



Intelligent Observation of Illegal Mining to Mitigate Pollution of Air and Water Resources in Ghana

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Outline

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- ❖ Research Methodology
- ❖ Expected outcome
- ❖ Conclusion and outlook

Introduction

- There is no denial of the fact that a lot of harmful substances are being released daily into our water bodies as a result of illegal mining and other unlawful land degradation activities.
- It has become a common knowledge that illegal small-scale mining has become rampant and technically complex in all regions of Ghana.
- The high visibility of the environmental impacts (especially on water) has caused a coherent public outcry and call for action by the government.
- The nature, scope and distribution of artisanal gold mining and its impacts on the environment in Ghana have been characterized by heterogeneities across geographical regions and over time.
- This warrants the need to monitor the overall environmental footprint of mining in general (whether small-or large-scale, legal or illegal) to disaggregate the impacts and delineate hotspots for specific policy attention.
- Effective monitoring of such widely distributed but spatiotemporally heterogeneous activities has huge resource implications in terms of manpower, finance and technology.

Introduction- Literature

- In spite of the positive contribution of the mining sector to the socio-economic development of Ghana, the negative impact of mining on the environment is on the ascendancy (Hilson, 2002; Kyere-Boateng & Marek ,2021), especially with the invasion of illegal miners.
- These impacts are often viewed with different spectacles depending on the level of impact and the area of interest. With regards to the environment, water courses are usually turned into reservoirs for the disposal of dangerous chemicals such as cyanide and mercury (Armah, et. al., 2010).
- Flooding has become an annual problem in most mining communities during rainy seasons with consequential loss of property and lives (Chan, 1997; Douglas et al, 2008) and Ghana is no exception (Agyemang et al, 2007; Armah et al 2010). As far back as 2011, floods caused by illegal mining activities killed five (5) people, rendering over 10,000 others homeless and huge destruction of farms (Nasirudeen & Allan, 2014).
- Much more havoc has been caused in recent times. In 2017, more than 40 precious lives were trapped in illegal mining pits and others were buried alive (Damoah, April 1 2017).
- Indirect effects of illegal gold mining are seen in the use of polluted water for agriculture and domestic and industrial purposes (Veiga & Hinton, 2002, February; Schwarzenbach, et al., 2010; Armah et al, 2013; Emmanuel, et al. 2018; Gyamfi, et al. 2019).

Introduction- Literature

- Currently, there is a lack of monitoring mechanisms to regulate and manage the activities in Ghana's forest reserves and around water resources (Agyenim, & Gupta, 2012; Mul, et al., 2015; Ankomah, et al., 2020).
- About 70% of artisanal gold mining in Ghana is found to be illegal (Long, et. al., 2015; Boadi et. al, 2016; Bansah et al, 2018).
- Research has shown that illegal mining has caused much harm to:
 - i. The local and the national economy
 - ii. The local communities
 - iii. The local and central government's businesses (Ghana Statistical Service, 2014)through the injection of harmful substances or heavy metals into our water bodies (Armah, et. al. 2010) resulting in higher cost of water treatment.
- The regional assessment of deforestation obtained from the Forest Commission of Ghana and water quality (that of water quality was obtained from the Ghana Water Company Limited) is worrying (Kyere-Boateng, & Marek, 2021).
- 60% of Ghana's water bodies is polluted (Water Resources Commission, 13 May 2017)

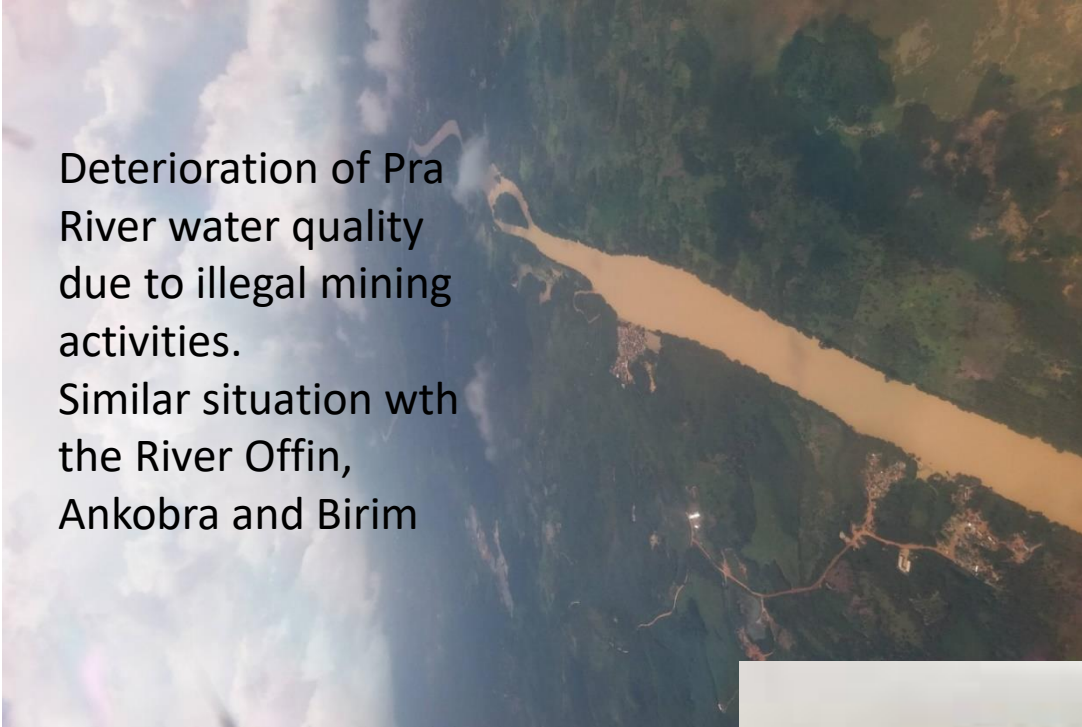
Introduction-Problem statement and Justification

- One of the footprints of illegal mining activities in a region is gaseous mercury (Hg) in the atmosphere. Illegal miners use mercury to form an amalgam with gold during the gold extraction process. heat is applied to the amalgamated gold causing the mercury content to sublime to the immediate atmosphere. West Africa is poorly sampled in global measurements of gaseous Hg and other aerosols
- airborne mercury emanates from both natural and anthropogenic sources, the latter is on the increase in the world and currently of huge environmental concern partly due to its deposition in water resources affecting aquatic life and humans through the food chain. In terrestrial and aquatic systems, Hg can be transformed to methylmercury, a neurotoxin that accumulates in biological tissues and distillates in food-chains to unacceptable magnitudes, toxic to flora and fauna and homo-sapiens (Mason et al. 1995; Selin 2009). Measurement of Hg in the atmosphere is vital to the understanding of Hg sources, deposition, cycling, and spatial and temporal trends in airborne Hg concentration.
- more comprehensive atmospheric monitoring is essential for evaluating the effectiveness of the recent Minamata Convention (which Ghana signed in 09/2014 and ratified in 03/2017), a global regulatory mechanism to decrease environmental Hg loadings (Gustin et al. 2016).
- Besides the introduction of Hg into our water resources, illegal miners also destroy forest cover (Agbo, 2019) which absorbs the Earth's carbon dioxide (CO₂) and exposes the land to erosion and vagaries of the weather

Introduction-Problem statement and Justification

Deterioration of Pra River water quality due to illegal mining activities.

Similar situation with the River Offin, Ankobra and Birim



Community involvement in illegal mining

- Illegal gold mining usually carried out in remote regions of Ghana.
- unlicensed miners employ unapproved methods to excavate the land indiscriminately.
- harmful substances like mercury end up in the nearby rivers, a major source of drinking water for the rural folks.



An illegal miner displaying a bar of gold

- These occurrences take place at the blind side of multitudes of Ghanaians including most, if not all, security and law enforcement officials in the affected regions.
- These activities happen in the remote forest and savannah regions which are not easily accessible and therefore the perpetrators are not apprehended.
- After destroying parcels of land that could have been used for agricultural purposes, they shift to another region to continue their nefarious activities without reclaiming the previous region as professional practice requires. What is more, most of these regions are not easily accessible by road or rail.

Introduction: **Aim and Objectives**

❖ **The main focus of the project is to:**

track illegal mining and pollution along buffer zones of water resources in real-time to aid law enforcement

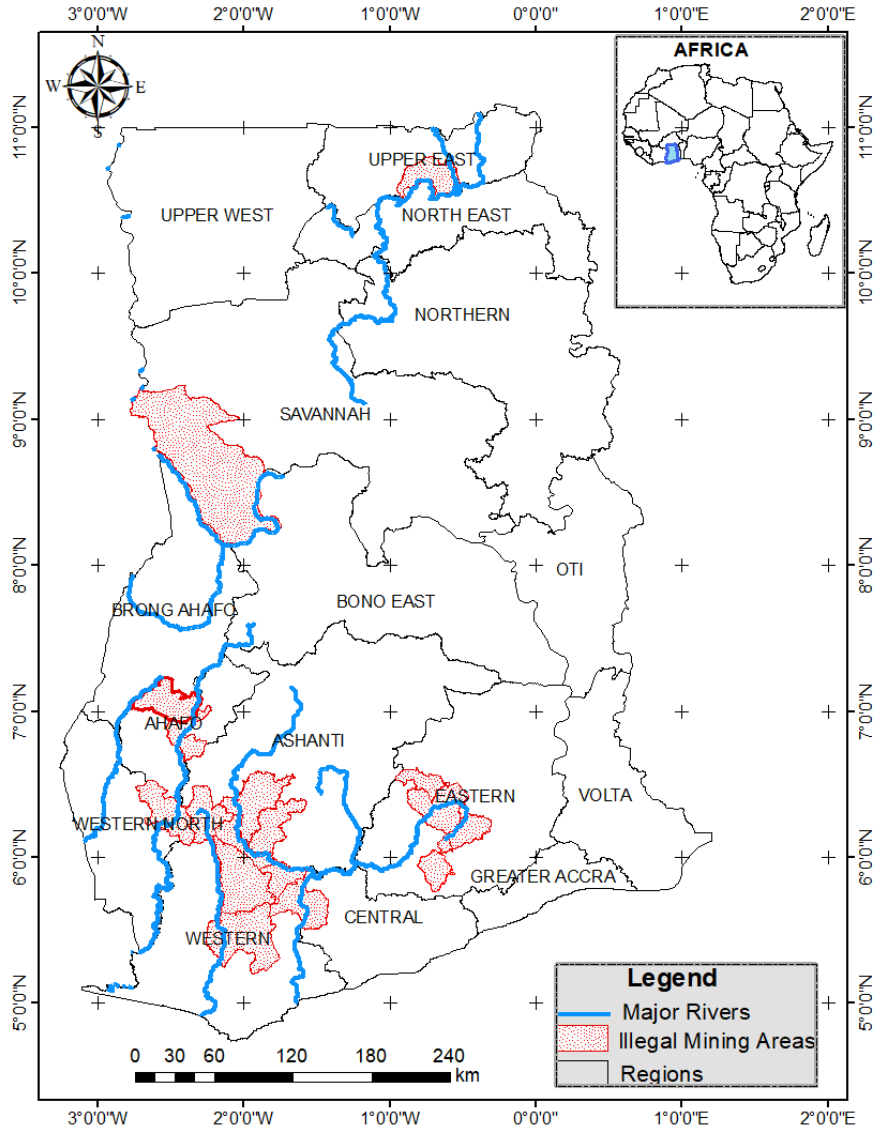
The specific objectives are to

- solicit information from stakeholders about illegal mining operations affecting water resources
- assess the current illegal mining and other water pollution mitigation strategies
- exploit space data to monitor illegal mining in Ghana to improve intervention against illegal mining organizations.
- empower End Users to make more timely decisions regarding interventions against illegal mining activities causing water and air pollution
- measure Changes in patterns of illegal mining across Ghana using the combined EO/drone surveillance,
- provide robust Monitoring platform to aid policy framework to mitigate pollution of water resources
- Help Government to regulate the activities of all artisanal gold mining as well as large scale mining companies in Ghana to prevent pollution of our water resources.

Introduction-Research Questions

- This study seeks to answer the following research questions:
 - How should a multi-sectorial solution be found to a multi-dimensional problem of water resources pollution due to illegal mining and other land degradation activities?
 - How can the exact areas of operation of illegal miners be determined and tracked?
 - How can a sustainable monitoring platform be built and maintained?

Research Methodology- **Study Area**



Size of regions affected by illegal mining

From space studies perspective, Ghana is not a large country. Almost every region in Ghana is experiencing illegal mining and/or other forms of land degradation activities, from north to south and east to west.

But the hot spot regions are Western Region (23921 Sq. Km) and Ashanti Region (24389 Sq. Km).

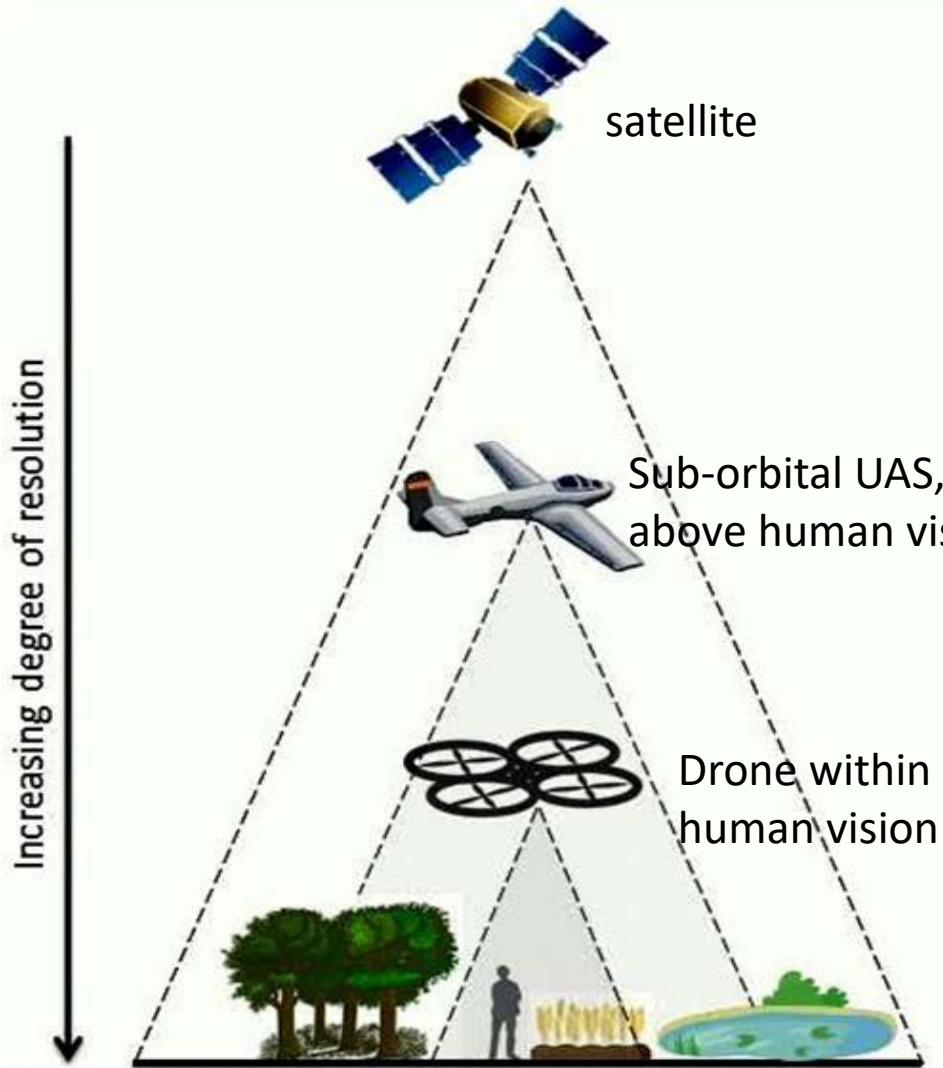
There are increasing cases of illegal mining taking place in the Eastern Region (19323 Sq. Km) and Central Region (9,826 Sq. Km), especially in Upper Denkyira District.

the project is focusing on these four regions and then later extend operations to the rest of the country.

A good number of illegal miners encroach on large-scale mining concessions.

Research Methodology-**Materials and method**

Remote sensing from space is a powerful tool that can be used to track activities such as these on the Earth's surface. Aside the advantage of wider coverage than in-situ data acquisition methods, remote sensing is a useful tool for capturing data from inaccessible areas and from dangerous terrestrial environment, and it is above the capabilities of precarious human traps, vision of mercenaries and unscrupulous land guards.



- ❖ Project will apply the qualitative research approach and Space technology and innovation:
 - Interviews and focus group discussions with stakeholders using **snowball sampling approach**
 - Satellite remote sensing and earth observation (EO) data
 - Satcom and GPS, wireless mesh , GIS
 - Remote mapping technologies
 - Object based image analysis using segmentation (ie for high resolution image) best method
 - Pixel based image analysis (most common, b/c of cloud cover)
 - Internet of Things (IoT) and sensors
 - High altitude unmanned aerial systems (UAS)
 - Artificial Intelligence (AI) and machine learning
 - Data analytics, data mapping

Research Methodology-Method

- **Stakeholder engagements and interviews**
 - using snowballing approach (indepth interview with key informants ie police , ministers, chief directors, CEO, EPA, etc)
 - Focus group discussion (indigens, small scale miners, water and water and sanitation , western regional coordinating council)
- Interacted with and interviewed Chief Directors, Deputy Ministers and Ministers of the affected ministries (MLNR, MESTI, MWS, W/R), EPA, Water Resources Commission, Ghana Water Company, Minerals Commission, Ghana Police personnel on the field, researchers in the university and Ghana Health Service and affected citizens in a snowball sampling approach
- **Gaps in the current method**
- Current method of joint police and military clamp down operations against illegal miners, operations (a.k.a operation Vanguard) largely based on tip off from concerned citizens or informants, this is not reliable enough. Chief culprits ran away leaving helpless caretakers behind, some equipment and tools are ceased and sometimes set ablaze, ceased tractors/escavators disappear sometimes, soldiers on foot could lose their lives eg Major Mahama lost his life during one such operation in 2017
- Drones deployed on such operations: not fit for surveillance and reconnaissance purposes, within human vision, short-lived, not sustainable. Suborbital UAS needed to work in tandem with EO satellites
- **No measurements or monitoring mechanism of Hg levels at the moment**

Results

- Stakeholder engagements and interviews
- heavy machines, mostly of Chinese technology, used by the illegal miners sometimes cause landslides into river bodies worsening the state of the already polluted water bodies making them more turbid.
- conflict between large scale miners and the illegal miners due to encroachment of illegal miners on large scale concessions.
- highly visible environmental degradation and water pollution associated with operations of the illegal miners.
- illegal miners do not rehabilitate mined-out areas.
- uncontrolled and unsafe use of mercury and cyanide in the processing phase is of great concern given its bio-accumulation tendencies in the ecosystem.
- From Ghana Health Service, mercury vapour through inhalation can cause memory and speech loss, numbness, vision problems, convulsion and in some cases death. The mercury vapour is removed from the atmosphere during rains and eventually gets into rivers and the root of crops. According to research scientists of CSIR, rivers, crops and vegetables harvested from illegal mining communities and their environs are infested with mercury and other heavy metals
- Ministry of Lands and Natural Resources (MLNR) agreed that there is poor tracking mechanism of heavy duty equipment used by some of these illegal miners.
- According to MLNR, the government of Ghana is seeking technical and donor support to help curb this menace

Expected outcome

❖ The outcome of this work will:

- enable more realistic evaluation of the actual footprints and extent of illegal mining and the corresponding pollution of our water resources and improve water quality by reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials
- Ensure the availability and sustainable management of water and sanitation for all communities in Ghana
- provide a cutting-edge solution to mitigate misuse of land and pollution of water bodies in Ghana
- solve land and environmental management problems using data obtained from satellite and other Earth observation platforms.
- complement the already existing great effort of the government in tracking a lot of water pollution and land degradation activities on the ground from space.

Limitations

- EORIC and Ghana Space Science and Technology Institute (GSSTI) have data scientists with transferable skills available to assist data processing and analysis but Ghana is yet to launch a satellite suitable for surveillance and reconnaissance
- Ghansat 1 is limited
- In respect of the sentinel freely available data imagery can be taken every 14 days with a ground resolution of 10m for RGB images (enough to allow for characterization and extent). However, in Ghana we will be restricted by cloud cover, with the images not being able to see through it. Therefore, there could be a possibility with RGB that numerous times may occur without results.
- need to establish either a link with Planet or Digital Global or Airbus Defence or the other option is to rely on the ESA imagery available or to purchase the images from the companies above (a considerable cost and therefore budget allocation will have to be in place).
- In respect of SAR based satellites (with radar to penetrate cloud cover) sentinel satellites are every 6 days passing and 5m x 20m resolution. This might not be enough to catch some of the slope movement as the tiles are large, this would mean that money needs to be set aside for interferograms at a higher resolution (expensive but necessary).
- New partners are needed to carry out this project in Ghana successfully

Conclusion and outlook

The implementation of the space application strategies for ground monitoring would:

- ❖ stem the tide of;
 - Wanton Water pollution
 - indiscriminate and illegal mining and
 - environmental degradation in Ghana and West Africa (a major hub of raw materials of the world) in particular and Africa in general.
- ❖ Provide technological innovation fusing earth observation data with data from high altitude drones for the identification of illegal mining activities to produce intelligence products to aid the decision-making of End Users in Ghana

Conclusion and outlook

- Hyper-spectral cameras and sensors aboard sub-orbital UAVs needed to track and map the areas of operation of illegal gold miners.
- After tracking the location of operation and obtaining the right geographical coordinates, the appropriate security agencies can then close in on the culprits using global navigation satellite system (GNSS, eg. GPS) receivers to provide the exact location (Weber, 2021; Congalton, & Green, 2019; Pelton, & Bukley, (Eds.) 2010).
- obtain the geographic coordinates of the illegal mining sites for possible superimposition on the maps. The main focus of the project is about tracking illegal mining in real time, though we would be doing other Earth observation activities.

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- **Ministry of Lands and Natural Resources**