covert and difficult to detect. Some respondents at the community level complained of economic hardships as a result of the ban, indicating that it had led to unemployment and increased criminal activities such as armed robberies and ritual murders in the area (Interview 37[45]) . Many people lost their jobs as a result of the ban and suffered economic hardship because mining is the only occupation they know (Interview 38[46]) .

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40. Interview with woman, 38yrs, Denkyira Fosu, June 15 2018.
41. Interview with man, 49yrs, Denkyira Dominase, June 20 2018.
42. Interview with man, 24yrs, Wasa Abreshia, June 23 2018.
43. Interview with small-scale miner, 29yrs, Wasa Gyapa, June 22 2018.
44. Interview with elder, 86yrs, Pokukrom, June 25 2018.
45. Interview with man, 24yrs, Denkyira Kyekyewere, June 15 2018.
46. Interview with man, 24yrs, Denkyira Abora, June 20 2018.

Small-scale gold production as a contribution to total gold production was 38% in 2016; in 2017, this reduced slightly to 34%. Most surprisingly, it rose sharply to 41.4% in 2018 while the ban was still in place and all legal and illegal small-scale mining was supposed to halt (Ghana Chamber of Mines 2019, p11). The ban did little to stop the activity, leading to the further destruction of agricultural lands and the loss of food and cash crops. This turn of events exposed the inability of the State to effectively tackle the environmental crisis, as it simply resorted to military crackdowns, similar to earlier actions in 2013; however, such measures have been unable to address the complex economic, political and diplomatic tensions involved in the small-scale mining situation in Ghana (Botchwey and Crawford, 2019; 2018).

DISCUSSION

We now turn our attention to the meaning of these findings in the light of environmental principles and conventions, which Ghana as a signatory State is bound to respect and observe following article 40 (d) of the 1992 Republican Constitution of Ghana, which enjoins the State to adhere to the principles and ideals of the United Nations, the African Union and any international organisation of which Ghana is a member. The Stockholm Declaration (1972) of the United Nations established the environmental rights of all persons, with responsibility imposed on the State to protect and improve the environment for the present and future generations. Ghana's legal requirements to protect the environment while undertaking small-scale mining activities based on the Environmental Protection Agency Act 1994 (Act 490) and Environmental Assessment Regulations 1999 (Legislative Instrument 1652) are also discussed here, given the findings from the study. Protection of the environment includes safeguarding natural resources on which the livelihoods of the present and future generations depend. Adopting a definition of livelihood to refer to the means to make a living and to secure the necessities of life such as food, water, shelter and good health, among others, the findings of this study reveal mainly detrimental consequences for the livelihoods of peasant farmers living in the mineral-rich communities studied. Farming activities have been disrupted in many ways, including blocking of access to farms due to increased depth of water bodies and extension of water banks as a result of mining within water resources; loss of farmlands to mining activities, which have affected the cultivation of cash crops and foods crops, leading to high prices of daily staples; families relocating to other areas due to lack of arable land, as a result of pollution of their land through diesel and mercury spillages from mining activities. Remote sensing analysis confirmed significant land degradation and the emergence of barren land in the study area from 1987 to 2016.

Water is the most crucial natural resource to be protected to ensure a reasonable livelihood for the present and future generations, as clearly stated under the Stockholm Declaration of 1972. Remote sensing analysis indicated a 77.78% net loss of water in the Upper Denkyira District and an 80.9% net loss of water in the Amenfi East District from 1987 to 2016. This corresponds with information from an interview with a senior official at a water treatment plant, who also reported more than 50% loss of water at abstraction points, where they obtain water for treatment. Furthermore, data from the 12 communities visited during the study also confirmed that 20 water bodies had been heavily polluted (no longer suitable for domestic or agricultural purposes), with 25 wholly extinct or covered with mud. Thus, findings regarding the impact of mining on water reveal severe damage and loss, which have already affected water treatment plants and water availability for domestic and agricultural purposes; climate change projections of higher temperatures, increased evapotranspiration, less rainfall and more frequent extreme weather events are very likely to make the situation worse. These findings clearly show that the principle of ensuring a means of livelihood for people in their environment has yet to be observed in the pursuit of small-scale mining activities, and the domestic laws and regulations regarding small-scale mining have also been ignored.

The Rio Declaration of the United Nations instituted the inter-generational equity, precautionary and polluter-pays principles to govern the environment. The study used satellite imagery revealed a net loss of 44.55% of high-density forest cover and a 13.26% net loss of low-density forest cover from 1987 to 2016 in the Upper Denkyira District. The data in the Amenfi East District revealed a net loss of 16% of high-density forest cover and a 10% loss of low-density forest cover during the same period. These need to demonstrate observance of the principle of inter-generational equity and others stipulated by the Stockholm and the Rio Declaration, to which Ghana is a signatory.

Article 24 of the African Charter on Human and Peoples' Rights 1981 establishes the rights of people to a generally satisfactory environment favourable to their development. With reference to health, the creation of mine pits with stagnant water in close proximity to communities has provided suitable breeding grounds for mosquitoes; this situation has also contributed to the prevalence of malaria in the study area. Other health problems related to the uncovered mine pits and polluted water bodies include Buruli ulcer, bilharzia, children and adults drowning in uncovered pits, with two recent deaths reported in the communities, studied and from other mining areas in Ghana (Ghanaweb.com, April 6 2020; Graphic.

com.gh, February 24 2020). Life has become more precarious and dangerous for residents, and this situation needs to reflect a generally satisfactory environment favourable to the development of people in mining communities as stipulated by Article 24 of the African Charter on Human and Peoples' Rights. Thus, based on the findings of this study, Ghana, as a duty-bearer in the observance and respect for environmental principles and conventions, has yet to live up to expectations in the areas studied.

CONCLUSION

This study examined how mechanised small-scale mining has impacted the environment and livelihoods of people in mineral-rich areas within the broader context of climate change processes in Ghana. It investigated how the consequences of small-scale mining, such as degraded lands, damaged forests, and lost and polluted water bodies, have impacted on livelihoods of community residents. It juxtaposed the findings with climate change processes such as rising temperatures, higher evapotranspiration and reduced rainfall which are likely to compound the situation and make things worse. The paper contributes to existing scholarship by demonstrating a convergence of evidence between direct field observations, interviews, land use changes from 1987 to 2016, and climate change processes regarding small-scale mining and the environment.

The findings show that these processes have worked together to make life more precarious for people in the affected areas studied. Mechanised small-scale mining has contributed significantly to environmental damage, which has affected the cultivation of food crops and cash crops; it has led to pollution of water bodies, removal of forests, increased health problems, and forced relocation of peasant farmers in search of new agricultural lands.

The environmental principles and ideals established by the United Nations, the African Union, and Ghana's legislation regarding mining and the environment have largely yet to be respected in the areas studied, resulting in detrimental consequences to the livelihoods of peasant farmers. For example, the 100-meter buffer zone between water bodies and mining sites was not respected, and indeed, the water bodies themselves were being dredged for gold, with mining equipment mounted directly within the water bodies. Gravels were being washed now in water bodies; no reclamation of mine pits was done; access to farms had been blocked with excavated pits and expanded banks of water bodies, and farmlands had been mined for gold. Mercury and diesel fuel have leaked into soils, making them less suitable for farming. The findings also show that the State still needs to articulate and implement an effective response to the challenge. However, it must avoid derogating from observing sound environmental principles and ideals if it is committed to tackling environmental challenges.

Artisanal small-scale mining remains a business, a livelihood, and a way of life for many. Most ASM operators who have been exposed to mechanisation are unlikely to return to the use of the pick, shovel and bowl type of mining. Therefore, the State needs to find a balance between promoting employment and economic productivity while protecting the environment in line with sound principles. Focusing on protecting the environment in the context of mechanised small-scale mining makes a lot more sense rather than seeking to outlaw it entirely.

To conclude, the study finds that small-scale mining has negatively impacted the environment and livelihoods of people living in mineral-rich areas and urban centres that rely on water supplies that take their source from the affected locations. This situation will likely worsen through rising temperatures, increased evaporation and frequent extreme weather events occasioned by climate change. The paper argues that the environment needs to be secured not only because of observance of sound environmental laws, conventions and principles to which the State is obligated domestically and internationally but also because our survival as humans depends on it.

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