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The Evil Couple: Illegal Mining in Water Bodies and Climate Change - A Case Study of Ghana

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Abstract: Climate change has detrimental impacts on almost every living thing including those that form component of livelihood. From agriculture, energy, tourism, transportation, recreation, fishing etc. to water resources, climate change has affected and would continue to impact these activities as emission of greenhouse gases continues unabated. The quality and quantity of most water bodies in Ghana have been marred due to extraction of minerals. Illegal miners, who are the main players of this social evil, floutover mining instruments that protect the environment and have tempered with the quality of water resource in most parts of the country. These water bodies which are polluted with contaminants such as heavy metals, cyanide, mercury etc. render water resources unsafe for human use. However, as repercussions of climate change have resulted in dryness of some streams and rivers, pollution from miners would make water situation precarious if care is not taken. Citizens whose livelihood depend on these water resources may need to relocate or take the law into their own hands to protect such water bodies which might result in conflict. The toxic chemicals, heavy metals and muddy nature of almost all the water bodies found in the southern part of the country speak a volume of the extent of the pollution and what future holds for the nation. If stringent measures are not put in place to protect aquatic life, animals and humankind, things would get out of hands in no time.

Key words: Missing

INTRODUCTION

Climate change is now universally recognised as a global threat which has come to dwell with humankind. The main argument has been what might be the nature of climate for tomorrow and what can be done to adapt to tomorrow's climate which has the propensity to change the success story of human race. Another debate has to do with what can be done to mitigate the impacts which primarily emerge from greenhouse gas (GHG) emission and land cover change. According to Fifth Assessment Report (AR5) of Intergovernmental Panel on Climate Change (IPCC), since 2011, concentration of GHGs has continued to rise in the lower atmosphere as a result of anthropogenic forcing, reaching annual averages of 410 parts per million (ppm) for carbon dioxide (CO_2), 1866 parts per billion (ppb) for methane (CH_4) and 332 parts per billion (ppb) for nitrous oxide (N_2O) in 2019. Over the past decade, the land and ocean have proportionately taken about 56% of GHGs emission from human-induced radiative forcing [1, 2].

The battle over the cost of adaptation and mitigation that became the order of the day during the summit in Copenhagen in 2009 clearly confirms the acceptance of the constraints that climate change presents to the globe by a larger community [Food and Agriculture Organisation (FAO), [3]. Access to good, reliable and adequate water supply augment the health status of people irrespective of age or class. According to International Water Association [2], 'access to good, safe and reliable drinking water is one of the most basic needs of human society'. An observation made by Global Water Partnership [4] suggests that several countries pay attention to satisfy the basic needs of their populace, however, one-fifth of the global population is without access to safe drinking water and service deficiencies mainly impact the poorest class of the population in the third world countries.

Climate change impact assessment has shown that nothing hides itself from the aftermath of the phenomenon and activities that are hard hit comprise rain-fed agriculture and water resources. A substantial proportion

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of people in recent times is experiencing restrictions on access to drinking water due to drought events, a vulnerable percentage of the natural and social action chains [5]. The science available to prove that the climate is changing is conspicuous and what is currently taking the centre stage of discussion is how to enhance adaptive capacity of the citizens to become resilience to the impacts of the climate change. Another topical issue which presides over every climate change conference is mitigation. However, politicians who are to spearhead the fight against climate change impacts and to promote emission cut are reluctant to do so. Admittedly, dispute over the cost of adaptation and mitigation at the summit of Copenhagen in 2009 is a crucial witness of the reception of the challenges of climate change by a broad society [3, 6].

The scientific proof for global warming is currently realised irreversible [7]; it is evidenced by unparalleled rates of rise in air atmospheric and oceanic temperatures and it is associated with swift rises in atmospheric carbon dioxide (CO_2). The unprecedented loss of icecap and glaciers on the world's mountaintops and unabated sea level rise which is 'swallowing' islanders and coastal stretches validate the unceasing warming trends of climate change phenomenon [3, 8].

Developing countries such as those found in sub-Saharan Africa which are least contributors to greenhouse gases, as it has been reported and estimated would bear about 70-80% of the cost of the damages that evolve from climate change [9]. Current projection shows that total cost of climate 'insurance' via mitigation actions to stabilise atmospheric temperature increase to 2°C at carbon dioxide content of 450 parts per million (ppm) will be less than 1% of world Gross Domestic Product (GDP) in 2100 [10, 11].

The changing climate would impact farming activities through higher air temperatures and irregular rainfall, with significant drop in precipitation likely in the mid-latitudes where the state of agriculture is perilous and normally irrigation dependent. It has been reported that rainfall for major and minor seasons have been compromised in duration and intensity in the transitional belt of Ghana [12] hence water resource availability and quality would not be spared either, as rainfall trend changes and evaporation increases. Hydrological alteration rising from change in climate would intensely affect aquaculture and inland fishery activities badly. The precarious rain-fed farming in the mid and low-latitudes would continue to suffer unlike those of higher latitudes (North America and northern Europe) which would experience rise in farming productivity (FAO, [3]; Haensler *et al.* [13]).

Climate Change: Trends Versus Predictions: The provision of temporary update to the climate change modelling, scenarios and impact assessment by Copenhagen Diagnosis [7] was captured in the report of IPCC Fourth Assessment Report (AR4) [14]. In recent years, there have been substantial advances with regards to modelling capacity and techniques, with much complex and historical analysis of observed pattern in climatic parameter. It indicates that atmospheric temperature increase has been monitored using the Special Report on Emission Scenarios (SRES) (Forero-Ortiz *et al.* [15]; Tian *et al.* [16]. Persistent measurements of increasing average air moisture content has offered adequate evidence for the acceleration of the water cycle and according to Fourth Assessment Report of IPCC, some of the process and modelling uncertainties resolved show a fast changing and more sensitive climate. Though shortwave radiation reaching the Earth is at its lowest recorded level, however, this phenomenon has not had any real impact on the warming planet, Earth due to excess greenhouse gases in the lower atmosphere. The modelling used for AR4 has, as a matter of fact, under predicted many observed patterns, given a feedback of more disturbing projections of effects in the future [15].

Although climate having received international attention due to its deleterious predicament, little attention has been given to climate variability which is equally risky to especially smallholder farmers. Climate variability is anticipated to rise in years to come, but its prediction is harder to do with regards to scale and time unlike climate change. The combined repercussions from both climate change and climate variability exhibit much deadly impact than one of the couple [17, 3]. In fact, supportive evidence for several climate extremes are bound to happen [7], coupled with evidenced-based countless of heat waves especially in areas such as North America and Europe, characterised with decreased manifestation of cold shocks. With respect to five years moving averages, it is documented that the United States has realised rise in precipitation and elsewhere, the state of climate variability has surpassed those estimated in climate modelling reports. Even though too early to draw relationships, there is available evidence that precipitation increases from 5 to 10% per degree Celsius temperature rise [3].

The story is different in low latitudes (e.g. areas around the Equator such as Africa) where decrease in precipitation in most regions is phenomenal. Rising atmospheric temperatures has resulted in excessive evapotranspiration rates and reduction in rainfalls 'conspire' to rise the harshness, length and occurrence of droughts in the sub region. According to the Fourth Assessment Report of IPCC, some estimated land of 75 million hectares which is currently viable for rain-fed agriculture, with a growing window of less than 120 days in sub-Saharan Africa would be lost in the coming years around 2080 [14].

According to report of Working Group I of IPCC, each of the last four decades has been successively warmer than any decade that preceded it since 1850 [2]. The report further stated that surface temperature globally in the first two decades of the 21st century (2001-2020) was 0.99°C higher than between 1850 and 1900 (1850-1900). The global surface temperature observed on average (1.09°C) is higher (2011-2020) than 1850 – 1900, with land surface (1.59°C) experiencing the greatest as compared to that of oceans (0.88°C). The current update from methodological advances and new datasets (AR6) place the present warming 0.1°C higher than the previous one [2].

Surprisingly, according to the data of the Sixth Assessment Report (AR6), released in 2021 by IPCC, in 2019, concentrations of carbon dioxide (CO_2) in the atmosphere were higher than at any period in, at least, two million (2 million) years and concentration of methane (CH_4) and nitrous oxide (N_2O) were higher than any other time scale in the past at least 800, 000 years. Since the rise of industrial revolution (1750), carbon dioxide has risen about 47% in the atmosphere. Apart from CO_2, other greenhouse gases such as methane (156%) and N_2O (23%) have alarmingly increased in their concentration in the atmosphere trapping more heat than ever [18, 2].

Global Climate Change and Precipitation: Most of the global projections on rainfall patterns in several regions have been confirmed, but the overall constraints of Global Climate Models (GCMs) in giving explicit spatial trends of precipitation remain problematic. Nevertheless, the latest Atmosphere-Ocean (coupled) Global Climate Models (AOGCMs) is working on the interactions and feedbacks obtained among topography, elevation and albedo [3].

There is enough evidence supporting acceleration of El Nino events and the relationship between sea surface temperature (SST) and frequent cyclones occurrence, however, GCMs cannot model them thoroughly. Climate variability is also sped up by these two internal phenomena (La Nina and El Nino) in some regions such as Kenya (La Nina) and southern Africa (El Nino) and their occurrences have accounted for droughts which is negatively affecting GDP [19].

When it comes to prediction of future precipitation, there are uncertainties from a lot of the models. For instance, a recent downscaling exercises across the width and breadth of United States established that there was discrepancies with respect to evidence on precipitation from ensemble GCM modelling and 'off-line'. Regional Climate Model (RCM) modelling projected mean rises in rainfall and runoff in contrary to the earlier report from GCM and ensemble GCM-based work for at least four major river basins [20, 21, 22]. The reason might be that slight differences in scenario specification and downscaling techniques do not necessarily preserve GCM rainfall per grid cell; GCM grids tend to smear out gradients, particularly precipitation; and poor representation of an estimated shift to winter dominated precipitation in the Colorado Basin and in California – a change that would improve runoff [2].

The story of precipitation, unlike atmospheric temperature, varies from latitude to latitude or from region to region per the various simulations. Rainfall is predicted to rise over high latitudes, the Equatorial Pacific and parts of the monsoon regions, but reductions over parts of the subtropics and small portions in the tropics in SSP2-4.5, SSP3-7.0 and SSP5-8.5. The part of the land mass experiencing detectable rise or reduction in seasonal average precipitation is estimated to rise as contained in the report of AR6 [2].

A warmer climate, as being experienced recently, would amplify very wet and very dry weather and climate events and seasons, with effects of drought or floods. However, the geographical position and frequency of these phenomena depend on estimated changes in regional atmospheric circulation, comprising monsoons and mid-latitude storm tracks. There is a possibility that rainfall variability in conjunction with the El Nino – Southern Oscillation is anticipated to intensify by the second half of 21st century in the SSP2-4.5, SSP3-7.0 and SSP5-8.5 scenarios [23, 2].

Climate Change and Water Resources: Water resource is already over-appropriated in many parts of the globe. It is estimated that more than 2.4 billion people, which represents one-third of the Earth's population, will live in water-stressed regions and it is projected that by 2025, the figure is believed to increase to two-thirds [23].

As rainfall has direct impact on running and groundwater, reduction in precipitation would desiccate most water bodies on the surface of the Earth. According to Adams & Peck [24], variation in rainfall in the face of climate change will influence quantity, variability, timing, form and intensity of water resources. It is worth noting that terrestrial climate change will equally alter or cause a rise in the rate of evaporation, increase proportion of precipitation received as rain instead of snow, reduce runoff seasons, augment water temperatures and decrease the quality of water in both hinterland and coastal zones [24].

As a matter of fact, many geographical regions will suffer from reduced water supplies. According to FAO [23], due to how man misuses water, groundwater tables and river levels are declining in several regions globally. Summer periods are projected to experience much shortfalls resulting in reduction in moisture content in the soil and more severe and regular agricultural drought [25].

Contrary, winter precipitation in the form of rain will rise as a result of increasing surface temperatures, with a deficit proportion falling as snow. Snow pack levels are equally estimated to develop later in the winter season, amass in minute quantities and thaw earlier in the season, resulting in reduced summer flows [26, 24].

A report of National Centre for Atmospheric Research [(NCAR), [27] has it that regions classified as 'very dry' have been doubled since 1970s. Besides, areas known to be drought prone regions are also expanding in an alarming rate and these areas comprise sub-Saharan Africa and Australia. Elsewhere in Northern Hemisphere, the flow of long-term annual rivers and natural water storage capacity have been experiencing deficit due to glacial/snowcap melting. Several Asia's largest rivers are estimated to drop off in coming years due to glacial thawing. Scientists have projected a possible dryness of Lake Mead, which serve over millions of inhabitants in the south-western United States, around 2021 [27, 26, 28].

Existing Challenge of Water Resources: One of the major problems that is threatening human survival especially in the developing countries is declining water quality. The situation is compounded by inadequate wastewater treatment due to unavailability of resources or capital. In most of less developed countries such as those found in African soil, running water (strings, streams, rivers etc.) traditionally used as sources of drinking water have been dangerously polluted by unscrupulous citizens and expatriate alike who want to get rich overnight. In China, for instance, several water bodies have been polluted beyond measure. It has been estimated that due to insufficient sanitation facilities and rising water demand as a result of growing population, it is documented that globally, 900 million people lack access to safe water while up to 5 million populace die each passing year from water-related illness [25, 29, 15].

Evidence of Climate Change in Ghana: According to IPCC forth assessment report [14], currently, Ghana is undergoing four physical impacts of climate change and these include temperature rising, changing regime of rainfall towards a longer dry season and vanishing rainy season. Climate change is impacting on trend of rainfall in all ecological zones but hard hit in the far north where rainfall regime is single maxima. Recent sea level rise coupled with floods being experienced in south-east (Keta) of the coast of Ghana is a clear indication that climate change is at work.

A projected trend of atmospheric temperatures from 2010 to 2050 by World Bank as cited by Asante & Amuakwa-Mensah [30] for Ghana shows warming over the entire West African country with the highest temperatures occurring in the northern part of Ghana with the lowest being experienced in the transitional belt (formerly Brong Ahafo). The current mean annual temperature ranges between 25°C to 30°C. However, occasionally, the air temperatures can be as low as 18°C (minimum) and as high as 40°C (maximum) in the northern part of Ghana [30].

Rainfall in Ghana has experienced an observable shift trend towards a longer dry season and shorter wet season. The phenomenon is however, characterised by disappearing short dry spell that separates the major farming season from minor season in the transitional ecological region [31, 32]. According to a study by Adjei & Kyerematen [32] (1960-2014), the transitional ecological zone of Ghana (a region separating forest from Savanna belt) has undergone late onset of rainfall (from early March to late March) and early cessation of it (from November to late October). This has compelled farmers to shift planting date from March to April [33] while others (farmers) too have turned their attention from their main occupation (maize) to cashew farming [12]. A long-term data analysis by Dietz *et al.* [34] shows that places in the northern part of Ghana around Upper East Region has equally experienced below average rainfall conditions for over 18 years (1972-1990). In the same vein, it is reported that drought years have risen in several parts of Ghana. According to a study by Adiku *et al.* [35], manifestation of drought year has reached 3 to 4 out of every 10 years in the late 1980s as compared to 1 to 2 years in the preceding years. The paper further argued that rainfall irregularity analysis substantiate the swing from drought to flood years have become pervasive posing great threats to most smallholder farmers in Ghana.

The climate change in Ghana is having a negative impact on vital water resources, energy supplies, crop production and food security. The three northern regions of Ghana are the most vulnerable with the experience of extreme high temperatures and severe flooding [36]. According to Akudugu and Alhassan [37], the northern part of Ghana has repeatedly experienced incidences of droughts and floods with several communities and families losing their farms as a source of their livelihood in the past years which is attributed to a change in climatic conditions. Furthermore, in 2007, floods in the northern part of the country, proceeded a long period of dryness which affected more than 325, 000 people [Global Facility for Disaster Reduction and Recovery (GFDRR), [38]. The capital city of the country (Accra) in 2015, also experienced days of torrential rainfall which resulted in severe flooding leaving 159 Ghanaians losing their lives [39]. However, Ghana as a whole is also experiencing increased extreme weather conditions [40] such as a rise in sea level causing flooding and displacing some communities in the coastal belt. Ghanaian farmers have identified erratic rainfall patterns, longer periods of dry season and desertification as the main current consequences of climate change [41]. Prolonged period of drought coupled with high temperatures are also experienced, changing rainfall pattern making it difficult for farmers to plan their planting season due to their inability to predict rainfall pattern [32]. This has affected food production and poor yield by farmers causing food insecurity in Ghana. Farmers are therefore forced to grow crops that are resilient to extreme weather conditions such as cassava, cocoa and cashew [33]. Furthermore, prolonged drought has caused drying up of major water bodies that serve as source of raw water to the Ghana Water Company Ltd (GWCL). This has caused water shortage in several communities, villages, towns and cities in the country (Ghana Water Resources Commission, [42].

There is also a current tension between Ghana and Burkina Faso over a decision to withdraw water from the River Volta which would lead to a reduction in the volume of water needed for the production of electricity in Ghana from a study carried out by [43]. This however could lead to trans-boundary conflict. In addition to the above evidence of climate change in Ghana is where nomadic herdsmen in search of water and grass to feed their cattle cause destruction to farmers in the southern part of the country. This has led to a number of conflict between the Fulani herdsmen and the farmers, [44, 37]. The decrease in the volume of water in the Akosombo dam has also had a negative impact on generation of hydroelectric power in that the country experienced severe power outages consistently as a result of drought [45]. Due to an increase in air temperatures, the countries inland fisheries in Lake Volta also experiences a reduction in stock [46].

Water Resources in Ghana: Basically, water resources in Ghana can be categorised into surface and underground sources. The known major water bodies (rivers) classifying under surface water in Ghanainclude River Volta and its tributaries (Oti, Black and White Volta), Pra, Bia, Tano, Todzie, Aka, Densu, Ayensu, Ankobra, Ofin and Och-Nakwa. Apart from the tributaries of River Volta, almost major rivers in Ghana drain the southern sector of the country [42, 47]. The largest river, which is River Volta, is shared among five other countries which include Cote d’ Ivoire, Mali, Burkina Faso, Togo and Benin. It drains about 70% of the total land of the country (Ghana) and the other rivers take over the 30% remaining [48].

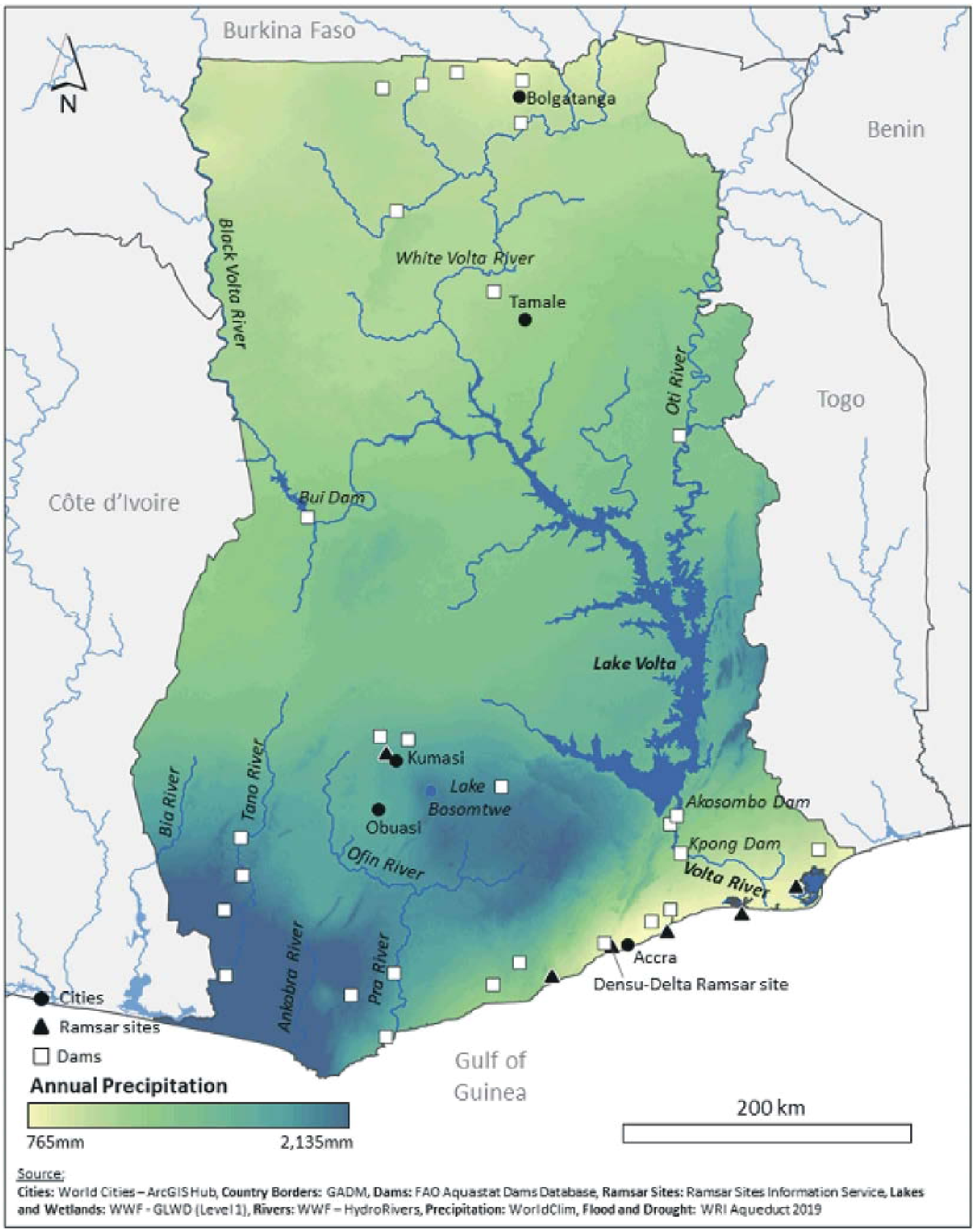
About 41% of the population of Ghana depend on groundwater for their livelihood. Nevertheless, this rate is higher in the small communities in the hinterland (59%) as compared to urban areas (16%). The dependency ratio of the populace on groundwater is highest in the northern part of Ghana due to low seasonal availability of surface water [49, 50]. Unlike precipitation where the projection is full of uncertainty, higher atmospheric temperatures are expected to be dominant hence will speed up evaporation and result in water losses and this will consequently affect water resources in most parts of the country [30].

An average annual precipitation of 2000mm/year, 950 mm/year and 800 mm/year occur in the South West, Northern and South Eastern parts respectively [51].

The surface water sources are made use by industries, home, transport services and tourist whereas the groundwater sources are mainly used among both urban and rural folksfor domestic purposes [47].

Most of the streams and rivers draining the gold mining areas get their channels diverted or blocked by the miners for their successful operations. While large scale miners take into consideration the impacts of diversion on the environment, the small-scale mining operators do not. However, the diversions by small-scale miners are altogether ad-hoc and haphazard [52, 47]. Almost all the water bodies that drain the southern part of Ghana such as River Ankobra, Pra, Tano, Bia, Ofin, Densu, Ayensu etc. are muddy or polluted by miners making them unsafe for use. Wildlife, man, aquatic life, domestic animals etc. have their lives in danger when they depend on such water polluted with mud and toxic substances. Unarguably, cost for treatment of water for domestic use has equally escalated [53, 54, 55].

A study conducted on River Offin [56] suggests that climate change has a great gravity on water resources. The study argued that several tributaries that feed the River Offin are drying up with some ceasing to exist. The dryness of the tributaries of River Offin has made the volume of the River small. So when dry season prolongs, the River reduces to pocket of stagnant water bodies. In 2013 for instance, the report maintained that the River Offin dried up and became dry land. Hand-dug wells were produced around the banks of the river to provide alternative source of water to the communities at the catchment area. Another river which has also been affected by this phenomenon is River Anyinam in the Eastern Region closed to Anyinamso. A research has established that the entire river, which the community was named after, has vanished (dried up) leaving behind its huge channel due to scanty rainfall and dissipation of streams that supply constant water to the river [56].



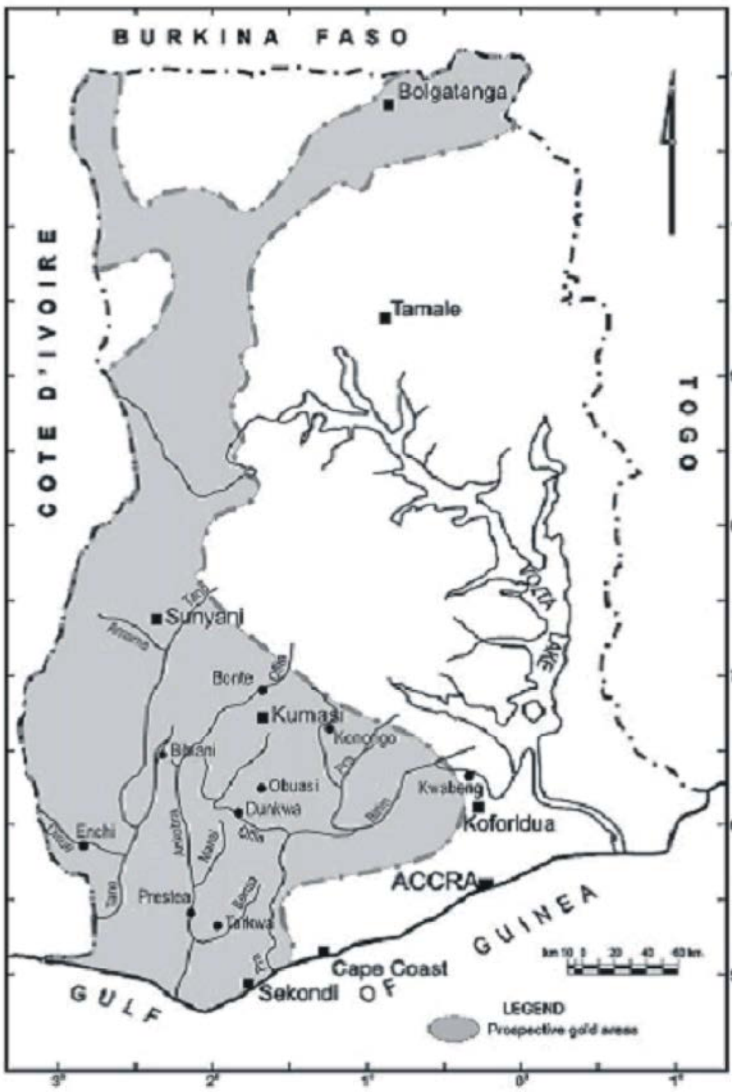


Fig. 2: Prospective Gold Mining Areas in Ghana
Source: Hilson, [53]

Nature of Galamsey Activities in Ghana: Ghana, a West African country formerly called Gold Coast, is blessed with enormous mineral deposits; the major ones being gold, diamonds, manganese and bauxite. Gold is principally the largest mineral produced in the West African country, accounting for over 90% of all mineral revenues accrued from minerals for the past two or more decades [57]. The sector is made up of large and small scale. The small scale also comprises legal and illegal mining sectors. The small scale sector absorbs about one million unemployed indigenous people [58]. The unregulated or illegal mining sector which is commonly known as galamsey, is the chief polluter of water bodies as its activities are not monitored by any legal instrument. According to Baah-Ennumh [59], illegal mining in Ghana depicts all mining activities done without obtaining proper license from regulatory bodies that govern practices of miners, hence such activities flout most of the mining laws and fail to observe appropriate buffer restrictions. They make use of rudimentary tools and techniques such as pick ass, chisels, sluices and pans for the exploitation of mineral reserves [60, 61].

In Ghana and many other countries in sub-Saharan Africa, predominant environmental challenges associated with small-scale mining activities consist of destruction of farmlands, pollution of water bodies, destruction of vegetation and habitats of wildlife [62, 61, 63].

Fig. 1: Polluted water body (of a tributary of River Ankobra) due to illegal mining

Fig. 2: Polluted water body (River Pra) due to illegal mining

According to a study by Yeleliere *et al.* [64], about 60% of surface water bodies in Ghana are polluted and the menace is worse in the southern part of the country where mining activities are predominant. High turbidity in the River Pra for instance has substantially increased water treatment cost and left some plants inoperable for couple of years [65]. A study has shown that River Volta basin contains high level of chromium that might have come from industrial or municipal pollution [66].

Impacts of Illegal Mining (Galamsey) on Drainage: There are countless of environmental problems and challenges linked to mining activities which evolve from competition for surface water and contamination [53]. The danger posed by illegal mining to water quality and water resources in Ghana has led to public outcry due to the closure of several treatment plants and how it has left several water bodies unusable [64]. Contamination, which is very deadly to both aquatic and living creatures such as man and animal, results from the discharge of effluents making up the various toxic chemicals such as cyanide, mercury and other organic chemicals used in the processing of mineral ores. These chemicals (with high percentage of acid) of effluent can either percolate into the soil affecting underground water or cause havoc towater bodies on the surface of the earth posing threat to humankind, domestic animals and even wildlife which depend on the water bodies in the catchment area [68, 69, 63, 67]. "Once in thenatural environment, mercury undergoes a change in speciation from an inorganic to a stable methylated state (MeHg) by non-ezymically and microbial action and when ingested, ecotoxicological effects result" [70].

Another concern of worry is the leaching of heavy metal oxides which comprises lead and zinc. Sometimes, these aforementioned metals spread throughout the environment following down pour (and soak the soil) causing mayhem to aquatic life, fauna, fora and the micro-organisms [68]. It is very hard, in recent years, to notice water resources such as crabs, fish, shrimps, snails etc. in the water bodies found in Ghana especially where mineral is mined due to the presence of hazardous chemicals in most water bodies [62].

It has been reported that Duncan *et al.* [67] the south-western basin of River Tano contains heavy metal from gold mining, but the situation is worse in the River Pra Basin where haphazard illegal mining is intensified. Again, arsenic levels near Prestea (River Pra Basin) have also been detected nearly 800 times the World Health Organisation (WHO) guideline limit for human consumption, most likely from unregulated gold mining in the country [42, 65, 71, 64].

Furthermore, a study by Duncan [42] in River Fena established that excessive pollution of the River poses health threat to the riparian communities around which rely on the River for their livelihood as most fisher men too had lost their jobs due to the death of fishes in the water body.

CONCLUSION AND RECOMMENDATION

Ghana has enough water bodies that can protect the country from water stress. There is also enough groundwater to shield the West African country from water scarcity. However, climate change and variability are currently impacting on these water bodies drying up most tributaries which feed up such streams and rivers. In recent years, most rivers are either reducing volumes drastically or completely drying up. The presence of illegal mining in water bodies is compounding the situation which might lead the country to experience water stress if measures are not put in place to contain mining in river banks and beds. Politicisation of sensitive issues in Ghana has made the fight against illegal mining in water bodies extremely difficult for the various ruling governments.

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