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Operational dynamics of "Galamsey" within eleven selected districts of western region of Ghana

J. Mantey[1*], F. Owusu- Nimo[2], K.B. Nyarko[2] and A. Aubynn[3]

1. Gold Fields Ghana Limited, Environmental Department, Tarkwa-Ghana
2. Kwame Nkrumah University of Science and Technology (KNUST), Civil Department, Kumasi-Ghana
3. Ghana Minerals Commission, Accra-Ghana

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**Corresponding author: mybryanjones@yahoo.co.uk (J. Mantey).*

Abstract

The uncontrolled spread of illegal artisanal small-scale gold mining (ASM), popularly termed "galamsey" in Ghana, has, for decades, impacted adversely upon water bodies, soils, wildlife, human health, and safety. A lack of understanding, however, of the types of galamsey, their operational attributes, and their relative impacts has unfortunately hindered an effective policy response despite numerous calls from civic societal groups to address this menace. This paper is part of a comprehensive study in 11 selected municipal and district assemblies of the Western Region of Ghana to help provide an in-depth understanding into the galamsey operations in Ghana. It discusses the various forms of galamsey, their operational attributes, and relative environmental impacts. Through extensive literature review, site visits, and task observations, five broad categories and 11 sub-groupings of galamsey were unearthed based on the gold deposit type, resources used, origin of technology used, mining, and processing style as well as the local names given. These include (1) Placer/alluvial galamsey ("dig and wash", "washing plant", "washing board", "anwona", dredging, and panning), (2) Underground galamsey (abandoned underground shafts and "sample pit"), (3) Surface ("chamfi") galamsey, (4) Mill-House galamsey, and (5) Selection galamsey. Whilst the underground and selection galamsey involve ore mining only, the mill-house focuses exclusively on ore processing. The alluvial and surface galamsey, however, involve simultaneous mining and ore processing activities.

The information presented in this paper could prove valuable to policy formulation efforts, design, and implementation of effective wasteland remediation programs by governments, conservation organizations, and other stakeholders in hard-hit regions with similar illegal gold mining dilemma.

Keywords: *Artisanal Small-Scale Mining, Galamsey, Chan Fa Machine[1], Alluvial, Underground Mining.*

[1]- Chan fa machine: A Chinese hammer mill popularly used by the galamsey operators for washing slurry in a sluice lined box with blankets to separate valuable gold particles from the finely-crushed sediment.

1. Introduction

1.1. Background

Ghana is recognized today as the second largest gold producer on the African continent (after South Africa), and the eighth largest gold producing country in the world [1-3]. This country is predominated by two main gold mining sectors, large-scale mining (LSM) and small-scale or artisanal small-scale mining (SSM/ASM) operations [1]. Within the SSM/ASM sector is "galamsey", a local term used popularly for the illegal or unregulated form of artisanal small-scale gold mining operation.

The uncontrolled activities of galamsey have adversely impacted upon water bodies, vegetation, wild animals, human health, and safety. In fact, the devastating impacts on water bodies is believed to be so widespread that almost every major water body in Ghana has, directly or indirectly, been affected by its activities [4-7]. In view of the many reported negative impacts, numerous calls have been made by stakeholders for the abolishment or regularization of galamsey as well as the restoration of all the affected or abandoned wastelands [8-11].

Unfortunately, the present operational disposition of galamsey is poorly understood. There is limited information on the operational types, attributes, and relative environmental effects, which are fundamentally required for an effective policy response to this galamsey menace [12-14]. This lack of information is a challenge for government authorities, and has resulted in policies and solutions that do not take into account the specifics of the problem at hand [15-17].

This study, therefore, seeks to unearth the current operational types of galamsey, their attributes, and their relative environmental impacts across eleven selected municipal and district assemblies (MDAs) in the western region of Ghana.

1.2. Galamsey

In Ghana, the terms Small-Scale Mining (SSM) and Artisanal Small-Scale Mining (ASM) are used interchangeably [7]. Under the current Ghanaian Minerals and Mining (Amendment) Act (703) 2014, a small-scale mining operation in Ghana is defined as a mining operation over an area of land in accordance with the number of blocks (21 hectares) prescribed by the L.I 2182 and under small-scale mining license. It generally entails the exploitation of mineral deposits using fairly rudimentary implements at low levels of production and with minimal capital investment. It is usually undertaken by an individual, group of persons or a co-operative society on a prescribed block [18]. However, the lack of enforcement of laws governing the ASM/SSM sector has led to the proliferation of galamsey.

Aubynn [7] has defined galamsey as the practice of discretely gathering minerals found either at or just below the soil surface and selling them in contravention to state laws. It is considered as a corrupt form for "gather and sell", a term coined by the colonial masters who observed how gold was being gathered and sold in an ancient gold coast [7]. This unregulated mining is referred to by different names in other countries: orpailleurs (in neighboring francophone countries) [19] and garimpeiros (in Brazil) [20]. In South Africa, they are popularly called zamazama [21] and ninja miners in Mongolia.

Galamsey in Ghana is normally concentrated in towns, villages, and forested areas of mineralized regions, and it is operated along major rivers such as the Tano, Ankobra, Ofin, and Pra. This illegal mining business has attracted and continues to attract not only Ghanaian citizens but also foreigners (Italians, Togolese, Indians, Malians, China, Nigeriens, Nigerians, Burkinabes, Ivorians, Germans, and Indians) [22-24].

Due to its illegal nature, galamsey used to be confined to hidden and remote locations, and sometimes performed under the cover of darkness [25]. In recent times, however, due to the high level of defiance and poor law enforcements, it is not uncommon to seegalamseyers[2] operating by the road sides and within settlement areas. Galamseyers also tend to forge a close working relationship between themselves and the regularized ASM and LSM operators. Thus it is almost certain to sight galamsey operations within the environs or concessions of LSM and ASM; they prey on these concessions, and sometimes invade their premises for ore.

Galamsey is a job patronized by all categories of persons who are physically strong including men, women, children, teenagers, and the aged, and requires no education, qualification or experience. Galamsey is historically known to be associated with simple tools and implements like pick-axes, shovels, barrels, head pans, sticks, sacks, and nets [25, 18]. The use of excavators, dozers, and other heavy equipment has, however, been recently reported [23, 26-28].

The galamsey business generally involves three operational aspects: ore mining, ore processing (gold extraction), and gold refining. These three

[2]- Galamseyers are galamsey operators.

operational aspects may or may not be co-located. The processing house or plant site could be located at a central place to serve a number of individual mines. Thus one could encounter a mining site only, processing or milling site only, a refinery site only or all the three operations occurring simultaneously in the same place [29].
The three critical factors that dictate the positioning or co-locationing of galamsey mining, extraction, and refining operations in Ghana are the (1) ore grade, (2) nature of operation, and (3) availability of resources [29-31].

1.3. Categorization of ASM methods for precious minerals

The characterization of galamsey operations is quite new with very little study on it. To be able to adequately characterize these galamsey operations, it will be prudent to situate it in relation to the existing knowledge on ASM. The section, therefore, reviews the approach used for classifying ASM, which will serve as a valuable guide in classifying the galamsey operations in the subsequent sections.
The International Council on Mining and Metals [32, 33] has socio-economically classified ASM into five categories (which are by no means mutually exclusive, and a combination of these categories will generally be found in any given ASM location):

- Traditional: ASM that has occurred for generations in a given area, and may form parts of the traditional livelihoods.
- Seasonal: ASM that complements other seasonal livelihoods such as agriculture and rearing of livestock.
- Permanent co-habitation: ASM that takes place in areas connected to large- or medium-scale mining such as miners working in abandoned areas, tailings dams or downstream of the larger operations.
- Shock: When unexpected events such as drought, economic collapse, commodity price fluctuations, conflict, retrenchment from mining parastatals, and unexpected commercial mine closure drive individuals into ASM.
- Influx: The opportunistic in-migration or influx of ASM miners to an area where minerals have been discovered.

Villegas et al. [34] have also listed four main types of ASM including Permanent ASM, Seasonal ASM, Rush-ASM or “rush mining”, and Shock-push ASM.

In Ghana, ASM is classified according to the concession size as defined by the number of blocks prescribed (presently, a maximum of 12 small-scale unit blocks or 25.2 acres) and the license duration (i.e. 5-years) (Ghana Minerals Commission, 2012). Aryee et al. [18] have categorized small-scale mining of precious minerals (including the illegal form) into shallow alluvial mining, deep alluvial mining, and hard rock (lode) mining. According to them, mining methods employed by small-scale miners of precious minerals vary according to the type of deposit being exploited and its location.
Similarly, in 2013, the Small-Scale Mining Unit of the Minerals Commission in Tarkwa has categorized illegal ASM types, based on their method of processing, into dredging, dig, and wash with Chan Fa, underground workings, and ghettos[3].
The mining techniques employed by the ASM operators, either legally or illegally, can generally be divided into two common excavation types: surface mining and sub-surface (underground) mining. The type of mining and extraction technique used depend on the nature of gold deposit (placer or vein/lode deposit). The placer deposits consist of valuable minerals contained within river gravels, beach sands, and other unconsolidated materials, whilst the lode or vein deposits are valuable minerals found in veins, layers or mineral grains generally distributed throughout a mass of actual rock [35, 36].
Both types of gold deposits (placer/alluvial and lode) can either be mined or extracted by the placer, hard rock (surface and underground) or by-product mining methods. Among these, are panning, shoveling, pan and cradle, cradling, dry blowing, shaft mining, puddling, dredging, rocker box, long tom, sluice boxes, rocker or cradle, hydraulic mining, ground sluicing, drift mining/tunnel mining/pocket waterwheel mining, stamp, hydraulic drills, quartz or hardrock mining, winnowing, and crushing quartz [36].
The placer mining techniques use gravity and water to separate the dense gold from the lighter sand and gravel. The placer mining targets "native" gold that is not chemically bound up within the rock itself. In underground operations, tunnels/adits/shafts are drilled to the source of the ore and then blasted with explosives. The ore is

[3]- Ghetto: It is a tunnel or an underground working that an operator has acquired and earmarked for galamsey or illegal mining activity.

then removed and transported to a refinery for processing [35].

The rock ore is processed by crushing it into powder and using some combination of gravity, centrifugation, and "froth flotation" to perform an initial separation of gold from the rock. In many cases, this is followed by some form of cyanide treatment to precipitate the remaining gold. The remaining waste ore, known as "tailings", are then disposed of. The disposal of this tailings is one of the major challenges in hard-rock mining [37]. A vast majority of the current gold production from ASM comes from the commercial hard-rock mining operations.

2. Materials and methods

2.1. Study site

Eleven out of twenty-two metropolitan, municipal, and district assemblies (MMDAs) with a total land size of 13,758.29 km^2, representing approximately 57.5% of the total land available to the western region (23,921 km^2), were selected for this study. This region (Figure 1) was chosen because it had the highest deposit of gold resources as well as the highest concentration of large-scale gold mining companies (LSMs) and regulated artisanal small-scale gold mining companies (ASMs) in Ghana [38]. Ten out of fourteen large-scale gold mining companies (LSMs) actively operating in Ghana are located in the western region (Table 1).

Again, approximately 396 (representing 30%) of the 1,342 registered and actively operating small-scale gold mining (ASM) companies in Ghana operate within the western region of Ghana [38].

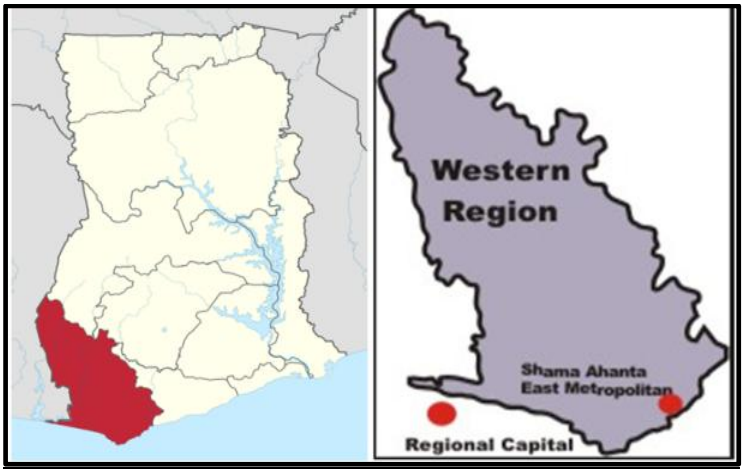

Figure 1. Map of western region of Ghana.

In selecting the eleven districts for the study, all the nine districts (Prestea Huni-Valley, Tarkwa Nsuaem, Ellembelle, Mpohor, Bibiani-Anhwiaso-Bekwa, Sefwi-Wiawso, Nzema East, Wassa East, and Amenfi East) hosting LSMs were selected. The remaining two districts (Amenfi Central and Amenfi West) were randomly selected, taking into consideration the number of licit ASMs and the history of galamsey within them.

2.2. Data collection framework

In this research work, varied classification modalities for illegal small-scale gold mining building upon those defined by [18, 32, 39] were considered. Emphasis is placed on arriving at a technical and environmentally related classification based on the deposit type, local nomenclature, resource use pattern, and technology, than on socio-economics alone. Summarized in Figure 2, is the framework used for establishing the operational dynamics of galamsey in the selected districts. It involves two distinct phases:

1. Desk Review and Preliminary Assessment Phase;
   - Host towns, villages, and site establishment
   - Preliminary establishment of galamsey types
2. Field Observations and Detailed Studies Phase

2.2.1. Desk review and preliminary assessment

The aim of this phase was to establish galamsey host towns, villages, and sites within the selected MDAs, and provisionally obtain details on the galamsey types and their distribution patterns. The existing information on towns and villages within each of the selected MDAs, especially on their respective websites, were found to be out-dated,

and had to be validated. A wide range of mining stakeholders including the Ghana chamber of mines, Ghana EPA, Ministry of Environment, Science and Technology, Geological Survey Department, Minerals Commission, Forestry Commission, Water Resources Commissions, Large-Scale mining firms, District Chief Executives and coordinators, security personnel (police, military, and other private security companies), traditional authorities, galamseyers, and ASM operators were all contacted and interviewed for diverse information on galamsey locations, scale, scope, resource use patterns, organization, source or origin, types, and many more.

A provisional list of host villages and towns for galamsey in each of the selected MDAs was then compiled. The base maps and available literature (annual reports, budget reports, special studies, etc.) on these villages and towns were also obtained.

The work for this phase also involved an extensive literature review on various mining and processing activities in Ghana within the selected MDAs and from global perspective. Information on both the small-scale mining (SSM) and large-scale mining (LSM) companies and operations in Ghana, geology as well as gold deposits of Ghana were gathered from the Minerals Commission, Geological Survey, and Ghana Chamber of Mines. The literature generally considered included the published and unpublished reports, media reports, internet reports, maps, statistical databases, and academic research works.

Within each selected district assembly, preliminary visits were made to at least three galamsey sites in order to validate the provisional list of galamsey types collated. The parameters observed were the resource and materials used, operators involved, physical characteristics of the sites, their environmental aspects and effects, their waste generation and disposal methods, and their scale and scope.

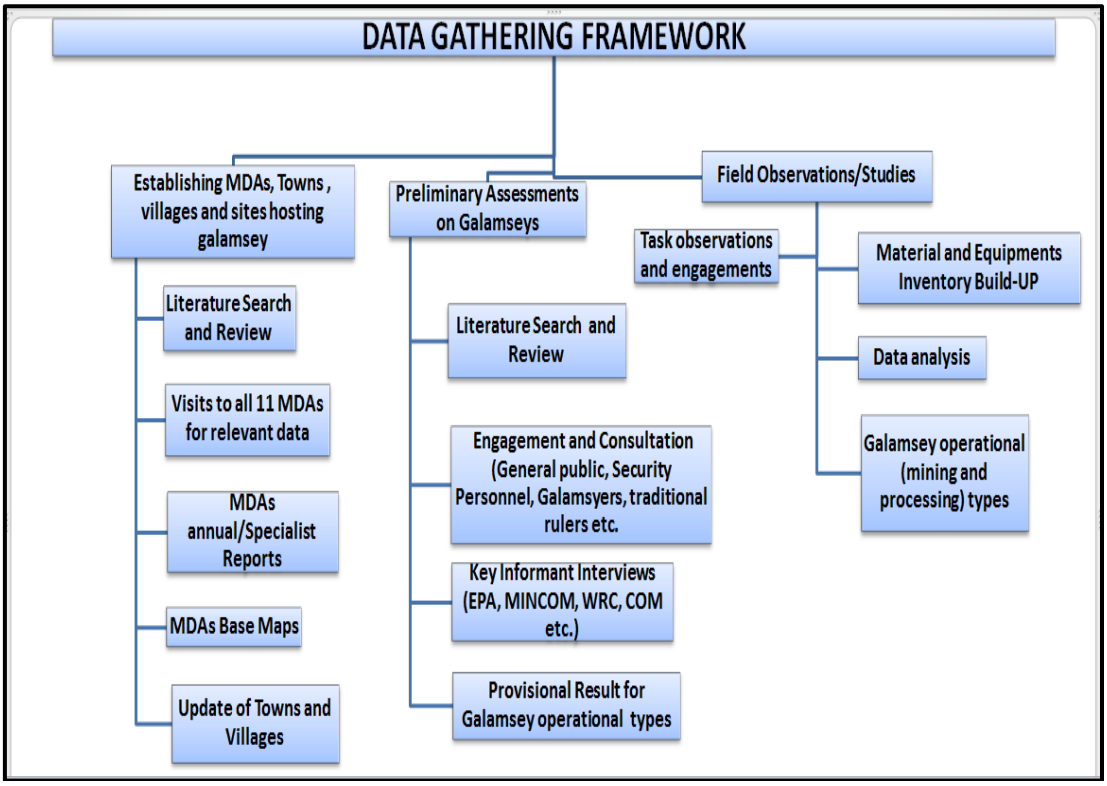

Figure 2. General layout of research framework.

2.2.2. Field study phase

A. Permission seeking

The galamsey operation is a socially complex venture, and the operators are often suspicious of the motives of strangers, even the harmless ones, perceiving them to be potentially dangerous to their operations. In view of this, gaining permission and access to the galamsey sites was seen as one of the key milestones to the success of the research work, and was carefully designed.

Locals from the operating communities were integrated into the research program and facilitated in gaining audience with the galamsey site bosses or owners. The research objective and

end use of the project was presented to them and permission was sought to undertake the study. Permission was also sought for the use of the equipment such as cameras and other image-capturing devices. This was necessary because the galamsey operators often detest research works that interface with politics, security, and public exposure programs.

B. Field data gathering

Field data gathering was undertaken over a two-month period across the eleven selected districts. It was ensured that the traditional and socio-cultural conditions such as religious and cultural days, rest or pay days, taboos, national days (including Independence Day celebrations, etc.) or specific weather conditions (seasons) were all noted and observed [8]. The field work involved validation of the names and characterization of the various galamsey types given during the preliminary assessment phase.

The field data collection involved:

- A face-to-face interview with an experienced galamseyer or an appointed person (by the "ghetto" or site boss);
- Observation of the mining and processing site to accurately pinpoint the material use, equipment use, site conditions, players or operators, organization, etc.
- Visual estimation of operation size or land-take, sensitivity of site (closeness to cemetery, schools, markets, wetlands, forest reserves, etc);
- Visual assessment of the environmental impacts of the operation on soil and water bodies, wildlife mortality, vegetation health, dust generation, etc.
- Photographic record and other features of interest.

The approach adopted sought to organize the various galamsey operations into a set of categories based on the criteria such as the mining and extraction style, equipment and material use, deposit type, origin of the operation, and local nomenclature used [18, 30, 31, 36]. The complexities of the various galamsey operations were simplified and structured into new representations that improved communication and enhanced understanding.

3. Results and discussion

Eleven galamsey mining and processing operations were identified in the studied districts. These operations can be grouped under five broad categories (see Table 2 and Figure 5) as follows:

1. Placer/alluvial galamsey;
   - Dig and Wash (Pohlepohle)
   - Alluvial Washing Plant/Trommel
   - Alluvial Washing Board
   - "Anwona" (Ewe)
   - River/Stream Dredging
   - Panning
2. Underground/hardrock (lode/vein) galamsey;
   - Abandoned underground shaft/tunnels
   - Sample hole/pit or "ghetto"
3. Surface/hardrock (lode/vein) galamsey;
   - Chamfi
4. Mill-House galamsey;
5. Selection (pilfering) galamsey.

Summarized below are the details of each operational type.

3.1. Placer/Alluvial galamsey

Alluvial gold in Ghana is primarily found in the basal gravels of river systems draining underlying weathered metasedimentary and metavolcanic bedrocks of the Birrimian and Tarkwaian Systems of Proterozoic age [43, 44].

The six different operational types of galamsey under placer or alluvial galamsey are washing plant, washing board, panning, dig and wash, "anwona", and dredging. For all the six operational types, gold mining and extractions were done simultaneously at the same location. They generally required extensive use of land and were set up close to or along the banks of water bodies, where sustainable water supply could be assured.

3.1.1. Alluvial washing plant (galamsey trommel)

This galamsey method has been reported to have been introduced by the Chinese in 2009. It involves the use of a trommel or "washing plant", as it is referred to by most galamsey operators, to simultaneously mine and extract gold from the surface of the earth near or at the banks of water bodies.

The galamsey washing plant is a rotating cylinder with many holes of varied sizes that act as a classifier, letting only the material smaller than the holes to fall through while the rest of the substrates flow out of the other end of the trommel [45-47]. It is a water-loving plant, driven mechanically, and is able to process large volumes of ore per session.

The main components of the alluvial washing plant (see Figure 3) are:

- Open hopper for material feeding (grizzly available for a rock size bigger than 150 mm)
- Screening system: double-deck vibrating screen for screening and separating (trommel available for different situations)
- Washing system: belt chute for washing out the mud, clay, and other lightweight materials, and concentrating the heavy materials for Knelson concentrators.
- Recovery system: sets sluice box with gold mats for recovering the coarse gold. Some are of Knelson batch-type centrifugal concentrators for recovering the fine gold size smaller than 6 mm, ensuring high recovery rate.
- Water supplying system: water/slurry pumps for supplying water
- Controlling system: control cabinet with buttons to control different parts of the washing plant
- Power supplying systems: diesel generator

Table 1. Eleven selected municipal and district assemblies (MDAs) and their respective LSMs within western region (source: [40, 42]).

	Selected MDAs/Districts	Capital	Size of MDAs (sq. km.)	Location/Coordinates (Lats & Long)	Registered SSM	Active LSM
1	Wassa Amenfi Central	Manso Amenfi	1,845.9	Details not available	4	Nil
2	Wassa Amenfi East	Wassa Akropong	1,558	Latitudes 5, 30 N, 6,15 N, Longitudes 1, 45 W and 2, 11 W.	38	Golden Star Bogoso-Prestea
3	Amenfi West	Asankragua	1,448.56	Latitude 400'N and 500 40'N and Longitudes 10 45' W and 20 10'W.	61	Nil
4	Bibiani-Anhwiaso-Bekwai	Bibiani	833.7	Latitude 60 N, 30 N and longitude 20 W, 30 W	86	Bibiani Gold Limited
5	Ellembelle	Nkroful	995.8	Longitude 20 05''W and 20 35''W, and Latitude 40 40''N and 50 20''N	2	Adamus/Nzema Mines
6	Mpohor	Mpohor	524.533	5.1040° N, 1.6731° W	3	Golden Star Wassa Mines
7	Wassa East	Daboase	1,651.992	Details not available	10	Golden Star Wassa Mines
8	Nzema East	Axim	1084.0	longitudes 2005' and 2035' west and latitudes 40 40' and 50 20' North of the Equator	16	Adamus/Nzema Mines
9	Prestea Huni Valley	Bogoso	1,809	Details not available	89	Gold Fields Tarkwa/Golden Star Bogoso-Prestea/ Golden Star Wassa Ltd./Sankofa Gold
10	Sefwi Wiawso	Sefwi Wiawso	1,101.6	Latitudes 60N and 60 300 N and Longitudes 20 450 W and 20 150 W.	1	Bibiani Gold Limited
11	Tarkwa- Nsuaem	Tarkwa	905.2	Latitude 400'N and 500 40'N and Longitudes 10 45' W and 20 10'W.	10	Nsuta Gold/Gold Fields Tarkwa/Anglo Gold-Iduapriem
	TOTAL		**13,758.29**		**320**	

Figure 3. A typical washing plant/trommel.

To feed the washing machine, the gold-bearing material (coming in the form of small-to-medium sized alluvial stones, gravels, and fine sand) is poured by an excavator into a hopper fitted with metallic grates or grizzlies for keeping very large rocks and boulders from entering the machine. As soon as the material enters the hopper, it is sprayed with water to help break up clods and loosen the gold-bearing particles from clays, roots, rocks, etc. As the material travels through the rotating drum, it is continually sprayed with water.

The action of water and the rotating cylinder continue to break up the material so the smaller gold-bearing particles can exit the trommel through the holes in the cylinder. The larger rocks pass on through the trommel cylinder. The smaller gold-bearing particles that fall through the holes in the trommel cylinder are usually passed through at least one sluice box to trap the gold and further reduce the amount of non-gold bearing material. The most predominant galamsey trommels encountered are the mobile types (on wheels), though a few stationary ones are sighted and generally incorporated into an entire wash plant setup (see Figure 3).

Recovering the gold that has been processed is the same as for any other sluice box system. The blanket lining the sluice box, which accumulates sediments and gold concentrates, is washed off into a basin. The blanket of the sluice box is again washed into a bowl containing mercury that amalgamates the gold particles. The gold is then extracted from the amalgam using a number of means including burning and retorting.

The environmental impacts associated with this type of galamsey can be very extensive, stretching over kilometers and many hectares. Highly turbid waters, stream and river banks erosion, many abandoned pits (average depth of 15 m and width of 30 m), destructions to vegetation and wild animals, oil spills and mercury pollutions, noise generation, scats and gravel wastes, extensive littering, abandoned shelters, and scrap equipment were the main impacts observed.

This operation was prominently encountered in the Amenfi east, Prestea Huni Valley, Tarkwa Nsueman, wassa East, and Bibiani Anhwiaso Bekwai districts. Conspicuous among the host villages are Ankosia, Nkyease, Afransie, Esikuma, Nsuaem, Adamanso, Bepoh, Wioso, Awodua, Kakabo, Dikoto, and Ntakam.

3.1.2. Alluvial washing board

Alluvial washing board is the commonest and most practiced alluvial type of galamsey across the studied sites. Just like the alluvial washing plant, this operation makes extensive use of water, and is set up close to or along the banks of water bodies, where sustainable water supply could be assured.

The complexity and capacity of the washing board set up depends on the wealth of the owner. The facility is predominantly metal, and is mainly manufactured locally by road side artisans or metal fabricators, and generally entails an open hopper or feed tray with grizzle to screen materials and cascading metallic sluice systems (see Figure 4). This setup is complemented by water pumps, generators, fuel truck, service truck, and other necessities required for an effective operation. Excavators and sometimes loaders are used for bush clearing, moving the earth, and loading the ore onto the washing board.

The "bucket" or the receiving tray of the board is fed by an excavator. Sorting or screening of materials is done manually by the operators after the ore has been deposited in the bucket. The load is then washed down the board or sluice system. The system operates using pressurized water to wash and break up the load onto the attached sluice system lined with blankets of different grits that captures the nuggets and gold powder. The blankets are washed into bowls containing water, and amalgamated with mercury. The amalgam is burnt off, leaving behind the gold.

The environmental damages caused by this form of galamsey are very similar to those by the washing plant. However, the impacts of this type of galamsey are more extensive and widespread due to its huge patronage. The negative impacts include land degradation, pollution to water bodies (siltation, turbidity, fillings, acid mine drainage, etc.), stream and river banks erosion, floods, many abandoned pits, destructions to vegetation and wild animals, oil spills and mercury pollutions (from water pumps, compressors, vehicles etc.), littering, abandoned shelters and scrap equipment, etc.

This operation is very popular in the districts such as Amenfi East, Amenfi Central, and Amenfi West. Other host districts include Wassa East, Tarkwa Nsuaem, Sewfi Wiawso, Prestea Huni-Valley, and Bibiani-Anhwiaso-Bekwai.

Figure 4. Washing board (coming in different sizes/capacities, configurations, setup, etc.) in operation.

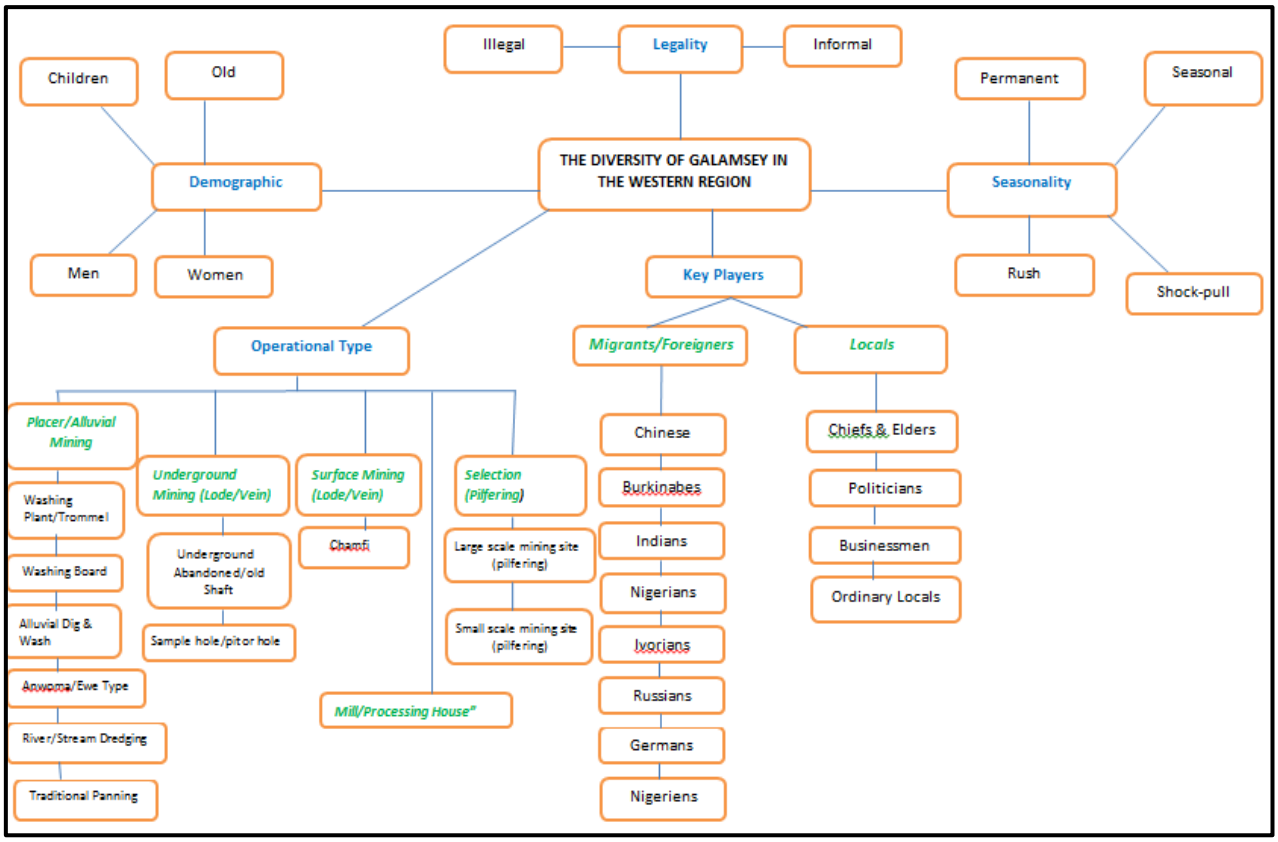

Figure 5. General overview of types of galamsey operations within 11 MDAs investigated.

3.1.3. Dredging ("Totototo")

The suction dredge or 'totototo[4]' vessel used for this galamsey entails a pontoon constructed mainly from empty oil drums or steel. The essential equipment is a diesel-powered chan fa engine, an impeller pump, cutterhead, suction or missile nozzle, a sluice box (on or off-board) fitted with fur mat or blanket, a gold retort, a gold scale, and mercury. The setup, depending on the wealth of the owner, could be made complex or varied.

The 'totototo' is an underwater-type of vacuum cleaner, which is designed to suck gravel from the bottom of a river, pull it up through a hose, and run it over a sluice box. It sucks up streambed material (rocks, sand, gravel, silt, gold, and other minerals), passes it through a suction hose, and runs it across a sluice box sitting on a floating pontoon (see Figure 6). Any gold that is present in the sucked material is trapped in the sluice box, and the lighter materials such as sand and gravel move down and out of the sluice box and back into the river. Mercury is added to the concentrate and mixed to form a gold amalgam, which is then heated to separate the gold [29].

The visual impacts recorded included suspended solids, siltation, colourization of the waters, death of fishes and other aquatic lives, oil-films on surface of waters, flooding, pollution from mercury (where it is used), abandoned or discarded scrap items within waters, etc. This type of galamsey was commonly observed in the five main rivers draining the western region; Pra, Ankobra, Bonsa, Tano, and Bia.

3.1.4. "Anwona" type (Pit/Pond dredging)

The set up for the "Anwona" type of galamsey is very similar to that for the stream/river dredge type. The name "anwona" is given to this type of operation because it is predominantly done by the operators hailing from the Volta Region of Ghana. It is performed in ponds using floating dredges. Whilst the "anwona" approach makes use of "artificial lakes" (mostly from abandoned pits created by washing plant and washing board "galamseyers") with no or limited water current, the stream/river dredge operates exclusively on water bodies with appreciable flow and current.

The "anwona" galamseyers are opportunists who scout around for abandoned pits created by their colleague galamseyers (washing board and washing plant) and situate the dredging machines

[4]- "Totototo" emanates from the sound or noise created by the suction dredge machine.

into them. "Anwona" galamseyers are, just like the river/stream dredgers, experienced swimmers due to the water hazards associated with the operation. They can operate close to a river side or far away from a river body but would at all times require adequate volume of water to float their pontoon or badge. The pit or pond-lake for hosting the pontoon must be of appreciable size, depth, and with adequate volume of water. Anchor or supporting rope is used, and in cases where the pontoon is required offshore for servicing, the roping systems are used to deck the pontoon.

There are two variants of the anwona, in-situ and ex-situ type. For the in-situ type, the sluices for washing the gold-bearing sand are attached to the pontoon or dredging platform, whilst the sluices of the ex-situ "anwona" type are located off the pontoon, and are situated at the banks of the pond (see Figure 7).

The visual environmental impacts recorded are similar to those of the stream/river dredging galamsey. However, due to the absence of flow or current, the impacts are localized. These impacts included high turbidity or suspended solids, siltation, colourization of the waters, and death of fish and other aquatic lives. Also oil-films on water surfaces, mercury contaminations, abandonment or discarded scrap machinery, etc. were recorded. Most of these pit lakes are abandoned after a few months of operation, and serve as breeding grounds for insects (including mosquitoes), death traps for humans and wild animals, etc.

Host districts include the Wassa East, Amenfi East, and Tarkwa-Nsuam districts. Villages habouring this galamsey include Ankonsia, Esikuma, Bepoh Ehyireso, Odumase, Dompim, Kakabo, Krobo, Abetumasu, Manponso, and Abetumasu.

Figure 6. Bonsa River being dredged for gold at Bonsaso in Tarkwa-Nsuaem Municipal Assembly. Districts popular with this operation include Tarkwa Nsuaem, Prestea Huni Valley, Wassa East, and Mpohor. Some of the host villages are Essaman, Norp, Aglika, Takyieman, Mile 7, Mile 10, Esuoso, Bonsawire, Tebe, Six Million, Kadedwen, Bonsaso, and Daboase.

Figure 7. "Anwona" type of operation in abandoned pits created by alluvial washing board operators.

3.1.5. Dig-and-wash (pohlepohle)

Until the recent arrival of chamfi, washing plant/trommel, washing board, and other sophistications into the galamsey business, this form of galamsey used to be one of the most implemented means of extracting gold from alluvial sources [18]. Here, gold-rich surface deposits are dug up and made into slurry before washing down a sluice (covered in towels, carpets, blanket or mesh-like materials), which capture the heavier deposits (Figure 8). These are then rinsed into a bucket, and the contents are skillfully sifted and separated until a small amount of material is left. At this stage, the gold particles are clearly visible.

The task of consolidating gold can be achieved in a number of ways. However, the most common approach is to add mercury. Once all gold particles have been consumed by the liquid metal, the amalgam is normally heated to burn off mercury, leaving behind the concentrated gold. Approximately 30-40% of gold is recovered through this process, with the remaining locked up in the processing waste (tailings) orshump [5] generated.

This type of galamsey is usually performed by those who, due to their weak financial strength, cannot afford either the Chinese washing plant or board for their operations. A dig and wash is normally done in groups comprising the diggers or miners, "loading boys[6]",carriers[7], and sluice box operators. It generally serves as lead for the highly intensive and profit-driven galamsey types like washing plant and washing board, as their trails suggest the presence of a good ore deposit.

There is another aspect of dig and wash that involves preying on the remains of washing plant, washing board, and Chamfi galamsey. These operators are popularly called "pohlepohle", as they are seen as opportunists and scavengers, and are non-profit driven. Thus "pohlepohle" is normally done by women or people who come in search of a "blade" (one blade equals a gram of gold) or two for their daily chop money (see Figure 8).

The dig and wash operation generally has a limited footprint, and thus has impacts that are relatively less extensive. These include abandoned pits, turbid water bodies, littered sites, abandoned sluice boards, pollution from mercury (where it is used), etc. Oil spills are generally rare in traditional dig and wash sites but may be found in "pohlepohle" dig and wash areas.

The operation was found to be common in the Amenfi Central, Amenfi East, Amenfi West, Ellembele, Mpohor, Nzema_East, Prestea Huni Valley, and Tarkwa Nsuaem districts. Host villages include, but not limited to, Pampe, Efuanta-dagati, Nyanso, around Gold Fields Mine, Mile 7, Damang, Pepesa-Ankwahu, Gwira, Gyamang, Asuopong, Mamieso, Hiawa, Wassa bekwai, Gyamang, Esuopong, Adonoi, Amoaman, Nkroful, Mpohor, Adum-banso, etc.

3.1.6. Panning galamsey

This is one of the most ancient and traditional gravity concentration methods used by individuals and families in the galamsey operations. It is, however, not very common these days; only a few sightings have been made in the Nstiakokrom of Damang, Tarkwa Mile 7, and Wassa Gyapa areas (see Figure 9). Panning is the basic means of recovering gold from alluvial and high-grade primary ore. It works best when the material is in the gravel or sandy form. This type of mining can occur anywhere; right in the home or house, after rainfall events, in washouts or run-offs, under cocoa farm lands, in water bodies, and in pits.

The galamsey panners serve as leads for other well-endowed galamseyers, as their trails suggest the presence of a good ore deposit. Where a suspected ore is rocky or stony in nature, it may be first of all pounded or crushed using mortar and pestle. It sometimes involves the use of a sieve or basket for screening the material. In most cases, the coarser oversize is kept and re-pounded or grounded for a better liberation.

Once a suitable amount of earth material suspected to habour gold is fetched, some gravel or sandy materials from it is scooped into a pan, where it is then gently agitated in water using the bare hand for the gold to sink to the bottom of the pan. Materials with a low specific gravity are allowed to spill out of the pan, whereas materials with a high specific gravity sink to the bottom, as "black gold", of the sediment during agitation, and remain within the pan for examination and extraction by the gold panner [48].

[5]- Shump: local term used by galamseyers for processed waste or tailings from their milling or extraction process. Shumps are rich in gold due to the relatively low recovery of extraction processes used.

[6]- Loading boys: men loading mine ore into carriage vast for transportation to processing site.

[7]- Carriers: mostly women, who carry or haul mined ore (on their heads using pans) to stockpile or gold processing/extraction site (sluice board or chang fa).

The panned concentrate is then rinsed into a bucket, skillfully sifted, and separated until a small amount of material is left. At this stage, the gold particles are clearly visible. The gold obtained is placed in a handkerchief and squeezed or, where mercury is available, used. A magnet may also be applied to the bottom side of the pan and moved in a circular motion with the pan slightly tilted. Panned concentrates may also be washed over a sluice lined with blanket or rubber matting.

Figure 8. Dig and wash operation at a site.

Figure 9. Galamsey Panners at work.

Impacts caused are also less extensive. Remnants of gold panning include large amounts of sand and numerous small pits, both away from and along riverbeds. The panned waste may choke water channels, and may result in flooding during the rainy season. The nature and extent of these adverse effects, just like the other forms of galamsey, however, depend on many factors including the location sensitivity, scale of operation, mining and processing methods used, and nature of the material mined and processed (whether ore or reef). The concentration of panners (miners) within an area also affects the extent of the adverse environmental effects.

3.2. Underground galamsey

The two main types of underground operations observed include the re-entry into old abandoned shafts and sinking of "sample holes or sample pits". Underground operations are predominant in Tarkwa-Nsuaem Municipality (Tarkwa, Nsuaem, Bogoso-junction areas), Prestea-Huni Valley district (Abosso, Prestea, Bompieso and Bogoso), and Bibiani district [49]. In Tarkwa, for instance, horizontal excavations (adits) are very common, often travelling many kilometers all the way to Abosso and Bompieso. In Prestea, shafts with many levels are predominant, travelling from Prestea Township to Bondaye. The two operations involve only ore mining activities; mined ore is either transported to a near or distant mill house for extraction and refining of the gold.

3.2.1. Old abandoned shaft/tunnels

This operation involves the illegal take-over of previously mined-out and abandoned underground shafts or tunnel by galamseyers (see Figure 10). The depths of these shafts vary but they were observed to range from hundreds of meters (vertically) to a few kilometers (horizontally). The diameters of the shafts and working platforms are of varying width of approximately 10 meters.

Mining within underground shafts normally involves rehabilitating deteriorating infrastructures and taking over the property. Access to the facility is re-engineered where possible, dewatering of levels of interest is conducted, and necessary support structures upgraded. The shafts have several levels, with "ghettos" (tunnels created within the shafts) belonging to groups of people known as "gangs". The shafts are descended using ropes, wooden staircases, declines or mechanical cages and lifts. Provision is made for suitable air ways or air conduits for the air to flow down the mine to the working places and suitable routes out of the mine. The primary ventilation system consists of an intake or intakes (or downcasts) through which the fresh air passes, and an exhaust or exhausts (or upcasts) where the air passes after having ventilated the working places of the mine areas. Mine fans and blowers powered by an electrical system were observed in most of the shafts visited [29, 40].

The mining process normally involves the removal of previously blasted material (muck out round), scaling (removing any unstable slabs of rock hanging from the roof and sidewalls to protect workers and equipment from damage), installing support or/and reinforcement, drill face rock, load explosives (where it is done), and blast explosives [29]. Galamseyers normally remove mined ore through manual means. Loaded sacs are carried sequentially bylined-up operators ("one-logo-logo-line", as the galamseyers call it) along the exit route until the load or sac-filled with mined ore reaches the outside of the underground. Others also carry the sacs on their backs, and gradually climb out to the outside. In some cases too, coarse ore is removed from the stope (referred to as "mucked out" or "bogged") using cages or lifts often powered by diesel engines or electric motors.

In this type of operation, galamseyers attempt tirelessly to obtain well-fragmented ore with limited volume of rocks for easy carriage or haulage. Once the ore reaches the outside or ground surface, it is either sold out to middle men, sent to a nearby chan fa processing site or sent to a milling house. In other instances, ore is processed by miners through manual pounding with a metallic mortar and pestle into fragments for mercury amalgamation.

The visual impacts recorded include destructions to vegetation/timber resources, abandoned scraps and structures, abandoned underground tunnels, and voids. The potential risks from this operation include ground movement and inundation in underground workings (subsidence/sagging, swelling, bulking, buckling, heave, elastic strain, inundation, and movement caused by explosions), noise and vibration from blasting activities (where blasting is observed), pollutions to surface and ground water bodies, and acid mine drainage challenges. The host districts include Tarkwa Nsuaem, Prestea Huni Valley, Bibiani Anhwiaso Bekwai, and Tarkwa Nsuaem. The sites hosting these activities include, but not limited to, Tarsco top, Donkoto Lineso, Aboso, Bogoso, Kroboline, Tarkwa main road, Tamso, Teberebie junction, Efuanta, and Prestea.

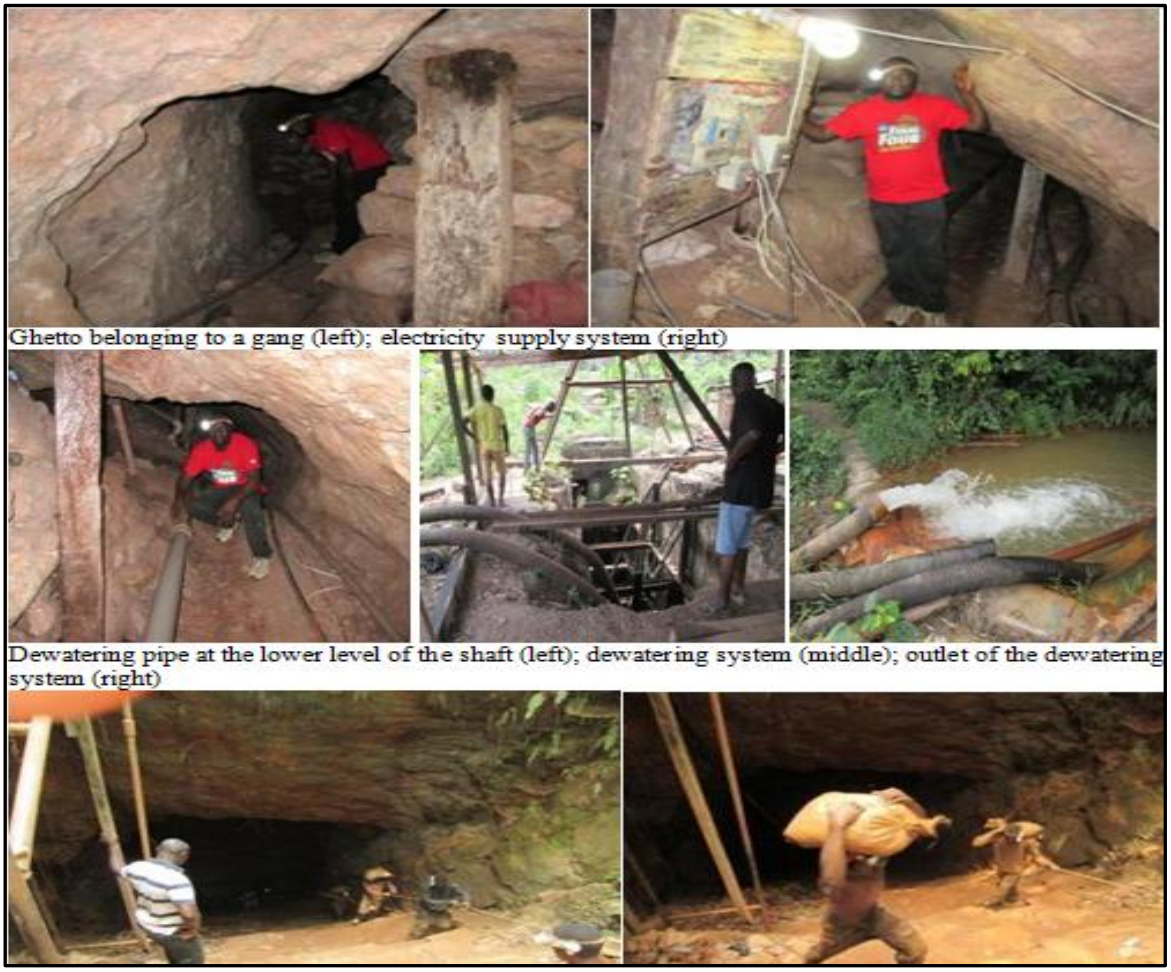

Figure 10. Underground galamsayers climbing out of an underground shaft at Abosso in Prestea Huni Valley District.

3.2.2. "Sample hole or sample pit" galamsey

This is the commonest underground mining type of galamsey practiced across the selected 11 MDAs. It involves the manual sinking of narrow pits or holes deep into the earth. In areas where abandoned shafts exist, sample holes are sunk and connected to the various levels of the shafts with the aim of taking advantage of their ventilation and dewatering systems in place. Sample holes could either be steep and vertical or gentle sloping horizontal workings, depending on the ore trend and resources available (see Figure 11).

Sample holes may have various "dries" (horizontal levels or junctions or branches created within sample holes for different gangs or groups to operate in) or none at all. Due to the laborious nature, time, and cost involved in sinking sample holes, it normally involves collective efforts from different gangs. Each and every group is spearheaded by a ghetto leader or champion who ensures that the rules binding the operation are strictly adhered to.

Sample hole or pit construction is done manually using earth chisels and other rudimentary digging tools. The experienced digger excavates the earth and passes the fetched waste materials, either in sacs, head-pans, baskets or other carriage systems to the next in line until the load reaches the surface or outside. The numbers involved may range from 5 to 10 or more people. They may also be transported out using a rope as support.

Host districts include the Amenfi Central, Amenfi East, Bibiani Anhwiaso Bekwai, Mpohor, Prestea Huni Valley, Tarkwa Nsueman, and Wassa East. Among the villages hosting the operation are Hiawa, Abreshia, Aniamote, Donkoto Lineso, Adiembra, Mpohor, Prestea obourho, Abosso, Bompieso, Atta ne Atta, Nsadweso, Badukrom, Akyim, Damang, Kwabenaho, Bompieso, Kumsono, and Bogoso.

Figure 11. Sample holes at a site (left); pit lined with wooden materials for (middle); researcher inside a sample hole (right).

Ventilation pits or holes are used in some places, for instance Abosso, to aerate the pits. The sample pit, just like the abandoned shaft galamsey, makes use of effective ventilation systems (blowers/ventilators powered by diesel where available) and dewatering provisions (pumps). Dewatering in areas that do not have any associations with shafts is by diesel pumps or submersible pumps. The declines of the sample holes are, in some areas, carefully engineered for easy and safe passage using chopped-of elastic hardwoods or timber beams (funtum or funtumea elastica) often with length ranging between 0.5 and 1 m. These wooden supports are carefully used to line the entire hole to serve as supports (caging system) for descending and ascending. In other areas, short steps are created along the entire stretch of the hole for ascending and descending [29].

The average diameter of sample hole is approximately 1 m, whilst the depth can be as far as the galamseyers can travel; often ranging from tens to many hundreds of meters till the groundwater is encountered. "Chock-passes"or supporting pillars are engineered to keep the pits safe. A combination of chock-pass, wooden cages, and pillars constructed within sample holes are effective at ensuring a much safer operation. Just like the abandoned shafts, the sample hole mining is well-organized and coordinated by ghetto lords/champions.

Due to limited lighting systems within the dark hole, sample pit workings are normally entered using handy torch lights or head lamps for good vision. Mined ore may come in the form of sand, gravels or hard rocks. Hard rock deposits are often broken up with explosives (blasting) or by manual hammering and prying at rock faces with rock hammers and steel bars. After that, mined ore is put into grain sacks and hauled out of the pit. Other operators employ the use of ropes for upward and downward movement of materials within sample pits. The ore (popularly referred to as "load") obtained from underground are mostly high in grade, often greater than 5 g/ton. The entrance to these pits is locked for security reason when there is no mining activity.

Once the ore gets to the surface, it is usually carried to the processing sites by women, children or other male carriers who are paid according to the number of trips they go per day at the end of working hours. It may be processed some few meters away from the sample hole sites using Chan Fa machines or carried in trucks or vehicles to process or mill house operational sites depending on the nature of the ore. Processing is the same as ore from abandoned mine shaft.

The impacts associated with the sample pit galamsey are very similar to that of the abandoned shaft type. However, the surface impacts caused to vegetation, surface waters, and soils/land appear to be serious for sample pit/hole galamsey. With this form of galamsey, it is possible to observe over hundreds of dug-out holes/pits on a particular unit of land, as the construction phase of the mining normally involved tree removal, digging, and loading of waste rocks and oxides.
Other potential hazards from this operation include ground movement and inundation in underground workings (subsidence/sagging, swelling, bulking, buckling, heave, elastic strain, inundation, and movement caused by explosions), noise and vibration from blasting activities (where blasting is observed), pollutions to surface and ground water bodies, and acid mine drainage challenges.

3.3. Mill or processing house (structure) galamsey

Mill houses or "structures [8] " are normally stationed by roadsides and adjacent water sources or wetlands. These mill houses may be owned by a private individual who receives and processes ore for a fee or purchases the ore from galamseyers and treat for his own profit. It may also be owned by a gold buyer or the gang/ghetto leader of a particular galamsey group.
Mill houses are normally used for high-grade ore, and sources of such ore could come from sample hole, selection or an abandoned underground shaft galamsey site.
At the mill house, gold-containing rocks, stones, and sands are screened. Large rocks or stones are first of all crushed to reduce the physical size and expose more surface area of rock and increase the probability of obtaining the gold from the rock by gravity (see Figures 12). The very large rocks may be broken into smaller pieces by the use of metallic mortar and pestle before they are sent to the crusher. The crushing plant reduces the ore into much smaller particles and further made finer by using a smoothening machine. In situations where crushed ore is found to be wet, they are first of all dried before [9]smoothening. Smoothed materials are thereafter taken to a washing area/yard (sluice board), where water is added manually or with a pumping machine, and further backwashed for mercury addition. Extraction and refining of the gold follows.
The processed wastes from the mill house operation are popularly called "shump" (tailings), and tend to be high in gold grade (usually above 3g/ton) due to the relatively low recovery methods employed. These processing wastes are either reprocessed by the galamseyers themselves (more especially during the rainy seasons, where mining is seen as challenge) or sold out to some interested LSM companies for reprocessing or retreating.
Environmental impacts associated with this form of galamsey includes surface and ground water pollution, depletion of surface water resources, mercury contaminations, hydrocarbon spills, extensive aesthetic or visual pollution, littering challenges, abandoned structures, waste generation, noise pollution, dust generation, etc.
The host districts are Amenfi Central, Amenfi East, Bibiani Anhwiaso Bekwai, Mpohor, Prestea Huni Valley, Sefwi Wiawso, Tarkwa Nsuaem, Wassa East, and Prestea Huni Valley. Villages hosting this operation include, but are limited to, Kongo, Bawdie, Asikuma Nkatieso, Bodie, Domeabra, Donkoto Lineso, Bogoso, Amoanda, Huni Valley, Nsadweso, Nsuaem, Nkwanta, Essaman, Bepo Akyir, Akyim, and Kyekyewere.

3.4. Surface mining galamsey

At present, this is the most economical way of mining lower-grade ores by galamseyers in the selected MDAs. The traditional surface galamsey mining was done rudimentarily and manually using shovels pick axes, earth chisels, and other simple equipment. In the recent times, however, heavy equipment such as earthmovers (excavators, bulldozers, dozers, loaders, etc.) have been introduced, and some of these equipment have been observed at a few sites at Wassa Gyapa, Mpohor, and Dadieso.
Explosives are rarely used for surface mining; where employed, they typically comprise chemicals which, when combined, contain all the requirements for a complete combustion without oxygen supply. The ore grade from this operational type is not as high as the underground operations. The most common form of surface mining is the chamfi galamsey.
Chamfi galamsey involves the mining of stony, rocky or sandy ore from some few meters into the earth, either manually or mechanically, using excavators, bull dozers, and loaders. Mined ore is normally processed immediately within some few meters away from the mining site. A "loading

[8]- Structure: a popular term used by locals for roadside mill houses used by galamsey operators.

boy" loads "carriers" to transfer the ore to where the Chang Fa machine is positioned [40].

Within a particular site, a number of Chang Fa setups could spring up due to the limited footprint of this operation. The setup normally includes shelter, the Chang Fa machine (crusher, diesel powered engine, a stand or an elevated platform for the Chang Fa to sit on, washing board), sand bags, empty sacs, water supply system, processing waste storage area ("shump"), and a mine waste site (see Figure 13).

The ore is first sorted or screened to ensure that only adequately-sized stone, rocks or sandy material are fed into the Chang Fa machine. Once the load is fed into the crushing head of the Chang Fa, the emerging crushed material is simultaneously washed using tap water, borehole or an adjacent wetland for the "black" or gold concentrate to be collected. The "black" is then washed using the attached washing or sluice board. Underlining the sluice is mesh-like or towel-like materials that trap the gold-bearing ore as it washes over the sluice. Backwashing is done to ensure that none of the gold-bearing ore escapes. The underlining materials are removed after several backwashing, and washed out into a bowl of water containing mercury to extract the gold from the sand [50].

Depending on the achieved recovery rate, the "shump" or processed waste received may be reprocessed or washed over and over again until the galamseyer is convinced that the "shump has limited gold left in it. The gold may be refined by roasting/furnace (to evaporate off the mercury) and addition of bolas or sold out to a buyer.

The visual impacts of chamfi galamsey can be overwhelming devastating. Due to the high patronage and clustered nature of the operation, the land take can be extensive. Other visual impacts recorded include surface and ground water pollution, depletion of surface water resources, mercury contaminations, hydrocarbon spills, extensive aesthetic or visual pollution, littering challenges, abandoned structures, pit creation, waste generation, noise pollution, dust generation, etc.

Host districts include Amenfi Central, Amenfi East, Amenfi West, Ellembele, Mpohor, Nzema East, Nzema East, Amenfi East, Prestea Huni Valley, and Tarkwa Nsueman. Villages habouring the activities include, but are not limited to, Hiawa, Dadieso, Abrehyia, Gyapa, Nananko, Adesu, Adiembra, Dompuase, Adonoi, Mensakrom, Wassa Saa, Afransie Nyamebekyere, Jukwa, Beposo, Wassa Kumasi, Akwadakrom, Aniamote, Abosso, Mpohor, Damang, Eziose, Efuanta, Awhitieso, Amantin, Tebrebie, Benso, Ata-ne-Ata, and Kotukrom.

Figure 12. Inside a mill house at Tarkwa.

Figure 13. Sluice box fed with "black" (left) at a chamfi site (right) at Mpohor.

3.5. Selection galamsey

Selection galamsey is the process where a galamsey operator clandestinely pays a visit to a Large Scale Mine (LSM) site or a regularized Artisanal Small scale Mine (ASM) site in order to select high- or medium-grade ore from the ROM pad, ore stockpile or waste rock dump site.

Visits are normally done in the night or on rainy days. Day time selection is possible but is not as common as the night and rainy days. Brightly coloured clothing is normally avoided; dull, dark, and dirty working gears are the main attires for these kinds of visits. Ore gathered is normally rocky or stony but could also be sandy or an oxide material. The target is always high ore grades.

There are times when local selection operators connive with dump truck operators in LSMs to dump high-grade ores onto waste dump sites or specified locations for selection or collection; these are high profile deals normally done between galamseyers and haul truck operators of LSMs.

Tools and materials for selection normally include hammer, water bottles, sacs, touch light, and cutlasses. Once a galamseyer arrives on a ROM Pad, pit or waste rock dump site, he carefully looks out for rock materials with gold traces or veins using experience. This grading exercise is sometimes done through washing the gold-bearing stones with waters until it is certain that the material is ore. The hammer is used to break off the ore away from any waste or separate wastes from ore in order to reduce the weight of load carried home. In the night, the touch light is used to spot the shiny gold stones.

The selected ore is sent to a designated processing site, where the rocky, stony or sandy/oxide material is reduced in size (where required) using mortar or pestle, chan fa machine set-up or mill house set-up before washing with a board/sluice box and extraction with mercury. With the mortar and pestle, crushing and grinding is achieved in a batch fashion manner. Pre-sized rocks are placed in a steel bowl with a rounded bottom or in a short length of wide pipe welded onto a steel plate, and pounded with a steel rod such as an automobile axle.

In Damang, Bogoso, and Mankesim (where Abosso Gold Fields Limited, Golden Star Bogoso/Prestea Mines, and Gold Fields Tarkwa Mines are, respectively, situated), for instance, a number of selection galamseyers were encountered pounding their gold-containing rocks. The selected ore is pounded by both men and women in mortars with pestles made of metals. The efficiency of this grinding process is very low, and it does not promote good liberation of

the gold. Selection is seen as very quick means of becoming rich, and appears to be the easiest among all the galamsey types encountered. Due to the high grades selected, a lot is achieved from this type of mining. The risks involved are also high since they are occasionally chased and arrested by security personnel of LSM sites visited. Women rarely get involved in selection galamsey.

Since selection galamsey involves no physical ore mining process, impacts associate with it are relatively minimal and very similar to those of the milling house. Observed impacts include surface water pollution, mercury contaminations, hydrocarbon spills, littering challenges, abandoned structures, waste generation, noise pollution (pounding, grinding, etc.), dust generation, etc.

Table 2. Summary of galamsey types and attributes.

Broad category	Galamsey types	Nature of gold deposit	Technology/resource used	Local name	Origin/source	Activity type
Alluvial Mining	Alluvial Washing Plant	Alluvial	Trommel, Excavator, loader, mercury, shovel/spade, water pumps/engine, gensets, engine, Kia trucks, Pick-up vehicles, coal pot etc.	Washing Plant	Chinese Nationals	Simultaneous mining and extraction
	Alluvial Washing Board	Alluvial	Washing/Sluice Board, Excavator, loader, mercury, shovel/spade, water pumps/engine, gensets, engine, Kia trucks, Pick-up vehicles, coal pot etc.	Washing Board	Chinese Nationals	Simultaneous mining and extraction
	Anwona or Pit Dredging	Alluvial	Pits lake, Suction Dredge/ "totototo", anchors, mercury, retort, coal pot,	"Anwona"	People hailing from Volta region of Ghana (Ewe/Anwona people)	Simultaneous mining and extraction
	River/Stream Dredging	Alluvial	River/Stream (with adequate current/flow), Suction Dredge, anchors, Mercury,	"Totototo/dredging"	Not available	Simultaneous mining and extraction
	Dig and wash	Alluvial	Pick axes, spade/shove, head pans, baskets, Sluice Board,	"Dig and wash"	Traditional (not known as in practice for many	Simultaneous mining and extraction
	Panning	Alluvial	Pans/sample tyres, pick axe, shovels/spades, mercury	"Poohlepoohle"	Traditional (has been in practice for many years)	Simultaneous mining and extraction

Table 2. Continued.

Underground Mining (Lode/Vein)	Abandoned Underground Shaft/tunnels	Lode/Vein	Underground tunnels/shaft, Blasting agents, dewatering pumps, hammers, sacs, ropes, blowers/ventilators, mortar and pestle,	“Ghetto”	Not available	Mining Only
	Sample hole/pit or “ghetto”	Lode/Vein	Manually dug pit/holes, Shaft, blasting agents, dewatering pumps, hammers, sacs, ropes, blowers/ventilators, mortar and pestle,	"Ghetto/sample pit”	Traditional (has been in practice for many years)	Mining Only
Surface Mining (lode/vein)	Chang-Fa	Lode/Vein	Surface Mining, Chan Fa machine, Mercury, Retort, mortar and pestle, spades/shovels, sacs, hammers, water pumps,	Chamfi	Chinese Nationals	Simultaneous mining and extraction
Mill-house Operation	Mill-house Operation	Lode/Vein	Chan Fa machine/Engine, Crusher, Smoothing Machine, Retort, Mercury, Borax, coal pots, sluice board, tarpaulins, hammers, mill house set-up	“Structure”	Not available	Processing/extraction only
Selection (“Pilfering Mining”)	Selection (normally from LSM sites)	Lode/Vein	Manual selection/pilfering of ore from stockpiles/pits/dump sites, morta & pestle, sacs, hammers, head lamp/touch light, mercury, sluice board	“Selection”	Traditional (has been in practice for many years)	Mining/ Extraction

4. Conclusions

This article described, in detail, the various operational forms of galamsey in eleven districts of the most mineralized region in Ghana. Through an extensive literature review, site visits, and task observations, 11 galamsey operational types under five broad categories were unearthed. These include (1) Placer/alluvial galamsey (“dig and wash”, washing plant”, “washing board”, “anwona”, dredging, and panning), (2) Underground galamsey (abandoned underground shafts and “sample pit”), (3) Surface (“chamfi”) galamsey, (4) Mill-House galamsey, and (5) Selection galamsey. Evidently, the introduction of Chan Fa diesel-powered engine by the Chinese has revolutionalised the galamsey business immensely. With the exception of the dig and

wash, washing board, and washing plant approaches, all other types of galamsey, in one way or the other, make use of the diesel-powered Chan Fa engine.

The washing plant and washing board galamsey have extensive footprints, and make use of heavy mining equipment like dozers, excavators, loaders, etc. Unlike the alluvial and Chamfi galamsey (which involves simultaneous mining and gold extraction), ore mined from the two underground operations (sample pit/hole and underground shaft types) and selection are processed either at a distant milling house or a Chan Fa engine plant located some few meters or kilometers away from the mining site.

Indeed since the influx by the Chinese and other foreign nationals into the galamsey business some eight years ago, the operational dynamics of galamsey have completely changed from being the rudimentary, low-profile, localized, and a poverty-driven business (we used to know) to a more sophisticated, semi-mechanized (dozers, excavator, loaders, washing plants, Chan Fa, etc.) one.

The information presented in this paper could prove valuable since it provides some of the basic ingredients required for policy formulation, design, and implementation of effective wasteland remediation programs by stakeholders in hard-hit regions with similar illegal gold mining dilemma.

The outcome of the work introduces a new paradigm for research in galamsey; a more appropriate definition of galamsey, considering the current dynamics in the illegal operation, is provided as the practice of illicitly mining and/or extracting gold found either at or just below soil and water surfaces.

It is recommended that a detailed operation-specific environmental assessment inventory (impact assessment) be carried out to validate the visual impacts observed within this paper. Also the spatial distribution pattern of the illegal operation should be established.

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References

[1]. Ghana Mining Summit. (2015). http://www.ghanaminingsummit.com/ghana-mining-summit/ (accessed on 8th May 2015).

[2]. Top 10 gold producing countries in the world, November 2015. http://www.countrydetail.com/top-10-gold-producing-countries-with-largest-gold-reserves-in-the-world/ (accessed on February 20th 2016).

[3]. Top 10 gold producing countries with largest gold reserves in the world, October 9 2015. http://www.practicalbusinessideas.com/2015/11/top-10-gold-producing-countries-in-world.html (accessed on February 20th 2016).

[4]. Kessey, K.D. and Arko, B. (2013). Small scale gold mining and environmental degradation, in Ghana: issues of mining policy implementation and challenges. Journal of Studies in Social Sciences. 5 (1): 12-30.

[5]. Alhassan, I.A. (2014). Galamsey and the Making of a Deep State in Ghana: Implications for National Security and Development.

[6]. Essabra-Mensah, E. (2014). Illegal mining killing cocoa farms; http://thebftonline.com/content/illegal-mining-killing-cocoa-farms (accessed on 6th January 2015).

[7]. Aubynn, A. (2009). Sustainable solution or a marriage of inconvenience? The coexistence of large-scale mining and artisanal and small-scale mining on the Abosso Goldfields concession in Western Ghana. Resources Policy. 34 (1): 64-70.

[8]. Kunateh M.A. (2012). Hammah calls for attitude change to stamp out galamsey. http://thechronicle.com.gh/hammah-calls-for-attitude-change-to-stamp-out-galamsey.

[9]. Ghanamma. (2013). Support Government To Eradicate Galamsey. http://www.ghanamma.com/support-government-to-eradicate-galamsey/ Published On: Mon, May 13th, 2013.

[10]. Cobbina, J.N.Y. (2013). Eradicating Galamsey Is The Responsibility Of All– Minister. http://newsghana.com.gh/tag/joseph-nana-yaw-cobbina/ (Accessed on Nov 19, 2013).

[11]. ASM Africa-Network (ASMAN). (2015). In Ghana Want A Dedicated Ministry, By News Ghana - Feb 22, 2015. Nii Adjetey-Kofi Mensah, Executive Director? ASMAN.

[12]. Hinton, J. and Hollestelle, M.R. (2012). Artisanal and Small-scale Mining in and around protected areas and critical Ecosystems Project. Methodological toolkit for baseline assessment and response strategies to

artisanal and small-scale mining in protected areas and critical ecosystems.

[13]. Resende, R.J.T.P., Alves, H.M.R., Andrade, H., Rebelatto, A. and Resteves, D. (2000). Environmental characterization and land use development in the Ribeirão Vermelho watershed in Lavras-Mg, Brazil. International Archives of Photogrammetry and Remote Sensing. Vol. XXXIII, Part B7. Amsterdam.

[14]. United States EPA. (2000). Abandoned Mine Site Characterization and Cleanup Handbook. EPA 910-B-00-001. Region 8 Region 9 Region 10. EPA 910-B-00-001 Denver, CO San Francisco, CA Seattle, WA.

[15]. Banchirigah, S.M. (2008). Challenges with eradicating illegal mining in Ghana: A perspective from the grassroots'. Resources Policy. 33 (1): 29-38.

[16]. Hilson, G. and Maponga, O. (2004). How has a shortage of census and geological data impeded the regularization of artisanal and small-scale mining?. Nat. Resour. Forum. 28: 22-33.

[17]. Collins, N. and Lawson, L. (2014). Investigating Approaches to Working with Artisanal and Small-scale Miners: A Compendium of Strategies and Reports from the Field.

[18]. Aryee, B.N.A., Ntibery, B.K. and Atorkui, E. (2003). Trends in the small-scale mining of precious minerals in Ghana: a perspective on its environmental impact. Journal of Cleaner Production. 11: 131-140.

[19]. Wikipedia, 2015. Galamsey. https://en.wikipedia.org/wiki/Galamsey (accessed on 4th Novembers 2015).

[20]. GEF (Global Environment Facility). (2002). UNDP (United Nations Development Programme), UNIDO (United Nations Industrial Development Organization): Global Mercury Project: Project Inception Document: Removal of Barriers to the Introduction of Cleaner Artisanal Mining and Extraction Technologies. Washington DC: Global Environment Facility.

[21]. Resende, R.J.T.P, Alves, H.M.R., Andrade, H., Rebelatto, A. and Resteves, D. (2000). Environmental characterization and land use development in the Ribeirão Vermelho watershed in Lavras-Mg, Brazil. International Archives of Photogrammetry and Remote Sensing. Vol. XXXIII, Part B7. Amsterdam.

[22]. Ishaq Akmey A. (2014). Galamsey and the Making of a Deep State in Ghana: Implications for National Security and Development. Research on Humanities and Social. 4 (16): 47-57.

[23]. Emmanuel, Opoku. (2013). 'Galamsey' A Canker in Western Region. http://www.modernghana.com/news/472110/1/galamsey-a-canker-in-western-region.html.

[24]. The Daily Guide, "Foreign Galamsey Operators Arrested". Available online: http://www.exposeghana.com/2013/05/51-foreign-galamsey-operators-arrested/ (accessed on 22 October 2014).

[25]. Owusu, E.E. and Dwomoh, G. (2012). The impact of illegal mining on the Ghanaian youth: evidence from Kwaebibirem district In Ghana. Research on Humanities and Social Sciences. 2 (6): 86-93.

[26]. Ghana Business. (2014). Galamsey– The good, the bad and the ugly; http://citifmonline.com/2014/02/16/galamsey-the-good-the-bad-and-the-ugly/ (accessed on 22nd October 2014).

[27]. Richard Owusu-Akyaw. (2014). Anti-Galamsey Task Force Impounds 15 Excavators … As Aga Seeks Regsec's Protection. http://thechronicle.com.gh/anti-galamsey-task-force-impounds-15-excavators-as-aga-seeks-regsecs-protection/ (accessed on 20th October 2014).

[28]. Ghana Armed Forces. (2014). Presidential Task Force Flush Out "Galamsey" http://www.gaf.mil.gh.

[29]. GEF/UNDP/UNIDO. (2006). Manual for Training Artisanal and Small-Scale Gold Miners/Veiga, M.M. et al./Vienna, Austria: GEF/UNDP/UNIDO, 2006, 144 P.

[30]. Andrew, J.S. (2003). Potential application of mediation to land use conflicts in small-scale mining. Journal of Cleaner Production. 11 (2): 117-130.

[31]. Chaparro Ávila, E. (2003). Small-scale mining: a new entrepreneurial approach, Comisión Económica para América Latina (CEPAL), United Nations, Santiago.

[32]. ICMM. (2009). ICMM workshop on Artisanal and Small-Scale Mining (ASM) and Mining Companies, Coconut Grove Resort, Elmina, Ghana.

[33]. CASM/ICMM/IFM CommDev. (2009). Working together: How large-scale mining can engage with artisanal and small-scale miners.

[34]. Villegas, C., Weinberg, R., Levin, E. and Hund, K. (2012). Artisanal and Small-scale Mining in Protected areas and critical Ecosystems Programme (ASM -PACE). Working Together Towards Responsible Artisanal And Small Scale Mining-A Global Solutions Study.

[35]. Hartman, H.L. (1992). SME Mining Engineering Handbook, Society for Mining, Metallurgy, and Exploration Inc.

[36]. Carl, W. (2012). Gold and gold mining - Methods of mining, Te Ara - the Encyclopedia of New Zealand.

[37]. Wikipedia. (2015). Gold Mining. https://en.wikipedia.org/wiki/Gold_mining (accessed on December 10th 2015).

[38]. Ghana Chamber of Mines. (2014). Performance of the mining industry in 2013. Ghana Chamber of

Mines. http://www.ghanachamberofmines.org/ (accessed on 13th November 2015).

[39]. Weber-Fahr, M., Strongman, J., Kunanayagam, R., McMahon and Sheldon, C. (2001). Mining and Poverty Reduction, (http://www.worldbank.org/wbp/strategies/chapters/mining/min 0409.pdf 5 June 2003).

[40]. Teschner, B. and Aidoo, A. (2012). Galamsey and Small-scale Mining Activities at Goldfields' Ghana Projects; Engaging with a semin-formal industry.

[41]. The Ghana Statistical Service (GSS). (2014). Districts analytical reports. Population and housing census, 2010. http://www.statsghana.gov.gh/docfiles/2010_District_Report/Western/ (accessed on 10th February 2016).

[42]. Ghana Minerals Commission. (2014). www.mincomgh.org/ (accessed on December 12th 2014).

[43]. Kesse, G.O. (1985). The Mineral and Rock Resources of Ghana. Published by A.A. Balkema, Rotterdam/Boston. 610 P.

[44]. Leube, A., Hirdes, W. and Mauer, R. (1986). The Birimian Supergroup of Ghana: Depositional Environment, Structural Development and Conceptual Model of an Early Proterozoic Suite. Technical Cooperation Project No. 80.2040.6: Ghanaian-German Mineral Prospecting Project.

[45]. Gold Rush Nuggets. (2016). How a Gold Trommel Works. http://www.goldrushnuggets.com/howgotrwo.html (accessed on 12th January 2016).

[46]. Gold Rush Trading Post, 2016. http://www.goldrushtradingpost.com/pro_gold_trommel (accessed on 12th January 2016).

[47]. Montana Gold Trommels- C&S Sales. (2014). http://www.montanagoldtrommels.com/trommels/how-a-gold-trommel-works.html (accessed on 12th December 2015).

[48]. Amegbey, N.A. and Eshun, P.A. (2003). Mercury use and occupational exposure in the Ghanaian small-scale gold mining industry. Ghana Mining Journal. 7: 54-61.

[49]. Asare Boadu's Stories. (2009). 'Galamsey' destroys environment in WR (PAGE 20). http://asareboadu.blogspot.com/2009/09/galamsey-destroys-environment-in-wr.html (accessed on 15th November 2015).

[50]. Hilson, G. (2001). A Contextual Review of the Ghanaian Small-scale Mining Industry, International Institute for Environment and Development (IIED) and World Business Council for Sustainable Development (WBCSD), London <http://pubs.iied.org/pdfs/G00722.pdf>.

عملیات Galamsey در یازده منطقه انتخاب شده در ناحیه غربی غنا

J. Mantey[1*], F. Owusu- Nimo[2], K.B. Nyarko[2] and A. Aubynn[3]

1- Gold Fields Ghana Limited, Environmental Department, Tarkwa-Ghana
2- Kwame Nkrumah University of Science and Technology (KNUST), Civil Department, Kumasi-Ghana
3- Ghana Minerals Commission, Accra-Ghana

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* نویسنده مسئول مکاتبات: mybryanjones@yahoo.co.uk

چکیده:

گسترش غیر قابل کنترل و غیر قانونی معدنکاری طلا در مقیاس کوچک در غنا اصطلاحاً به galamsey معروف است که متضاد با منابع آب، خاک، حیات‌وحش، سلامتی و ایمنی انسان‌ها است. کمبود دانش در زمینه مورد بحث، ویژگی‌های عملیاتی و تأثیرات مرتبط با آن‌ها متأسفانه مانع از اقدامات مؤثر در این زمینه شده است، اگرچه اقدامات فراوانی از طرف انجمن‌های مردم‌نهاد انجام شده است. این تحقیق، قسمتی از یک مطالعه جامع در یازده مجموعه منطقه مختلف از غرب غنا برای کمک به فراهم آوردن دانش عمیق در خصوص عملیات galamsey انجام شده است. در این تحقیق مباحث مختلف از galamsey، ویژگی‌های عملیاتی و تأثیرات زیست‌محیطی مرتبط با آن را مورد مطالعه قرار داده است. از طریق بررسی منابع علمی مختلف، بررسی مناطق مورد مطالعه و بررسی شرایط کاری موجود، پنج طبقه مختلف و یازده زیرمجموعه از galamsey بر اساس نوع ذخیره طلا، منابع مورد استفاده، تکنولوژی مورد استفاده، روش معدنکاری و روش فرآوری شناسایی شد. این موارد شامل galamsey های ۱) آبرفتی، ۲) زیرزمینی، ۳) سطحی، ۴) آسیا و ۵) انتخابی است. در حالی که galamsey زیرزمینی و انتخابی فقط درگیر معدنکاری کانه طلا هستند اما galamsey آسیا تمرکز بر روی فرآوری کانه طلا دارد و galamsey آبرفتی و سطحی درگیر فعالیت‌های همزمان معدنکاری و فرآوری کانه طلا هستند. اطلاعات ارائه شده در این تحقیق می‌تواند کمک ارزشمندی برای تعیین خط‌مشی‌های مناسب در خصوص طراحی، اجرا و سایر مسائل مرتبط با این موضوع به دولت‌ها، سازمان‌های منابع طبیعی و سایر مجموعه‌های دست‌اندرکار برای معادن طلای غیر قانونی را کند.

کلمات کلیدی: معدنکاری مقیاس کوچک، Galamsey، ماشین Chan Fa، آبرفت، معدنکاری زیرزمینی.