Final report

Costed reclamation and decommissioning strategy for galamsey operations in 11 selected MDAs of the Western region, Ghana

Jones Mantey
Kwabena Nyarko
Frederick Owusu-Nimo

November 2016

When citing this paper, please use the title and the following reference number:
S-33205-GHA-1

International Growth Centre

DIRECTED BY

FUNDED BY

COSTED RECLAMATION AND DECOMMISSIONING STRATEGY FOR GALAMSEY OPERATIONS IN 11 SELECTED MDAs OF THE WESTERN REGION, GHANA

[IGC Research Theme: State Effectiveness]

Mantey J., Owusu- Nimo F. and Nyarko K. B.

Kwame Nkrumah University of Science and Technology (KNUST), Civil Department, Kumasi-Ghana

mybryanjones@yahoo.co.uk,/frednimo@gmail.com/ nyarko.k.b@gmail.com

NOVEMBER, 2016

SUMMARY

The illegal artisanal small scale gold mining and processing (galamsey) cycle is well known: discovery, migration, and relative economic prosperity are followed by resource depletion, outmigration and economic destitution. Drugs, prostitution, disease, gambling, alcohol abuse, and degradation of moral standards are frequent consequences of the chaotic occupation at galamsey sites. It is apparent that the economic benefits obtained by the miners do not compensate for the deplorable socio-economic conditions left to surrounding communities. After depletion of easily exploitable gold reserves, sites are abandoned, and those who remain contend with a legacy of environmental devastation and extreme poverty. These people have little opportunity to escape their circumstances. Thousands of abandoned artisanal mines can be found in the Western Region of Ghana, and those currently operating will undoubtedly experience the same fate.

This paper focuses on an important consequence of galamsey: closure and reclamation. By better understanding the magnitude of impacts caused, closure, decommissioning and costing principles relating to the various types of galamsey generally found within the Western Region of Ghana, effective measures for prevention and mitigation of pollution are more likely to be developed and implemented.

This costed reclamation and closure plan is prepared for the nine galamsey types that generally exist within the Western Region with the objective of returning the site to a suitable state which would support pre-mining land use activities such as small-scale agriculture, hunting, and artisanal forestry. In addition, the intent is to leave the site at closure with better water quality in available drainage system downstream than existed when the galamsey businesses were in operation.

Key information gathered for the development of this plan included; types of galamsey, their spatial distribution pattern, their land-take estimation, stakeholder consultations and contaminant levels measurements. The chamfi (45.47%), alluvial washing board (43.4%) and river/stream dredging (4.94%) galamsey are the three operations with most extensive footprint. The chamfi and alluvial washing board galamsey are only next to the underground sample pit as the galamsey types with the highest number of individuals within clusters. The chamfi operation, having the third highest number of sightings made and second highest number of individuals within clusters (sightings), operates using the Chan Fa engine for simultaneous mining and gold extraction. It has since its introduction over a decade ago in Ghana by the Chinese enjoyed much popularity among galamsey operators. It requires a small parcel of gold-laden land and a relatively low start-up cost. It is a highly efficient, easy to use, mobile or potable and can handle both alluvial and lode/vein deposits with ease. The low feeding rate or loading capacity is compensated for by having many set-ups per an area; thus having them in clusters.

The washing board galamsey is the most sighted and comes after the underground sample pit and chamfi as the operations with highest number of individuals within clusters due to the abundance of alluvial deposits and water bodies across the entire stretch of the Wassa Amenfi East district and some vast portions of the Tarkwa Nsuaem and Prestea Huni Valley districts (which are identified as the three main washing board MDA hotspots). The washing board also represents the most economical way or profitable means of commercially extracting low grade and alluvial deposits. It is the galamsey type most practiced by foreigners, especially the Chinese. It is also very popular within all three Amenfi Districts (East, Central and West) considered due to the very rural certain they present, their alluvial deposits and drainage networks, low level of law enforcement and limited activity of LSMs. With the exception of the Nzema East, Mpohor and Ellembelle, the eight remaining MDAs considered in the research were found to be hosting alluvial washing board galamsey.

The three most impacted districts, in terms of land-take or operational footprint, are the Amenfi East (58.272%), Tarkwa Nsuaem (17.532%) and Prestea Huni Valley (8.452%). This is due to the fact that these districts host the highest percentage of chamfi and alluvial (washing board) operations, which generally requires a large area of land to profitably operate. Although the Tarkwa Nsuaem (276 sightings with approximately 3,628 individuals), Amenfi East (223 sightings and 1,397 individuals) and Prestea Huni-Valley Districts (153 sightings and 1,114 individuals) were earlier on noted as the three main galamsey hotspots, their land-take information did not follow the same pattern. Generally, underground and mill house operations have very limited land sizes compared to the chamfi and alluvial washing board; hence their footprint trends recorded. The Sefwi Wiawso (0.002%), Bibiani-Anhwiaso-

Bekwai (0.344%), Wassa East (0.414%) and Nzema East Districts (0.416%) are the four MDAs least proliferated by galamsey operators.

From the geochemically perspective, the four main pollution concerns requiring attention in galamsey are high TSS or turbidity levels, oil and grease, arsenic and mercury; most especially for the commercially driven alluvial operations and mill house galamsey. The underground operations (sample pit and abandoned shaft) employ the use of diesel and petrol for water discharges but rarely use mercury since virtually any form of gold extraction takes place at the mining sites. The radiological analysis of water and soil matrices at the various galamsey sites revealed that the illegal mining and or processing activities have minimally impacted on the soil and surface water resources and does not pose an immediate environmental hazard to the human population, wildlife and the surrounding ecosystem.

The closure plan includes driving away galamsey operators and restricting access to the general public; long-term drainage management; the demolition, dismantling and removal of the galamsey infrastructures (mill houses, washing board sluices, washing plant/trommel, electrical installations, chan fa diesel engines, smoothing machines, concrete platforms, roofing systems, compressors, blowers etc.); the filling of backfilling of open pits and sealing of holes; housekeeping and general clean-up of sites; salvaging of abandoned heavy duty equipments and other related machinery (dozers, excavators, graders, Toyota Pick-ups/Tundras etc.); conduct of site characterization/geochemistry exercises; pumping and treatment of polluted waters; phytoremediation of affected land and wetlands; the revegetation of disturbed areas with native seedlings grown; and the monitoring of surface water quality, rehabilitated sites and general care and maintenances of facilities until parameters meets the Ghanaian EPA and Best Management Practices.

An estimated total amount of ***GHS 987,707,164.53*** is required for returning galamsey affected lands to states close to originality. The closure details or spreadsheets can be found in attached appendices.

1.0 INTRODUCTION

Ghana, the number one gold producer in West Africa and the second largest producer on the African continent, has had a long and somewhat troubled history when it comes to illegal artisanal small scale (ASM), also called galamsey. The mad rush for Ghana's gold, which commenced a decade ago has attracted and continues to attract millions of people some foreigners and other locals, to become artisanal miners (mostly illegal miners) in order to escape complete socio-economic hardships and marginalization.

The foreign illegal miners either travel from neighboring West African countries such as Togo, Benin, Nigeria, Niger, Burkina Faso, Mali and Cote d'Ivoire, or from faraway lands such as Asia, the Americas and Europe, particularly China and Russia, into the country. Their influxes have significantly increased the dynamisms within galamsey, more especially within the most mineralized and currently the most active gold mining region in Ghana, the Western region.

The galamsey life cycle is well known: discovery, migration, and relative economic prosperity are followed by resource depletion, outmigration and economic destitution. Mining operations under galamsey are generally conducted either by alluvial, vein/lode or selection approaches. The alluvial involves digging pits or excavations along water bodies or dredging water bodies for gravity gold and extracting them using either sluice boards, washing plants or panning approaches. Whilst the selection galamsey basically involves pilfering of mined ore from the ROM pads or stockpiles of regulated LSM and ASM operations, the hardrock mining involves either the use of the chamfi system or underground via the sample pit and abandoned shaft processes. The fragmented rock, soil or gravel from chamfi, selected ore and underground operations are mostly grounded into powder form and mixed with water and mercury to attract the gold particle. The mercury-gold amalgams are then burnt to evaporate the mercury and recover the gold.

A recent operational characterization exercise undertaken by Mantey et al., **[1],** in the Western region for instance, unearthed five (5) broad categories and eleven (11) sub-groupings of galamsey (based on gold deposit type, resource used, players involved, origin, mining and extraction style or technology as well as the local or traditional name given). These five categories are: (1) Placer/alluvial galamsey (Dig and Wash, Alluvial Washing Plant/Trommel, Alluvial Washing Board, "Anwona" (Ewe), River/Stream Dredging and panning), (2) Underground/hardrock (lode/vein) galamsey (Abandoned underground shaft/tunnels, Sample Hole/Pit or "Ghetto" and (3) Surface/hardrock (lode/vein) galamsey (Chamfi), (4) Mill-House galamsey and (5) Selection (pilfering) galamsey. See **Table 1** for a brief summary of the galamsey types and their respective operational attributes.

Equipments used for galamsey mining and mineral extraction can be differentiated between those whose operations are purely manual, like those used for dig and wash, panning, sample pit and abandoned shafts and those that have introduced some semi-advanced technology which utilize hydraulic and electronic mechanisms such as those used in dredging, washing boad and plant, anwona, mill house and chamfi galamsey operations. These semi-advanced technological equipments include drilling and blasting machines, graders, excavators, loaders, generators, sluice box, chan fa diesel powered engines, trommels, retorts, crushers and grinding machines.

The activities of galamsey typically take place in a variety of locations ranging from remote, inaccessible locations, urban centres and even around residential areas. Whilst some aspects of the mill house, chamfi and selection galamseys are situated right in the heart of villages, towns and cities and mostly located along roadsides, school premises, market areas and also within residential locations, others like the alluvial and underground galamsey types take place in very remote, vegetated areas and along water bodies. These multiplicities in galamsey's positioning tend to affect their identification and positioning accuracies when remotely sensed imageries are solely used **[1].**

Table 1: *Summary of galamsey types and attributes* **[1]**

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		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	
	Anwona or Pit Dredging		Pits lake, Suction Dredge/ "totototo", anchors, mercury, retort, coal pot	"Anwona"	People hailing from Volta region of Ghana (Ewe/Anwona people)	
	River/Stream Dredging		River/Stream (with adequate current/flow), Suction Dredge, anchors, Mercury, retort, coal pot	"Totototo/dredging"	Not available	
	Dig and wash		Pick axes, spade/shove, head pans, baskets, Sluice Board, Mercury	"Dig and wash"	Traditional (not known as in practice for many years)	
	Panning		Pans/sample tyres, pick axe, shovels/spades, mercury	"Poohlepoohle"	Traditional (has been in practice for many years)	
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, gensets, head lamps/touches, Kia trucks, Pick-up vehicles etc.	"Ghetto"	Not available	Mining Only

	Sample hole/pit or "ghetto"		Manually dug pit/holes, Shaft, blasting agents, dewatering pumps, hammers, sacs, ropes, blowers/ventilators, mortar and pestle, gensets, head lamps/touches, Kia trucks, Pick-up vehicles etc.	"Ghetto/sample pit"	Traditional (has been in practice for many years)	
Surface Mining	Chamfi	Lode/Vein & alluvial	Surface Mining, Chan Fa machine, Mercury, Retort, mortar and pestle, spades/shovels, sacs, hammers, water pumps, gensets	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

Thus one can easily confuse a galamsey site with either a regularized ASM, a quarry, sandwinning operation, hamlets or other related infrastructure due to their textural similarities and the thin line that exist between them.

Operationally, the alluvial and chamfi galamsey types involve simultaneous mining and gold extraction. The two underground operations (abandoned shafts and sample pit/hole) and selection galamsey generally involves only mining, whilst the mill-house galamsey entails gold extraction or processing only. The hardrock (lode/vein) galamsey, by virtue of the chemistry of the ore deposits, involves some form of blasting and crushing. Mined ore from underground and selection (mostly high grade ore) are transported, sometimes across districts, to a mill/processing house site which makes use of crushers, smoothening machines or chan fa diesel powered processing systems for extraction **[1].**

Figure 1: *A typical washing plant/trommel*

The mill-houses (also called “structure”) are normally stationed by roadsides and adjacent water sources or wetlands; easily accessible areas where electricity can be tapped for gold extraction. The “structure” may be owned by a private individual who receives and process ore for a fee or purchases the ore from galamseyers and treat for a profit. It may also be owned by a gold buyer or the “gang/ghetto” leader of a particular galamsey group for the processing of their mine ore. Mill houses are normally used for high grade ore and sources of such material commonly received sample hole, selection and abandoned shafts; so long as the grades are high and revenue would exceed the cost of processing **[1**].

Traditional surface galamsey mining is often done rudimentarily and manually using shovels pick axes, earth chisels and other simple equipments. Depending on the thickness and nature of the orebody, and the resources (funds, equipments, labour) available to galamseyers, it may be removed as a single vertical interval or in successive intervals or benches. With the larger ore bodies, they are typically mined in benches either by excavating or cutting vertical holes from the top of the bench. Explosives are rarely used by galamseyers for surface mining. Where used, they typically comprise of chemicals which, when combined, contain all the requirements for complete combustion without oxygen supply [**1, 2**]. According to Mantey et al [**1**], the chamfi (a typical surface galamsey) is presently one of the most popular and economical way of mining lower-grade ores from both lode/vein and alluvial sites by galamseyers.

Figure 2: *washing board (comes in different sizes/capacities, configurations, set-up etc.) in operation*

The introduction of the 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 the washing plant approaches, all remaining types of galamsey, in one way or the other, makes use of the diesel powered Chan Fa engine. The washing plant and washing board galamsey, which are very popular in the Wassa Amenfi East District Assembly, have extensive footprints and make use of heavy mining equipments like dozers, excavators, loaders etc. The most commonly used chemical for galamsey are mercury, borax and hydrocarbons [**1-3**]. They appear to be the most profitable and commonly practiced alluvial galamsey type around at the moment.

Modern day galamsey, especially those undertaking via abandoned shafts, sample pits, washing board, washing plant, mill house and chamfi, are well-organized, resourced and highly empowered (either by chiefs/traditional ruler politicians or by wealthy sponsors). The security network and intelligence used can be very efficient too. Often employed are personnel whose role is to establish close surveillance over operating areas and report intruders or visitors even before they arrive on their sites. Such people (who could either be male, female, lottostakers, draught (“dame”) and ludo players etc.) are normally positioned in the heart of host towns and villages, along accesses to ghettos or operational sites and are sometimes empowered to interrogate, restrict entry and divert attention of people whom they suspect of having the potential to expose their operation to the general public.

Figure 3: *Bonsa River being dredged for gold at Bonsaso in the Tarkwa-Nsuaem Municipal Assembly*

Galamsey operations are mostly viable for a period of10 years (especially the alluvial and surface mines), but the environmental and social impacts are felt long thereafter. The impacts of galamsey-related harms on the environment and quality of life of affected communities have been increasingly documented and are often severe, wide-ranging and long-term in nature. It often generates a legacy of extensive environmental degradation, both during operations and well after mining activities have ceased. Their uncontrolled spread across Ghana, poses many adverse impacts to water bodies, vegetation and wild animals. Varying degrees of injuries and fatalities are sustained on regular basis by galamsey operators, host community personnel and wild animals often resulting from failed walls of pits, landslides, equipment usage, skin contaminations from chemicals used, drowning, accidental fall of trees etc. Socially, the challenges from drugs, prostitution, disease, gambling, alcohol abuse, and degradation of moral standards are frequent consequences of the chaotic occupation at mining sites. It is apparent that the economic benefits obtained by the miners do not compensate for the deplorable socio-economic conditions left to surrounding communities.

One of the most significant environmental impacts is derived from the use of mercury (Hg). The general population is unaware of the capricious nature of mercury and artisanal mining activities. Other environmental degradation such as mining waste, acid mine drainage (ARD), soil erosion, deforestation, ground contaminations from oil and grease, wildlife mortality, geotechnical impacts, aesthetics and surface water pollution outlasts the lifespan of a mine, resulting in a legacy that poses a daily threat to the health, safety and well-being of communities.

After depletion of easily exploitable gold reserves, sites are abandoned, and those who remain contend with a legacy of environmental devastation and extreme poverty. The liabilities, often referred to as a “negative legacy,” are passed on to the current generation of stakeholders by the previous mine owners who may no longer exist. The potential for creating new orphaned and abandoned galamsey sites in Ghana is considered to be high due to the absent of stringent regulations. Advances in reclamation techniques and technologies, and developments in best practices within the mining industry do not currently apply to the galamsey or illegal ASM sector.

Figure 4: *"Anwona" type of operation in abandoned pits created by alluvial washing board operators*

Approximately thousand eight hundred and forty-five (1845) abandoned galamsey sites can be found in approximately 50% of the 22 MMDAs available to the Western Region, and those currently operating (approximately 5532) will undoubtedly experience the same fate. The environmental and financial costs of the devastations are likely to be borne by the government and the whole of society. In particular, affected communities continue to live with the severe harm to health and well-being associated with galamsey legacy pollution, which threatens the social fabric.

Figure 5: *Dig and wash operation at a site*

In view of the financial liabilities generally associated with mining, government agencies in a number of jurisdictions have recently adopted policies of requiring mining companies to provide environmental financial assurance (EFA) to guarantee the costs of reclaiming lands affected by mining in order to prevent or repair environmental damage at the end of a mine's life. The Ghanaian legislature has developed mechanisms to promote sound management of mine closure and rehabilitation. The Mineral and Mining Health and Safety and Technical Regulations (L.I 2182) sets out requirements with respect to mine closure that all mines must adhere to. In addition, Ghana Environmental Protection Agency signs an agreement, Reclamation Security Agreement (RSA) with Mines and mandates them to provide security to EPA as a guarantee against the company's reclamation of disturbed as a result of its operations. The RSA sets aside financial provision for the discharge of their rehabilitation obligations, which can be returned to mining companies on the issuing of a closure certificate by the state regulator.

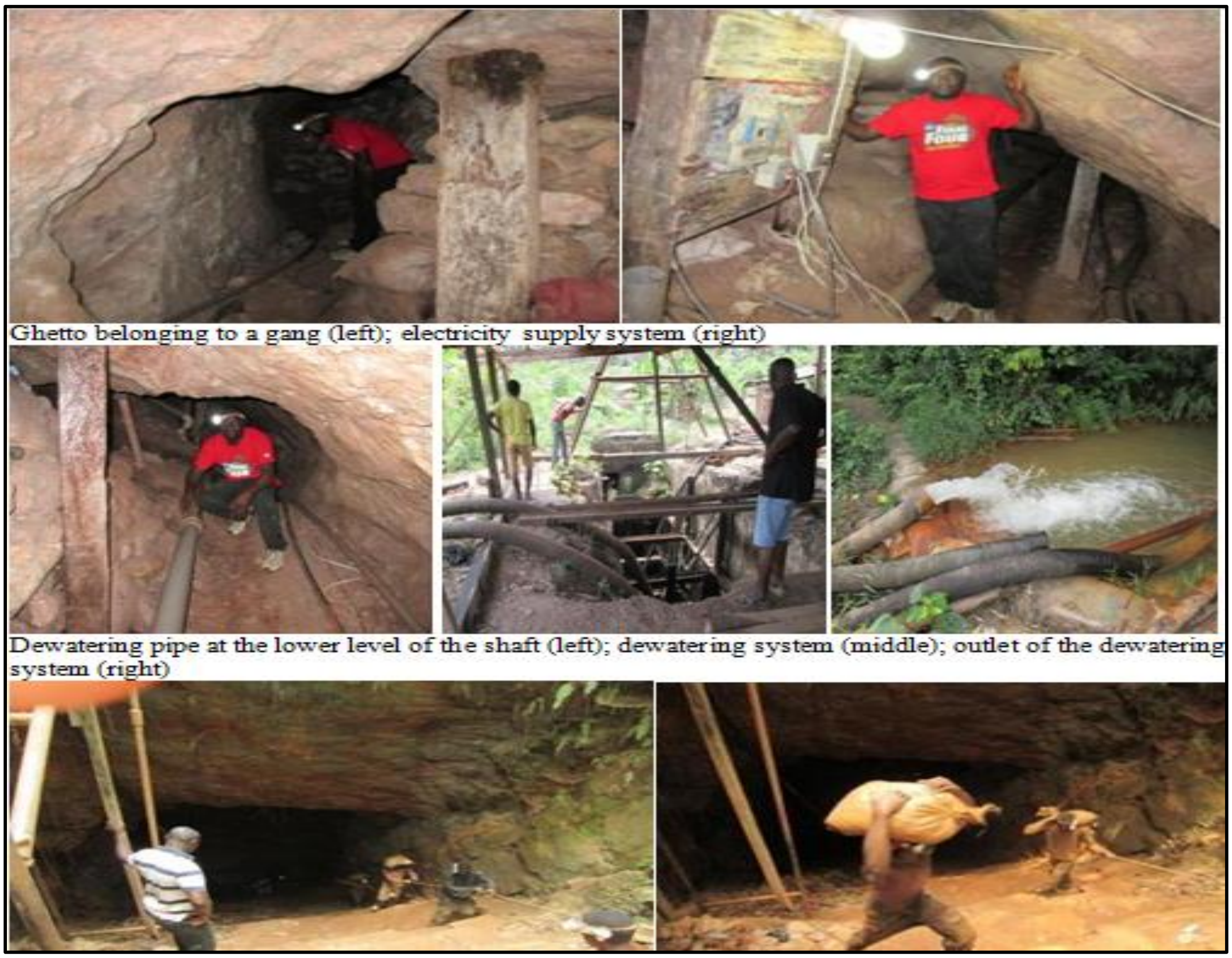


Figure 6: *Underground galamsayers climbing out of an underground shaft at Abosso in the Prestea Huni Valley District.*

In the case where a regulated ASM or LSM operator declares bankruptcy before the mine is closed, the responsible regulatory agency would use the security deposit to cover the eventual costs of repair, maintenance, cleanup, and closure of the mine's site; this unfortunately cannot be said of galamsey operation. Unfortunately however, due to the illegal nature of galamsey, the above legal requirements and provisions for mine closure and reclamation are not observed. Devastated lands are left abandoned; pits are left uncovered or unseeded, waste dumps are left ungraded or graded, no form of housekeeping and waste management are undertaken, no form of water treatment exercises are observed and no form of chemical clean ups are undertaken.

Figure 7: *Sample holes at a site (left); pit lined with wooden materials for (middle); researcher inside a sample hole (left)*

To date, no formalized exercise has been undertaken to develop closure scenarios and model the closure liabilities of galamsey types existing in Ghana. No one is aware of the exact amount of money needed and the approach required for scientifically reclaiming impacted lands. This article therefore focuses on an important consequence of the abandonment of galamsey or illegal artisanal mines: closure liability. By better understanding the closure scenarios of the various types of galamsey and their respective closure costs or liabilities, effective decommissioning and reclamation measures are more likely to be developed and implemented. This lack of information is a challenge for government authorities and other key stakeholders looking to develop effective policies and programmes to reclaim devastated and abandoned lands, and generally mitigate the negative impacts of galamsey [**4-5**].

The over-arching policy-relevant question that guides this research is; how much land has the various operational forms of galamsey taken so far? The objective of this paper is to contribute to filling this gap by proposing and testing a ground-based mobile method to quantify land take dynamics associated with galamsey operations.

The impetus for this project has come directly from ongoing efforts from the Minerals Commission, the various Regional Security Councils (RCC) and galamsey tasks forces towards the eradication of galamsey challenges and reclamation of the many desolate wastelands in Ghana that are dependent on up-to-date information about the operational attributes, spatial distribution pattern, land-take information and relative impact trends.

Figure 8: *Inside a mill house at Tarkwa*

Destruction caused to the environment by activities of galamsey (illegal miners) operators is no longer news to the itching ears. What most people worry about the uncontrolled waste done on the environment is whether there is ever going to be a solution. Galamsey operators have since time immemorial been the bane of several governments in this country. The results for doing nothing tangible to curb this practice are now staring us in the face as the environment is being destroyed at an alarming rate. Farm lands have been encroached upon by ravenous youth who, due to lack of any professional or vocational training, are caught in the trap of unemployment or under-employment. It is very difficult if not impossible to reclaim land and return it to its original state if miners take over and dig into it haphazardly in search for bullion. What has now become very worrying is that galamsey operators have also encroached on some water bodies prospecting for precious metals. The famous river Pra in the Central Region is now being destroyed by illegal miners.

Figure 9: *Sluice box fed with "black" (left) at a chamfi site (right) at Mpohor*

Since illegal miners are operating outside the laws of the land, it is difficult to regulate their activities and ensure that they respect and follow environmental regulations. Large concessions paid for by multi-national mining corporations are also encroached upon by galamsey operators which sometimes breed high tension in mining communities. Many farming communities in the Ashanti and now the Upper East Regions have fallen prey to the greed of illegal miners. Large pits are left uncovered at places hitherto known to be farm lands posing great danger to farmers and other road users. Lack of support to farmers by central government has made farming unattractive which has only succeeded in fuelling illegal mining. Whiles the environment is in danger of being destroyed, the country's food security is in dire situation.

Objectives

The main aim of this research work is to develop a costed reclamation strategy or plan for the return of affected galamsey lands within selected district assemblies of the Western Region, Ghana.

2.0 MATERIAL AND METHODS

2.1 Research approach

The study employed a field-based survey; using ODK (open data kit) programmed questionnaires implemented on mobile smartphones running on Android operating system **[6, 7].** It was used to collect the estimated land areas of impacted galamsey sites. The detail information on the contemporary galamsey socio-environmental information such as galamsey types, host village or community names, GPS coordinates and activity statuses of respective galamsey operations were gathered by Mantey et al, 2016 as part of their project entitled "the operational dynamics and spatial distribution pattern of galamsey in the 11 MDAs of the Western Region".

The use of ground based surveying instruments such as theodolite, measuring tape, total station, 3D scanners, **GPS**/GNSS, level and rod were not used here due to the offensive and violent nature of some galamsey operators. It will be dangerous to employ these provocative equipments on illegal mine sites unless perhaps one is accompanied by a team from the Military and Police. The ground conditions and general conditions on galamsey sites are also such that the use or setting up of instruments may pose challenges and affect accuracy of results expected. The use of georeferenced high resolution remotely sensed imageries (aerial photos, LiDAR and satellites) were not considered in this paper due to the associated cost for a developing economy like Ghana. Again, locating and identifying galamsey operation on remotely sensed imageries may pose a challenges and affect accuracy of results due to their, scattered, clandestine nature (of some operations) and difficulty in distinguishing legal ASMs from galamsey operation owing to spectral resolution and outlook similarities. Whilst a great number of galamsey are within forests, highly remote areas and deep under the earth, some are undertaken in homes and in residential areas thereby making them difficult to discriminate.

Galamsey operators (especially those operated by foreigners and within sensitive environments like water bodies and forest reserves) are mostly armed, can be very violent and have little regards for rules, security personnel, LSM officials and even sometimes, chiefs, the police and military **[8-9].** For instance, a number of widespread conflict, violence and deadly attacks between illegal Chinese artisanal mine workers (who mostly possess guns (AK 47 assault rifle) and other dangerous weapons) and Ghanaian natives have been reported. These triggered violence and armed attacks often leads to widespread unrest, injuries and deaths **[10]**.

Hence the decision to employ site visits and physical estimation of impacted sites using the ODK programmed questionnaires implemented on mobile smartphones running on Android operating system. Although field-based survey in galamsey areas using ODK can be tedious and risky, it is not inordinately time-consuming (particularly if performed for a sizeable number of districts within regions using enumerators from catchment communities) and the quality of output is much reliable and accurate than the use of remotely sensed imagery alone. Whilst the challenges associated with textural similarities that exist between galamsey and other similar undertakings (regularized ASM sites, quarry, sand winning, agricultural projects, building construction projects etc.) were overcome, a much higher number of operational sightings were made; underground operation and those operating in homes and under forest canopies were all identified and areas estimated (basically their length and breadth values) with relative ease. Again other ground-based socio-environmental information needed for enhanced data analysis was straightforwardly gathered using the approach employed in this work.

Using a Samsung Galaxy Fame smartphone, its built-in GPS provided acceptable level of positioning accuracy in outdoor situations of approximately 4m, which is still good enough to locate galamsey operations within a specific neighborhood or location. The aims of the ODK field survey exercise were in four-fold; firstly to identify host towns and villages within MDAs, secondly to locate galamsey sites and determine operational types, thirdly to record their relative GPS coordinates, fourthly to visually estimate the land size and sixthly to generate adequate additional data such as their activity status and visual environmental impact inventory.

2.2 Baseline-environmental context of the Western Region

Introduction

The Western Region is situated in the south-western part of Ghana. It shares common borders with La Cote d'Ivoire on the west, the Central Region in the East, parts of Ashanti and Brong Ahafo Regions in the North and the Gulf of Guinea (Atlantic Ocean) in the South. It covers an area of 23,921 square kilometers representing about 10 percent of the total land surface of Ghana. It has a total of 192 kilometers coastline. The Southernmost part of Ghana, Cape Three Points near Busua in the Ahanta West District, is also located in this region.

The Western Region is one of the ten (10) Administrative Regions of Ghana. The Region was carved out of the former Western Province in July 1960. It has Sekondi as its administrative capital. Section 140 of the Local Government Act 1993 (Act 462) also established the Regional Co-ordinating Council (RCC) with the sole objective of co-ordinating, monitoring and evaluating the activities of Sector Departments such as Metropolitan, Municipal and District Assemblies (MMDAs) and Ministries, Departments and Agencies (MDAs). The RCC does this with the view of improving the lives of the people.

Physical Features

The relief of the Western region falls in the physiographic type classified by Dickson and Benneh (2001) as the forest dissected plateau. Much of the region is a plain between about 240 and 300 metres above sea level with isolated hills.In the North-West (covering about five districts) the topography is rugged and hilly. Much of the region is covered by Pre-Cambrian rocks which he calls the "Birrimian" and "Tarkwaian" series. According to him, the two rock types are important because most of the gold, manganese and diamonds mined in the country are obtained from the Birrimian rocks, while the Tarkwaian provides large quantities of gold. Also, rich deposits of bauxite occur in areas covered by the two types of rock (Boateng, 1960).

Four main rivers flow through the region: Pra, Ankobra, Tano and Bia. Apart from the Ankobra, the other rivers have their source in forests in neighbouring regions and flow southwards into the sea. The Tano and Bia enter the sea outside Ghana through the La Cote d'Ivoire. River Pra has potential for hydro-power generation (Dickson & Benneh, 2001). The authors have further noted that these rivers do not lend themselves to use by large boats because of interruptions in many places by rapids and waterfalls. The Sutri falls on the lower Tano near Abuoso and the rapid on the Pra just south of TwifoPraso are sited to buttress the point.

The region is the wettest part of Ghana. Rainfall decreases northwards and eastwards from the extreme south-west which is the wettest part of the region and the country. Rainfall distribution in the region is characterized by two seasons; with the major one reaching its maximum in May/June and the minor one in October. Apart from these, Boateng (1960) has noted that there is practically no month without rain. The region falls under two main climatic types: the south-western equatorial and the wet semi-equatorial (Dickson & Benneh, 2001).The south-western equatorial climatic type roughly coincides with the evergreen forest and the wet semi-equatorial climatic type with the semi-deciduous forest.

The south-western equatorial climate is the wettest in the country with rainfall patterns as described above. The highest temperatures which occur in March/April are around 30 degrees centigrade while the lowest temperatures of 26 degrees occur in August. Relative humidity is between 70-80% all year round. The wet semi-equatorial climate has average yearly rainfall between 1250 and 2000 millimetres with sharp dry seasons.

The vegetation types found in the region is evergreen or rain forest, semi-deciduous forest, Guinea savannah and coastal savannah. The rain forest can be found in the south-western equatorial climatic region at the extreme south-western corner of the Region. The high temperatures and heavy rainfall facilitate all year round speedy growth of plants. The trees of the forest are evergreen as only a few of the top two out of three layers shed their leaves. The semi- deciduous forest which covers a larger part of the region is similar to the rain forest in its structure except a much higher proportion of trees shed their leaves. Like the rain forest, the trees do not all shed their leaves at the same time, and so is never bare of leaves. Human activities such as farming have led to the destruction of most of the virgin forest, hence only secondary forest currently remains.

For most part of the Jomoro district, the guinea savannah covers a narrow strip along the south-western coast. The yearly rainfall is barely below 1000mm or 1250mm.The dry season is intense and humidity is low. The coastal savannah covers the coastal areas of Shama district and parts of the coastal areas of SekondiTakoradi Metropolis. The vegetation is made up of thick scrub. The area has the lowest amount of rainfall in the country but has high humidity throughout the year.

Natural Resources

The Western Region is the largest producer of cocoa and timber, the second highest producer of gold, with the potential to become the highest producer of this commodity. There are five major gold mines, namely Teberebie and Iduaprem goldfields, both now owned by Ashanti goldfields, Prestea/Bogoso mines now owned by a South African company, Tarkwa goldfields, and Aboso goldfields located at Damang near Huni Valley. There are other proven but as yet unexploited ore deposits at Tarkwa, Aboso, Bondaye, and the forest reserve areas of Jomoro and Nzema East, Aowin-Suaman, Amenfi and Mpohor-Wassa-East districts.

The region has the largest and only economically viable rubber plantation in the country, stretching from Agona Junction to Bonsa on the Tarkwa road, from Agona Junction to Dadwen on the Axim road, and Baamiangor in the Dwira traditional area on the Esaaman to Dominase/Enibil road. The plantations used to support the erstwhile but still potentially viable Firestone tyre factory at Bonsa, but now support only the rubber-processing factory at Agona Junction, which processes rubber into semi-finished material for export. The only commercially viable manganese mine in the country, located at Nsuta, which has been exploited for over seventy years, is still operating.

Commercial productions of vegetable oil palms such as coconut and palm oil, both of which have the potential of rivalling cocoa, are most actively pursued in this region. The Benso Oil Palm Plantation, owned by Unilever Ghana Limited, is one of the largest in the country. The country’s only bauxite mine currently in production is at Awaso in the Sefwi District. Other potential areas of deposits in this region are yet to be fully explored for exploitation. It is scientifically proven that the large but as yet unexploited iron deposits at Oppong Manso also have about 25 per cent of exploitable bauxite that can be a valuable by-product if ever the iron deposits are exploited. The region used to have commercially viable deposits of alluvial diamond in the Bonsa River Basin, which was actively exploited by small-scale miners in the 1940s and the 1950s, but exploitation of these deposits declined and finally stopped in the early 1970s. It is however believed that the river basin could still be prospected for diamonds.

The largest potential deposits of gas and crude oil that are nearest to possible economic exploitation can be found in the Tano Basin and offshore in the Jomoro (Western Nzema) District. The same district has high quality limestone and fine sand deposits upon which the country’s cement and glass industries can rely. Major timber and wood-processing factories are found in Takoradi, Sefwi-Wiawso, Samreboi and Bibiani. Following the deterioration in capacity of the hydroelectric generation at Akosombo and Akuse, the Western Region now supplies the whole country with the largest single quantity of electricity with the three thermal plants at Aboadze near Sekondi. Current share of the Aboadze plant is estimated at between 50 and 70 per cent of national output. Another gas-fired thermal plant is expected to be operational soon at Effasu in the Jomoro district. It is expected that both plants will eventually make use of the region’s own gas deposits, as well as gas from Nigeria when the West African Gas Pipeline project comes on stream.

Tourism in the region has been described as the country’s sleeping giant. Even though the Central Region often comes to mind when tourism is discussed, the sheer mass of the tourism potential of the Western Region is yet to be properly assessed and exploited. The region has the second largest concentration of forts and castles in the country6, accounting for seven out of the country’s fifteen selected tourist forts under the Museums and Monuments Board. Central Region also has seven of these. (Anquandah, 1999). Fort St. Anthony in Axim is the second oldest Fort and European settlement in Ghana. The University of Ghana and the University of Pisa in Italy are now mapping out the slave routes from Fort Apollonia in Beyin to northern Ghana. Other forts and castles are Fort St. Sebastian at Shama, where the famous Ghanaian Philosopher Dr. Anton Amo of Axim, (who was captured and sent to Germany as a slave boy in the early 18th century, and who is reputed to have lectured in the University of Halle-Wittemberg in Germany), is buried. Others are Fort Orange in Sekondi, Fort Batenstein at Butre, Fort Gross-Friedrichsburg at Princestown, the only German Fort in the country, and Fort Metal Cross at Dixcove.

Figure 10: *Map of the Western Region-Ghana showing mineral deposits*

The southernmost part of Ghana, and perhaps the whole of West Africa, is Cape Three Points near Busua. The very substantial eco-tourism potential of the region is yet to be fully exploited. The famous Nzulezo village built on stilts on water, and the Amanzule wetlands, which include the internationally recognised bird sanctuary, are located in Nzema East. In the same district can be found the sea turtle conservation area at Krisan near Eikwe. There are clean and still unspoilt coconut palm-lined beaches, well-preserved wildlife parks and forest and game reserves such as Ankasa and Nini-Suhyien, full of forest elephants and other very rare plant and animal species.

The unexplored caves of Mpohor-Wassa-East, including the Rock Shrines of Wassa Domaa, can attract many visitors if exploited. The region has some good moderately priced hotels dotted around the beaches and the industrial areas of Sekondi-Takoradi and Tarkwa. Indeed, economists have predicted that the economic survival of Ghana will depend on what Governments will do to, and how they will treat, the Western Region.In all Ghana has about 80 castles and fortifications built over a period of 300 years, with many of these now in ruins or disuse, and dotted along the coast from Keta to Half Assini.

2.3 Study Site Selection

Eleven (11) out of the twenty-two (22) districts, 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 the study. The Western Region **(figure 10)** was chosen because it represents the most active mining region in Ghana; having the highest concentration of large scale gold mining companies (LSMs) and regulated artisanal small scale gold mining companies (ASMs) as well as being the highest producer of Gold in Ghana **[11-13]**. The region has also become the epicenter for a chunk of the illegal gold mining business in Ghana due to galamsey's close association they tend to foster with LSMs and regulated ASM operations; meaning, it is most likely to find a galamsey operation in the vicinity or on the concessions of a regulated ASM and LSM. Out of the fourteen (14) large scale gold mining companies (LSMs) actively operating (extracting gold) in Ghana, ten (10) of them are alone located within the Western Region **(Table 2)**. Again, approximately 396 (representing 30%) of the 1,342 registered and actively operating small scale gold mining (SSM) companies in Ghana operates within the Western region of Ghana **[14, 15].**

In selecting the districts of interest, the twenty-two (22) MMDAs within the western region were reorganized into classes based on the presence and number of LSMs and regulated ASMs as well as the richness of galamsey history. All nine (9) 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 two remaining (2) district assemblies (Amenfi Central and Amenfi West), were randomly selected from the remaining 13 MMDAs observed to be hosting ASMs and having a rich galamsey history (***see table 3*** **and Appendices** ***for details***). **Table 3** provides a brief summary of the physical features of the 11 selected districts, including their drainage, geology, minerals, rainfall figures, vegetation, and main economic activities.

Table 2: *The 11 selected municipal and district assemblies (MDAs), their respective sizes, coordinates and LSM/ASM overviews within the Western Region* [**16-30**]

	Selected MDAs	**Capital**	**Size of MDAs (sq.**	**Location/Coordinates (Lats & Long)**	**Registe red**	**Active LSM**
1	Wassa Amenfi Central	Manso Amenfi	1,845.9	Details not yet available	4	Nil
2	Wassa Amenfi East	Wassa Akropong	1,558.0	Latitudes 5, 30 N, 6,15 N, Longitudes 1, 45 W and 2, 11 W	38	Golden Star Bogoso-Prestea/ Perseus Mining (Ghana)
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	Noble Gold Bibiani Limited/Kinross (Chirano) Gold/Awaso Bauxite Mines Mines Limited/Ghana
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 yet 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	1,809.0	Details not yet available	89	Gold Fields Tarkwa/Golden Star Bogoso-Prestea/ Golden Star Wassa Ltd./Sankofa Gold Limited/ Anglo
10	Sefwi Wiawso	Sefwi Wiawso	1,101.6	Latitudes 60N and 60 300 N and Longitudes 20 450 W and 20 150 W.	1	Noble Gold Bibiani Limited/Kinross (Chirano) Gold Mines Limited
11	Tarkwa – Nsuaem	Tarkwa	905.2	Latitude 400'N and 500 40'N and Longitudes 10 45' W and 20 10'W.	10	Gold Fields Tarkwa Mines/ Nsuta Manganese Mines Limited/Anglo Gold-Iduapriem Limited
	TOTAL		**13,758.29**		**320**	

Table 3: Physical features of the 11 selected MDAs **[16-30]**

MDAs	Drainage	Geology	Minerals	Rainfall Figures	Vegetation	Main Economic Activities
Ellembelle	Ankobra River, Ahama River, Nwini River, Ankasa River, Draw River, Amansure River	The underlying rock is made up mainly of the Cambrian type of the Birimian formation and the Tarkwaian Sandstone-Association of Quartzite and Phylites types.	Kaolin, silica and gold, as well as sandstone deposits.	Mean annual rainfall figures range from 26.8mm to 46.6mm	Moist semi-deciduous rain forest (northern part), secondary forest (southwards). Game and wildlife	Majority of the people in the northern belt of the district are mainly engaged in tree crop farming such as cocoa, coffee, rubber, oil palm, in addition to cassava and plantain while large proportion of the people along the coastal belt engage in fishing and coconut farming as the main sources of livelihood. The relief and drainage system of the district also favours the development of fish farming and cultivation of rice, sugar cane and dry season vegetables. The district ranked second as far as marine fishing in the country is concerned. Out of 90 landing beaches in the region, 31 could be found in the district. Land acquisition, sharecropping, tree tenure, and exploitation of Non-Timber Forest Products (NTFP) among others still pose constraints to agricultural development in the district.
Bibiani-Anhwiaso-Bekwai District	The major river in the district is river Ankobra. Other forming tributaries are Awa, Krodua, Atronsu, Subriso, Kroseini, Suraw, Chira and Akataso.	Precambrian Metamorphic rocks of the Birrimian and Tarkwain formation	gold and bauxite	annual rainfall average between 1200mm and 1500mm.	Equatorial Rain Forest Zone- The natural vegetation is moist-deciduous forest. Six forest reserves in the district with the total area of about 264 sq.km	The companies dealing in mining include; Ashanti Goldfields Bibiani Limited (AGBL) at Bibiani; Chirano Goldfield Limited at Chirano and Ghana Bauxite Company Limited at Awaso. Climatic conditions favour the production of such tropical cash crops as cocoa, coffee, oil palm, black pepper and citrus.

Mpohor	Subri, Butre and Hwini	Lower Birimian, Dixcove granite, Cape Coast granite and Tarkwaian	gold, traces of iron and kaolin	The mean annual rainfall is 1500mm and ranges from 1300 to 2000mm.	tropical rainforest/Subri Forest	cocoa and oil palm. Oil palm is cultivated on a large-scale by Benso Oil Palm Plantation (BOPP), NORPALM Ghana Limited, West Agro- Processing Factory and Ayiem Oil Mills.
Wassa East (Daboase)	River Pra, runs through Twifo Hemang Lower Denkyira District through Daboase to Shama. Other rivers are the Pra, Subri, Butre, Brempong, Suhyen, Abetumaso, Hwini and Tipae which serve as tributaries to the Pra River.	Lower Birimian, Cape Coast granite and Tarkwaian	The District has large deposits of gold and traces of iron hence the upsurge of mining activities which has resulted in the pollution of water resources in the District.	mean annual rainfall is 1500 mm and ranges from 1300 to 2000 mm	Tropical rainforest, with a number of forest reserves including Subri River Forest Reserve, Pra Suhyen Forest Reserve, Ben West Block Forest Reserve and Ben East Forest Reserve. These forests are the semblance of virgin forest in the District.	The predominant cash crops are cocoa, oil palm and rubber. Golden Star (Wassa mines) Limited in Akyempim, the SOCFINAF plantations limited
Nzema East	Ankobra River and its major tributaries like the Ahama and Nwini rivers.	Cambrian Rocks of the Birimean formation and the Tarkwaian sandstone-Association Quartzite and Phyllites types	kaolin, silica, gold and sandstone deposits	annual average rainfall between 1800mm and 2000mm	moist semi-deciduous rain forest (north) and secondary forest southwards. There are three forest reserves in the Municipality. These are the Shelter Forest Reserve, Draw River Forest Reserve, and Ndumfri Forest which is the largest of the three.	mechanized stone quarry plant, marine fishing, hosts the second oldest Fort (Fort St. Antonio and “Boboyise” Island) in sub-Saharan Africa
Prestea Huni-Valley	Ankobra, Huni, Oppon, Bogo, Peme, Subri, Bonsa and Mansi	Birimian rocks	Gold	mean annual rainfall of 187.83mm.	forest reserve is the Bonsa Reserve (Aboso), Ben West (Huni-Valley) with 26.00 square	Major companies in the District are Aboso Goldfields, Golden Star Resources, Bogoso/ Prestea Ltd, Prestea Sankonfa Gold Ltd, New Century Mines (Prestea), Tarkwa Goldfields and Anglogold Ashanti

					kilometres and Nkontoben (Hun-Valley) with 49.98 square kilometres	Ltd.
Tarkwa Nsuaem	Bonsa River and its numerous tributaries including Buri, Anoni, Sumin, and Ayiasu	Birimian and Tarkwain geological formations	high mineral deposits (gold, manganese, iron-ore and bauxite)	mean annual rainfall of 1,500mm	rain forest belt; Bonsa Reserve, Ekumfi reserve, Neung South reserve and Neung North reserve	The municipality has three major large-scale mining companies (Goldfields Ghana Ltd, AngloGold Ashanti, and Ghana Manganese Company) and a great number of Small-scale mining outlets which give employment to an appreciable percentage of the population.
Wassa Amenfi Central	Tano and Ankobra	lower Proterozoic Volcanic and the Flyschoid Meta sediments of the Birimian System-Asankrangwa-Manso-Nkwanta Gold Belt	bauxite, manganese and iron-ore	average annual rainfall ranging from 173mm in the south to 140mm in the north	High Rain Forest Zone-semi-deciduous forest, tropical rain-forest and transitional zone. Four forest reserves; Mamire Forest Reserve, Fure Headwaters Forest Reserve, Bura River Forest Reserve, Angoben Shelterbelt Forest	Agriculture is the main economic activity in the district. Cash crops grown are mostly cocoa, oil palm and rubber;
Wassa Amenfi East	Ashire and Manse rivers. Lake Broso	Three main geological soil formations identified in the district are: Upper Birimian, Lower Birimian and Granites. The granite deposits in the district make most parts of it rich in minerals like gold.	Gold and clay deposits	Average annual rainfall ranges between 1400 mm to 1730 mm.	Semi-deciduous forest (north) and tropical rain forest (south). In between is the transitional zone. four forest reserves covering a total of 212.62 sq km. These are the Opon-Manse, Bowie, Tonton and Angoben forest reserves.	The people of Wassa Amenfi East are predominantly farmers. The main products are Cocoa, Oil Palm, Rice, Plantain and Cassava. Vegetable growing is mostly done on subsistent basis.

Wassa Amenfi West	Tano and Ankobra rivers	lower proterozoic volcanic and the flyschoid metasediments of the birimian system- Asankrangwa-Manso-Nkwanta, which is associated with the birimian rocks	The main mineral found in the district is gold.	Average annual rainfall tapers off from 173mm at the south to 140mm at the north	Semi-deciduous forest found in the northern part, the tropical rainforest to the south where rainfall is heaviest and the transitional zone situated between the two. Three main reserves: Bura, Angoben and Totua Forest reserves.	The district has one commercial wood industry, Samatex Timber Company Limited at Samreboi. The district also has a potential for Agro-based Industry, due to the availability of oil palm, rubber and cocoa husk. There are over ten (10) licensed gold exploration companies working at various stages in the district. Illegal gold mining is intensive within all tributaries of River Tano and River Ankobra in the communities.

Sefwi-Wiawso District	Tano River and its tributaries, which cut through the district roughly in a north-south direction and enters the sea in Cote d'Ivoire	gold deposits found in river and streambeds and alluvial deposits. The main geological formations that cover the district are the lower and upper Birimian. The occasional granite intrusions give the district its undulating nature and forms the long hills ranges known as the Bibiani range. Lower and Upper Birimian types with the Lower Birimian formation to the East and North Eastern part of the Municipality	Gold and diamonds. are gold deposits at Kokokrom, Paboase and Akoti areas.	1524mm and 1780mm per annum	moist semi-deciduous forest zone of Ghana, which covers most of Ashanti, Western, Brong-Ahafo and Eastern Regions	About three-quarters of the economically active population are engaged in agriculture. Major crops cultivated in the district include cocoa, maize, cassava, plantain, cocoyam and oil palm. Cocoa is the most dominant cash crop in the district, and productivity is very high. All farming activities are rain-fed. Currently, however, there is only one timber processing factory in the district. This is Logs and Lumber Limited, formerly Glisten Forest Afric Ltd. There are gold deposits found in river and streambeds and alluvial deposits in places near Kokokrom, Anyinabrim, Akontombra and Nsawora/Nkwadum areas. Diamond deposits too, found to the south of Wiawso near Bopa, are yet to be exploited. In this regard, investors interested in exploitation and actual mining operations can count on the support and co-operation of the District Assembly as long as they respect existing environmental laws and considerations. Large deposit of gold has been discovered at Akoti and its surrounding areas. It is being mined in commercial quantities by Chirano Gold Mines Limited, an Australian mining firm.

It is worth stating that, the presence of high mineralization, LSMs, regularized ASM and rich history of galamsey may alone not be adequate to cause galamsey proliferation within a locality; thus, a locality may possess all the ingredients and resources for a booming galamsey business, yet one may not encounter galamseyers. Factors that may reduce or discourage the proliferation of galamsey within a particular area or locality include (but not limited to); existence of strict security regime (military, police, company security patrol etc.), the presence of an actively operating underground mining operations (which tends to engage more youth and locals than other mining ventures), the existence of other important and more profitable economic ventures (factories, agri-businesses etc.) and where locals or youth are traditionally prohibited from engaging in galamsey due to some taboos and superstitious beliefs.

2.4 Spatial Distribution Pattern of Galamsey across the 11 MDAs

Described here is a brief summary of the findings obtained from the attached paper, "spatial distribution pattern of galamsey operations".

General Trend

A study conducted by Mantey et al., 2016 within the 11 MDAs selected for this project revealed a total of 868 galamsey sightings in approximately 269 different towns and villages; out of which 502 were found in clusters (corresponding to approximately 7013 individual units) and 364 as stand-alone operational units. In terms of their activity statuses, 628 active, 45 semi-active and 195 abandoned galamsey sites were encountered. Operationally, the alluvial washing board, mill-house and chamfi galamsey were found to be the three most popular galamsey types practiced. From the municipal and district assembly's (MDAs) angle, the Tarkwa Nsuaem (276 sightings), Amenfi East (223 sightings) and Prestea Huni-Valley Districts (153 sightings) were noted as the three main galamsey hotspot.

The reasons for abandonment or inactivity of a galamsey operation normally stems from either the receipt of too much rains within a particular season (leading to flooding or pits, decline/ramp, inclined vertical shaft or adit, accesses and other working areas), intensified patrols by responsible security agencies (Police, Military teams, Mine Security Team etc.), depletion of ore resources, low gold prices, lack or resources for mining/processing, land disputes or from an imposed ban on galamsey and its related trades in a particular area.

Trend per MDAs

From the MDAs angle, the three main galamsey hotspot encountered are the Tarkwa Nsuaem (276 sightings with approximately 3,628 individuals), Amenfi East (223 sightings and 1,397 individuals) and Prestea Huni-Valley Districts (153 sightings and 1,114 individuals). The Sefwi Wiawso (4 sightings and 4 individuals), Ellembelle (6 sightings and 29 individuals) and Nzema East Districts (6 sightings and 20 individuals) are the three MDAs least proliferated by galamsey operators. See figures 4-13 for more details. See **Table 4** for details.

Trend per Operations

Galamsey has in recent years, transitioned from being an artisanal, traditional, localized, rudimentary or a "hand-to-mouth" venture into a capital intensive, mechanically and politically driven cash generating venture with many players including local businessmen, politicians and other foreign nationals **[16-74].** Hence, the high patronage of the alluvial washing board, mill-house and chamfi types of galamsey among the 11 MDAs considered (see figure 12). These three represent the best and profitable way of extracting gold from alluvial and vein deposits **[1].** The washing board galamsey is most popular due to the abundance of alluvial deposits and water bodies across the entire stretch of the Wassa Amenfi East district and some vast portions of the Tarkwa Nsuaem and Prestea Huni Valley districts (which are identified as the three main washing board MDA hotspots). The washing board represents the most economical way or profitable means of commercially extracting low grade and alluvial deposits. It is the galamsey type most practiced by foreigners, especially the Chinese.

Although somehow cumbersome to transport (as it requires either a Kia truck or low-bed), the washing board equipments are easy to set-up on the field and operationally require no special skill or education. Unlike the mill-house and chamfi, which can be done in the heart of towns and villages, the washing board is normally confined to remote, vegetated and well drained areas with limited security or enforcement protocol to permit the free movement of the washing board machine, its accompanying excavators or earth moving equipments and other core resources such as diesel. Washing board is also very popular within all three Amenfi Districts (East, Central and West) considered due to the very rural certain they present, their alluvial deposits and drainage networks, low level of law enforcement and limited activity of LSMs. With the exception of the Nzema East, Mpohor and Ellembelle, the eight remaining MDAs considered in the research were found to be hosting alluvial washing board galamsey.

The mill-houses are fairly distributed across the selected MDAs, except in Ellembelle and Nzema East where none was encountered. They are especially in locations (Tarkwa Nsuaem, Prestea Huni-Valley Amenfi East and Bibiani-Anwhiase-Bekwai districts) where hard-rock or underground mining and selection galamsey predominates **[1].** This is because they serve as the processing bay for mined ores from abandoned underground shafts, underground sample pits/holes and selection galamseyers. They can be set up anywhere so long as vehicular access, electricity and constant water supply are assured; most especially along road sides, on school premises, in homes or close to residential areas. Mill-house operation employing the use of a crusher and smoothing machine (and not just the diesel powered chang-fa machine for the entire processing) requires constant power/electricity supply **[14**].

The chamfi operation, the third most practiced galamsey type, which operates using the Chan Fa engine for simultaneous mining and gold extraction, has since its introduction over a decade ago in Ghana by the Chinese enjoyed much popularity among galamsey operators. It requires a small parcel of gold-laden land and a relatively low start-up cost. It is a highly efficient, easy to use, mobile or potable and can handle both alluvial and lode/vein deposits with ease. The low feeding rate or loading capacity is compensated for by having many set-ups per an area; thus having them in clusters. The sample pit/hole galamsey, the fourth most popular galamsey types, also presents an excellent opportunity to tap underground resources without the use of sophisticated machinery. The digging or mining is done rudimentarily and manually and the grades mined are relatively high; hence its popularity within the 11 selected MDAs (except in Amenfi West, Ellembelle, Sefwi Wiawso and Nzema East, where none was sighted) **[1].**

Dig and wash galamsey, the fifth most practiced galamsey type was observed within eight (except in the wassa east, Bibiani-Anwhiase-Bekwai and Sefwi Wiaso) of the 11 MDAs considered. It is one of the most traditional galamsey types for mining alluvial deposits and practiced mostly within the Tarkwa Nsuaem, Amenfi East and Prestea Huni-Valley districts. The alluvial washing plant (18 sightings) is the least practiced due to the high cost of acquiring and operating the trommel. This is followed closely by the Anwona (21 sightings), abandoned underground shafts (22 sightings) and dredging (43 sightings) galamsey operations. The abandoned shaft galamsey were observed mostly in the Tarkwa Nsuaem municipality (10 sightings), Bibiani-Anwhiase-Bekwai (6 sightings) and Prestea Huni-Valley (6 sightings) district assemblies due to their historical associations with large scale underground operations.

In terms of their organization, the alluvial washing board, chamfi and underground sample pit are respectively the three main operations usually found in clusters or having more than one operation on the same piece of land. These operations are commercially driven and are testaments of the high intensity involved the clustered operations recorded. The most stand-alone operation is that of the mill-house galamsey. In terms of the their activity statuses, the three galamsey operations mostly abandoned or having a high site abandonment rate are those practiced mostly for high profit margins or commercially purposes, and include the alluvial washing board, mill house and underground sample pit. The factors that tend to drive galamsey operators away from their activities or lead to their closure (either permanent or temporarily) include high rainfall and flooding events, ore shortages, low gold price, intensified security patrol programs.

Alluvial dredging galamsey was found to be very popular in the Tarkwa Nsuaem, Wassa East and Prestea Huni Vally districts, mostly along the channel of the Bonsa River, Ankobra River and their numerous tributaries including Buri, Anoni, Sumin, Ayiasu, Huni, Oppon, Bogo, Peme, Subri, Bonsa and Mansi. The Ankobra River is also dredged heavily by illegal miners and has left large sections of the water very turbid. See **Table 5** and **figures 11-17** for details.

Table 4: Summary table showing galamsey operational types and their respective distributions (sightings) across the 11 MDAs

Host MDAs	GALAMSEY TYPES/NUMBER OF SIGHTINGS MADE									
	AWB	AWP	ANW	CHAM	D&W	MH	R/S DREDG	UOAS	USP	Total (Sightings)
Amenfi Central	*36*			*7*	*7*	*3*			*7*	**60**
Amenfi East	*109*	*9*	*5*	*61*	*15*	*15*			*9*	**223**
Amenfi West	*34*		*1*	*1*	*1*	*1*				**38**
Bibiani-A-Bekwai	*29*	*2*				*12*		*6*	*5*	**54**
Ellembele				*5*	*1*					**6**
Mpohor				*9*	*2*	*1*	*1*		*3*	**16**
Nzema East				*5*	*1*					**6**
Prestea-H-Valley	*6*	*3*		*29*	*12*	*67*		*6*	*30*	**153**
Sefwi Wiawso	*2*					*2*				**4**
Tarkwa Nsuaem	*7*	*3*	*5*	*34*	*25*	*111*	*38*	*10*	*43*	**276**
Wassa East	*11*	*1*	*10*			*4*	*4*		*2*	**32**
Total (sightings)	**234**	**18**	**21**	**152**	**64**	**216**	**43**	**22**	**98**	**868**

Chamfi=Chamfi; AWP=Alluvial Washing Plant; MH=Mill House; R/S Dredg=River/Stream Dredging; USP=Underground Sample Pit/Hole; AUS/T=Abandoned Underground Shafts/Tunnels; AWB=Alluvial Washing Board; ANW=Anwona; D&G=Dig and Wash

Table 5: summary table showing galamsey operational types and their respective distributions (individual operations within cluster sightings) across the 11 MDAs

DISTRICTS	TYPES OF GALAMSEY/INDIVIDUALS WITHIN CLUSTERS									
	AWB	AWP	ANW	CHAM	D&W	MH	R/S DRED	UOAS	USP	Grand Total
Amenfi Central	104			92	43	6			382	**627**
Amenfi East	374	32	14	703	105	21			148	**1397**
Amenfi West	151		1	18	15	3				**188**
Bibiani Anhwiaso Bekwai	95	6				12		6	25	**144**
Ellembele				25	4					**29**
Mpohor				52	11	1	1		25	**90**
Nzema East				16	4					**20**
Prestea Huni Valley	25	9		254	78	83		9	656	**1114**
Sefwi Wiawso	2					2				**4**
Tarkwa Nsuaem	63	6	46	583	173	155	162	15	2425	**3628**
Wassa East	23	1	55			4	13		40	**136**
Grand Total	**837**	**54**	**116**	**1743**	**433**	**287**	**176**	**30**	**3701**	**7377**

Chamfi=Chamfi; AWP=Alluvial Washing Plant; MH=Mill House; R/S Dredg=River/Stream Dredging; USP=Underground Sample Pit/Hole; AUS/T=Abandoned Underground Shafts/Tunnels; AWB=Alluvial Washing Board; ANW=Anwona; D&G=Dig and Wash

Table 6: Summary table showing galamsey operational types and their respective operational statuses (activeness and abandonments) across the 11 MDAs

	abandoned/inactive		**active**		**semi active**		**Total Sightings**	**Totals within cluster**
Types of Galamsey	**Sightings made**	**Clusters**	**Sightings made**	**Clusters**	**Sightings made**	**Clusters**		
alluvial washing board	89	289	143	528	2	20	234	837
alluvial washing plant	4	8	14	46			18	54
anwona	5	24	16	92			21	116
chamfi	16	230	125	1469	11	44	152	1743
dig and wash	17	108	44	310	3	15	64	433
mill/processing house	37	49	161	219	18	19	216	287
river/stream dredging	3	25	33	135	7	16	43	176
underground old abandoned shaft	1	1	21	29			22	30
underground sample pit	23	1111	71	2124	4	466	98	3701
Grand Total	**195**	**1845**	**628**	**4952**	**45**	**580**	**868**	**7377**

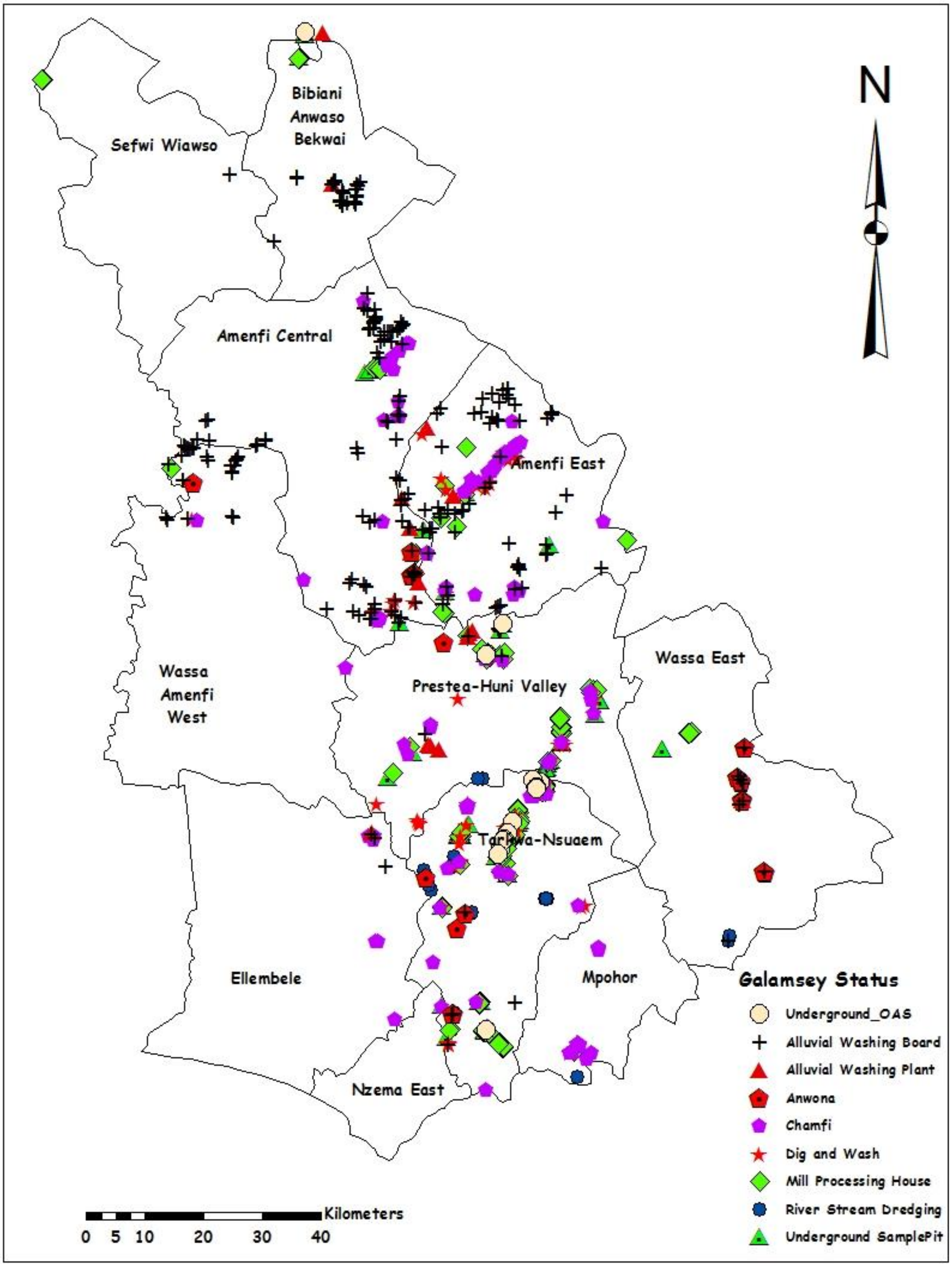


Figure 11: Distribution of galamsey types across the 11 selected Districts

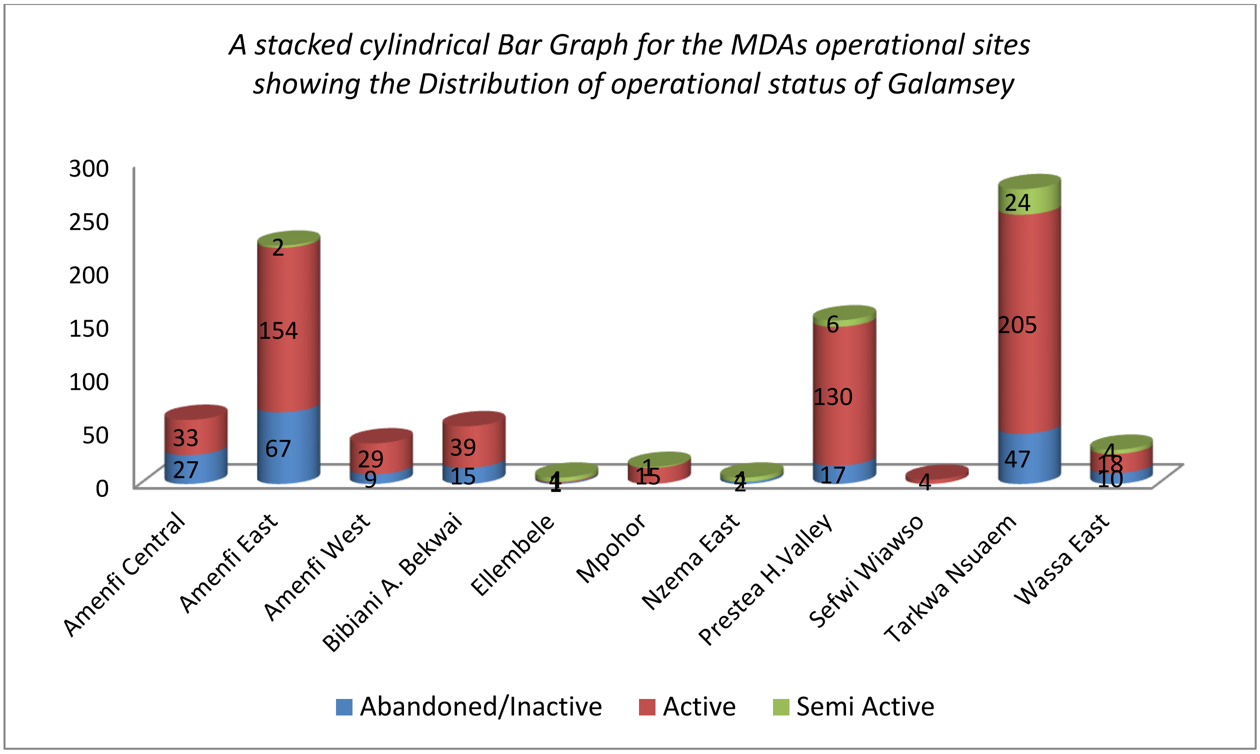


Figure 12: Operational statuses of galamsey across the selected MDAs

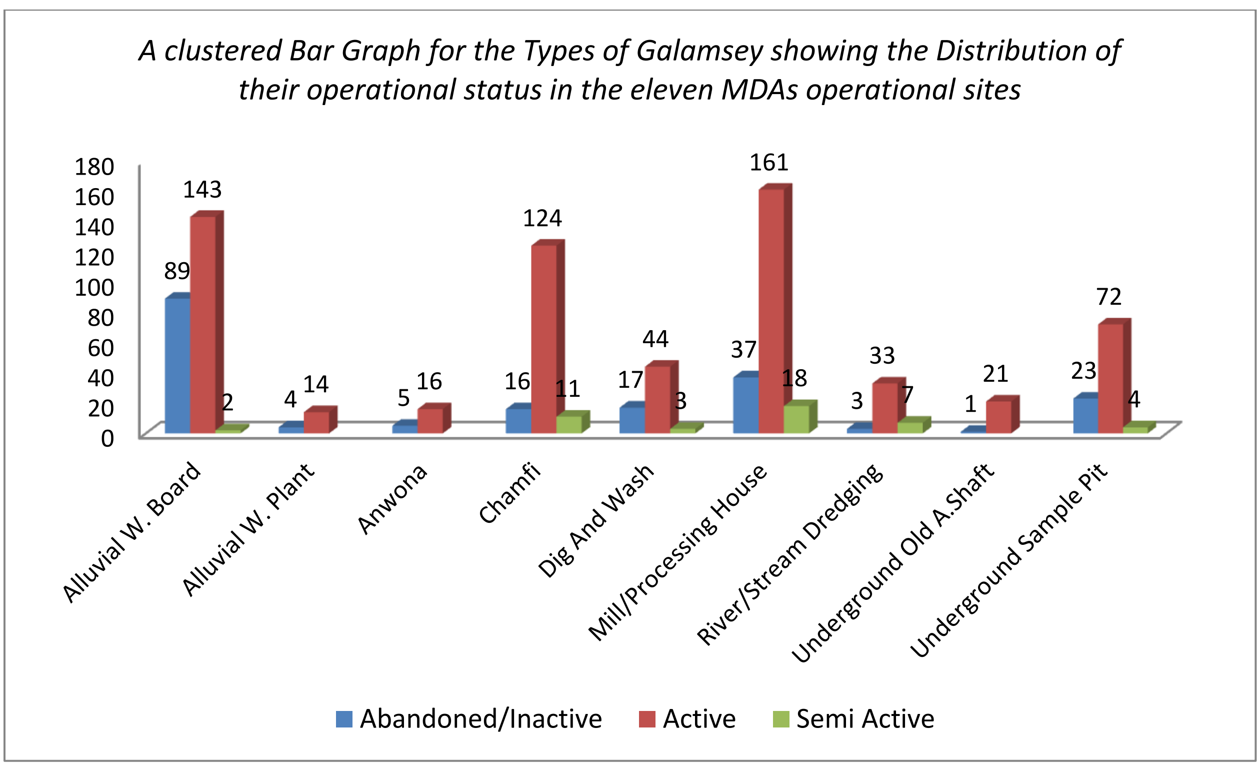


Figure 13: Operational statuses relative to types of galamsey across the selected MDAs

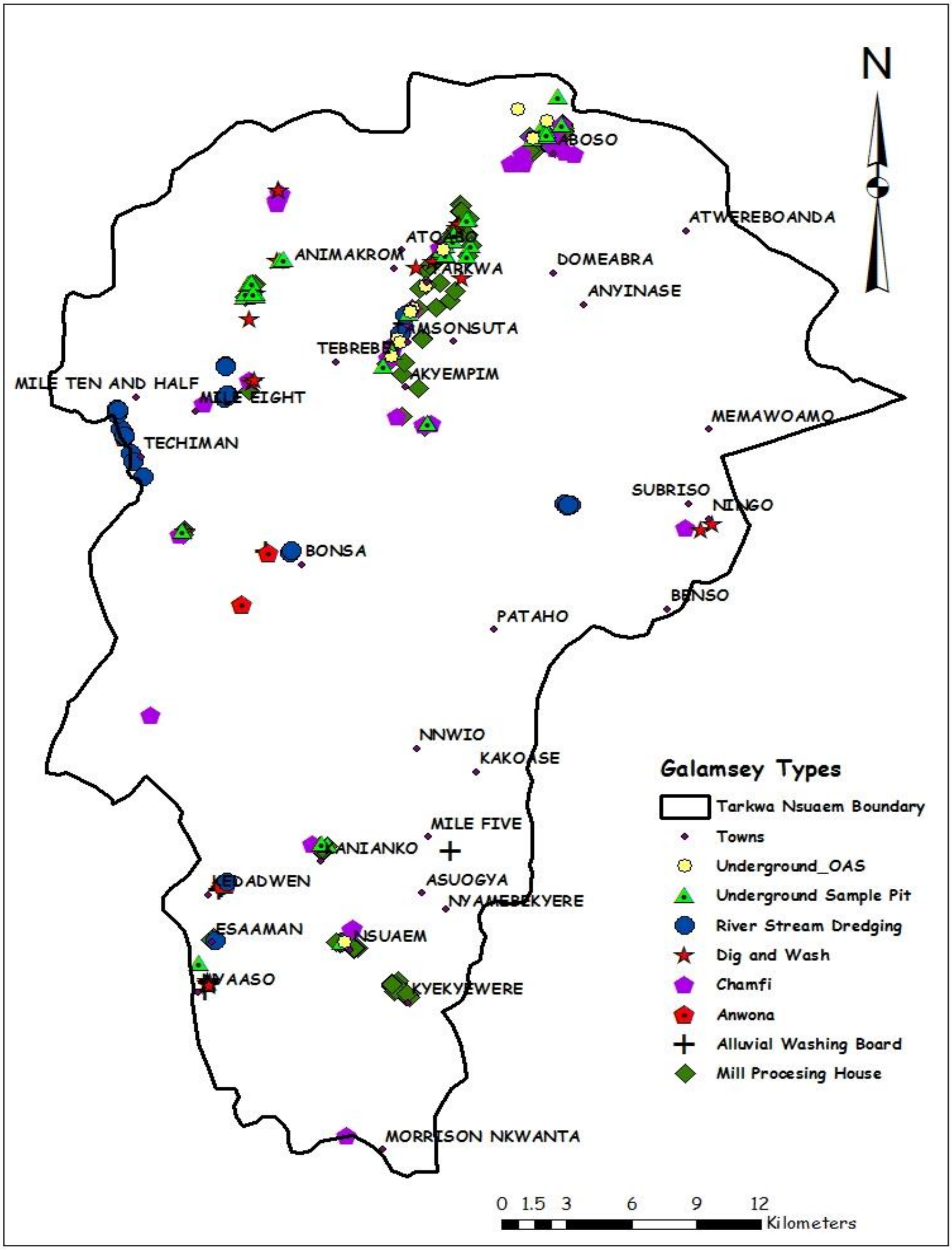


Figure 14: Distribution of galamsey types within the ***Tarkwa Nsuaem Municipality***

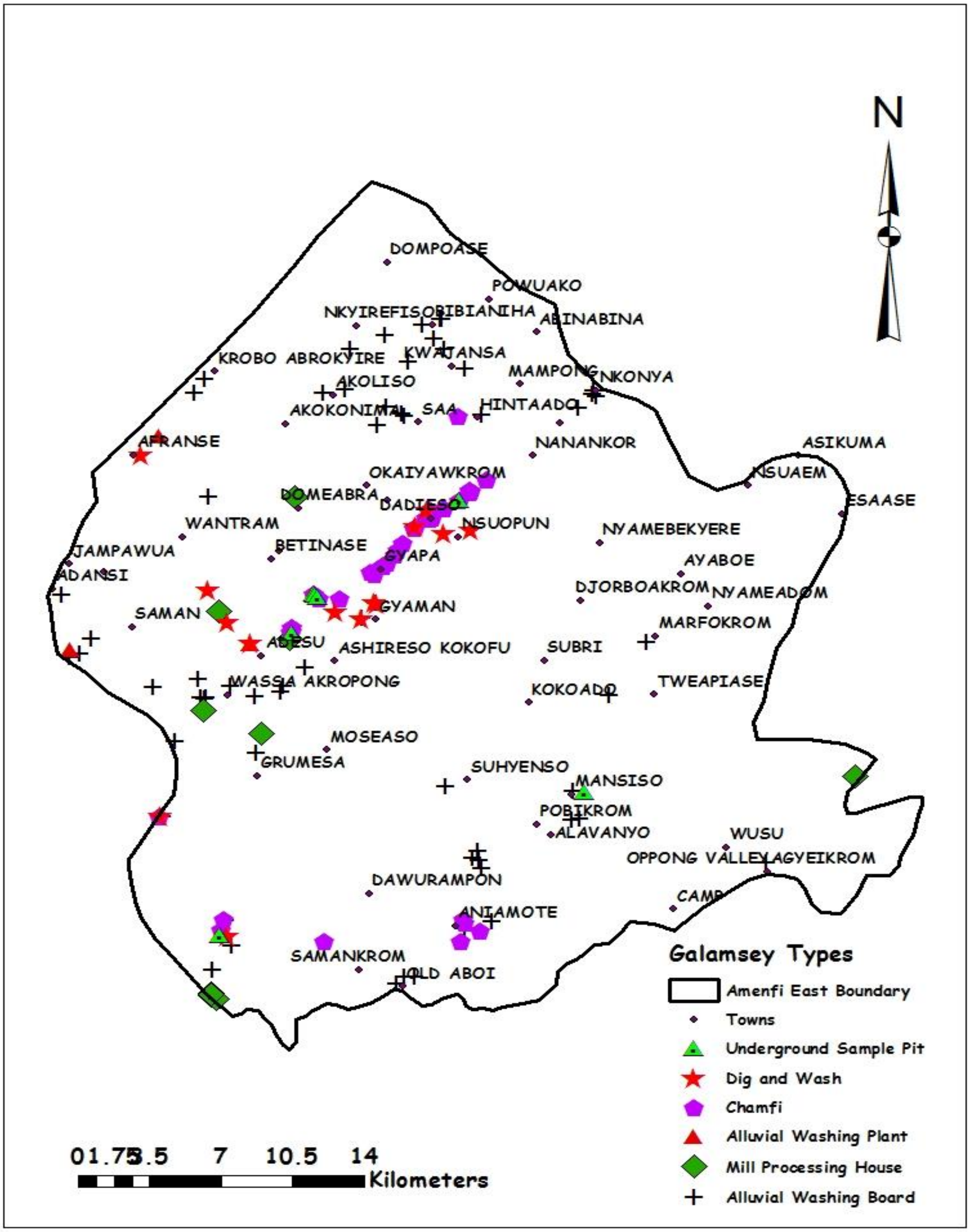


Figure 15: Distribution of galamsey types within the ***Amenfi East District***

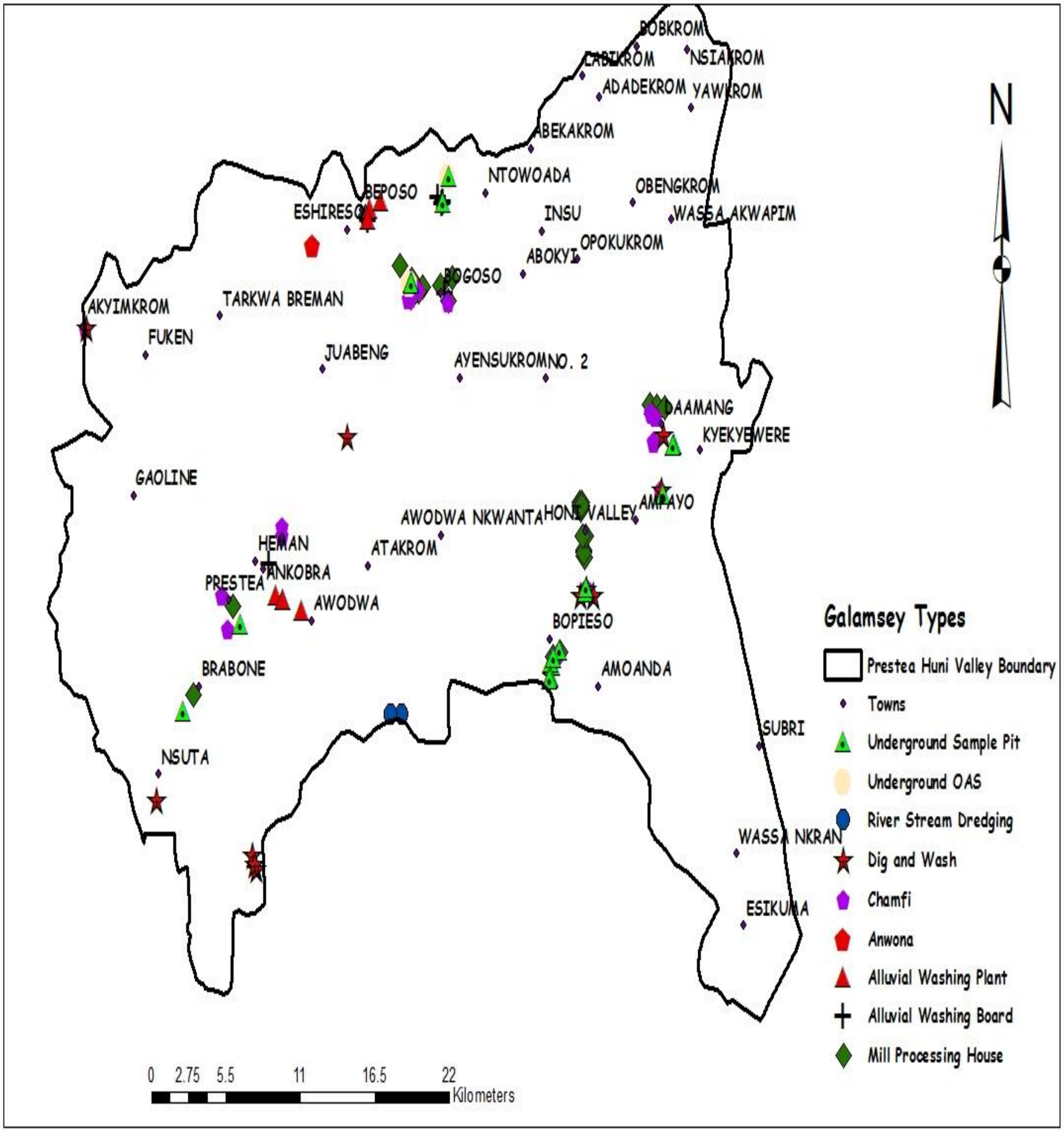


Figure 16: Distribution of galamsey types within the ***Prestea Huni Valley District***

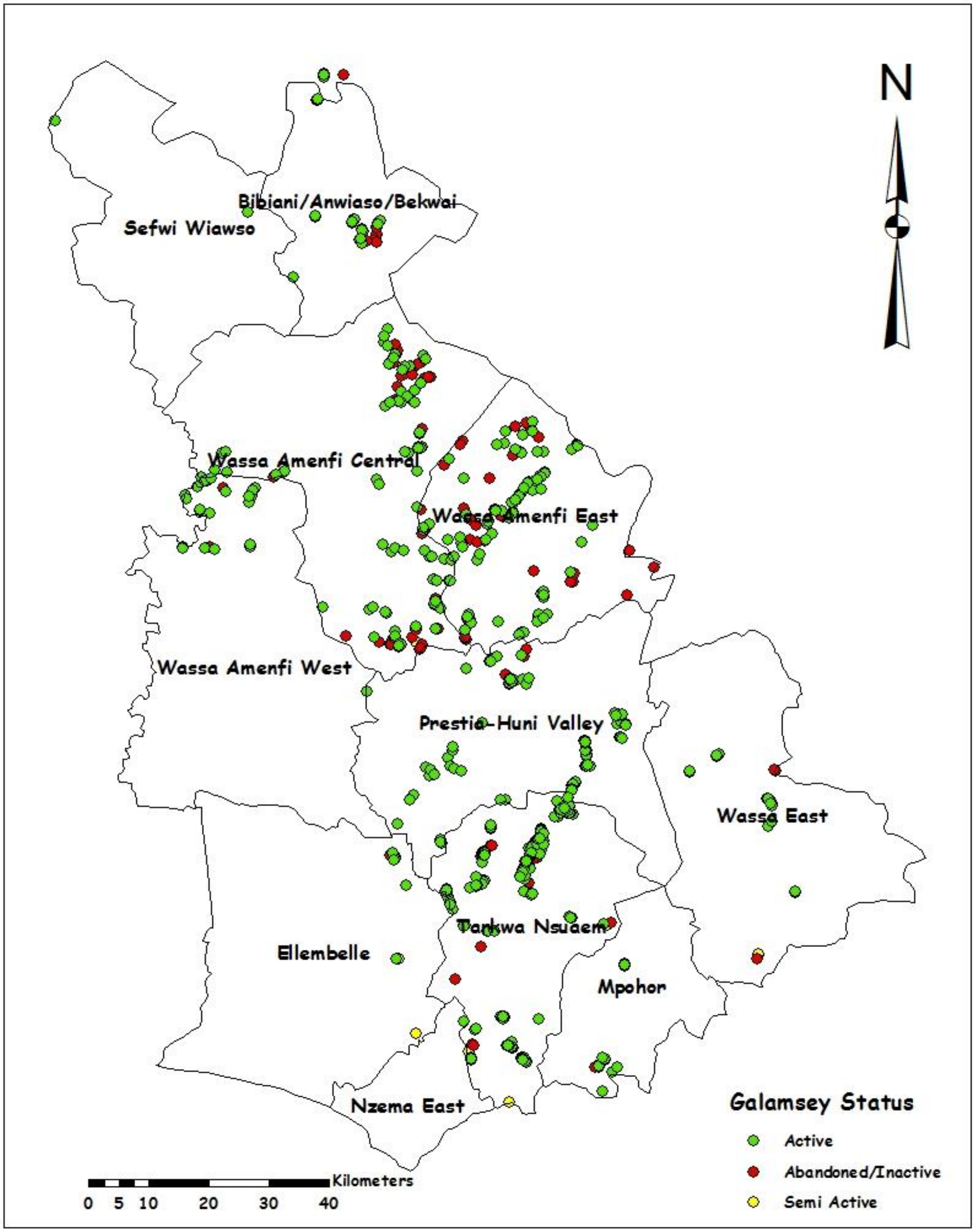


Figure 17: Distribution of the activity statuses of galamsey within the 11 MDAs

Table 7: *Towns and villages hosting galamsey within the 11 selected districts of the Western Region*

Tarkwa Nsuaem	***Amenfi East***	***Bibiani-Anhwia-Bekwai***	***Ellembelle***	***Prestea-Huni Valley***	***Wassa Amefi Central***	***Wassa Amenfi West***	***Wassa East***	***Mpohor***	***Nzema East***	***Sefwi-Wiawso***
Aklika	Abesewa gyaman	Asawinso	Bamiago enyinase	Abosso	Aboum	Aboi Nkwanta	Abetum asu	Anwonak rom	Abeliba	Asawinso
Akyim	Abrehyia	Asempaneye	Eshiem site2	Aboso-Gyante krom	Akyimkrom	Adaase	Daboase	Mpohor	Akanko	Dansokro m
Amantin	Abrokyire krobo	Beposo	Nkroful	Aboso-wassa nkran road	Alavanyo	Afiena	Kakabo	Adum-banso	Awroso	Nsuosua
Awhitieso	Adananso	Bugamso		Ahomkakrom	Atonsu-sunkwa	Amoabeng	Krobo	Norp	Buale	
Badukrom	Adansi	Donkoto Lineso		Amoanda	Ayiemu	Amoaman	Manpon so		Eziose	
Benso	Adesu	Nkatam		Atta ne Atta	Dwabo	Asankragua	Nsadwe so		Gwira	
Bepo akyir	Adiembra	Nkatieso		Awodua	Hiawa	Asankran saa				
Bogoso junction	Adjakuso			Bogoso	Kakaa	Breman				
Bonsaso	Adonoi			Bogoso grade 1	Kongo	Dunkwa				
Bonsawire	Afransie			Bogoso Kojokrom	Manso amenfi	Efiena				
Brahabobom	Afransie Nyamebekyere			Bogoso Kookoase	Nkakaa	Gyaman				
Dompim	Akatrika			Bompieso	Pampe	Krofofrom				
Efuanta	Akoreso			Bumase	Pensanom	Kwabeng				
Efuanta dagati	Akropong			Damang	Slaha	Kwesi pongkrom				
Esaman	Akropong rivers			Densu	Subinho	Moseaso				
Esuoso	Akwadakrom			Huni valley	Wassa bekwai	Oda				
Gold fields-Tarkwa Mines	Amanikrom			King		Oda Anhwiam				
Kedadwen	Anhwiam			Kontaina		Oda Kotoumso				
Kroboline	Aniamote			Kotukrom		Odumase				
Kyekyewere	Ankonsia			Kroboline		Subriso				
Mile	Ankosia			Kumsono		Wassa Dunkwa				
Mile 10.5	Ankwansia			Kwabenaho		Wassa Kwabeng				
Mile 5	Ankwaw-gya			Nsuta nduase		Wassa Saa				
Mile 7	Aserewadi			Nyamebekyere		Woni panyina due				
New atuabo junction tkwa	Asesensu			Odumase						
Nkran	Asikafoanmantem			Pepesa-Ankwahu						
Nkwanta	Asikuma nkatieso			Prestea						

Nsuaem	Asomdwe			Prestea obourho						
Nyanso	Asundua			Prestea-Bumasi						
Old railway quarter	Asuopong			Wioso						
Takyieman	Ataasi									
Tamso	Awonaga									
Tarkwa aba junction	Babianiha									
Tarkwa ackoon top	Bawdie									
Tarkwa Akoon	Bepoh									
Tarkwa Atoabo junction	Bepoh ehyireso									
Tarkwa B junction	Beposo									
Tarkwa Bobobo	Bodie									
Tarkwa Gold fields-Akontansi	Boraso									
Tarkwa Green compound	Bridgeso									
Tarkwa Kamponase	Dadieso									
Tarkwa Main road	Dikoto									
Tarkwa-na-bosso	Domeabra									
Tarkwa New Atoabo	Dompuase									
Tarkwa New Site	Donpim									
Tarkwa RaiI- Ways	Edwumako									
Tarkwa Tamso road	Epom-kokofu									
Tarkwa Teberibie Junction	Esikuma									

Tarkwa UMAT	Esuopong										
Tarkwa-Ackoon	Francis										
Tarsco	Galile										
Tarsco Top	Grumisa										
Tebe	Gyamang										
Teberibie junction	Gyapa										
Teberebie	Hiawa										
Tarkwa Ackoon Gold Fields Access	Hintado										
Tarkwa Bogosu Junctiob	Jadua										
Tarkwa Boobobo	Japa										
Tarkwa Boobobo Top	Jukwa										
Top	Konkonso										
Nyanso	Krofuom										
	KTK										
Old Railway Quarter	Kwajansa										
Takyieman	Kwajansa no 2										
Tamso	Ma										
Tarkwa aba junction	Mahame										
Tarkwa Ackoon Top	Mamieso										
Tarkwa Akoon	Manpong										
Tarkwa Atoabo Junction	Manseso										

Tarkwa-Bogoso Junction	Mansiso									
Tarkwa Borborbor	Mensakrom									
Tarkwa Gold fields-Akontansi	Nananko									
Tarkwa green compound	Nkonya									
Tarkwa Kamponase	Nkyease									
Tarkwa Main Road	Nkyirifi									
Tarkwa new Atoabo	Nsuaem									
Tarkwa new site	Ntwintwina									
	Nyame adom									
	Old aboi									
	Oppong valley									
	Oppongkrom									
	Powuako									
	Priciso									
	Rubber site									
	Saamang									
	Subriso									
	Suhyenso									
	Wantram									
	Wassa Kumasi									
	Wassa Saa									
	Wawase									

2.5 The Data Gathering Framework

Summarized in figure 2 is the framework used for establishing the spatial distribution pattern of galamsey in the 11 selected districts. It involved two distinct phases: Planning and Preparatory Phase and Field Data Collection Phase.

The data collection form or questionnaire was developed with Microsoft Excel in a unique syntax called "xls", using a prescribed set of logical commands, to make them compatible with the ODK application and programmed or saved directly to an Android based smartphones **[34-35, 36, 37-38]**. These commands together with other features enable flexibilities and restraints such as: skipping sets of questions that may apply for one respondent but not for another; multiple or single selection of options, registering time period over which a form is administered, restraining entry of certain unspecified or mistyped responses, editing completed forms, validating entries, and crosschecking for miscalculated entries. All these contribute to minimizing errors in entries and reducing the time and effort spent in manual data entry, cleaning and validation **[39, 40].**

ODK Aggregate, the software that powers the internet server, is hosted on the campus of Kwame Nkrumah University of Sciences and Technology-School of Civil engineering precisely (KNUST). It is a repository for blank forms (designs) and completed forms (data). ODK Collect is the application that runs on the device, and users interact with it to complete the survey. It is essentially a user interface for XForms. It can download blank forms (designs) from an ODK Aggregate server, and upload completed forms (data) to the Aggregate server as well. ODK Briefcase is the software that downloads completed forms (data) from the Aggregate server and converts them into CSV (spreadsheet) format **[37, 38]**.

Development of health and safety plan prior to conducting the fieldwork was observed to ensure the safety of the investigation team, considering the hazardous nature of galamsey sites and operators. In order not to appear too different from the galamseyers (and attract too much attention), Personal Protective Equipment (PPE) requirement was limited to safety boot. Wearing helmets, goggles and gloves would make one stand-out among galamseyers and were therefore not considered **[4].**

The need for a safer transport system, eating healthy and hygienic food, conducting mini risk assessments to identify potential hazards on the field and drinking safer potable waters was stressed and adhered to. The availability of digital cameras, external hard drive (data storage drive), a dedicated laptop, stationeries and Android Mobile Phones with ODK systems were crucial to the success of the entire investigation.

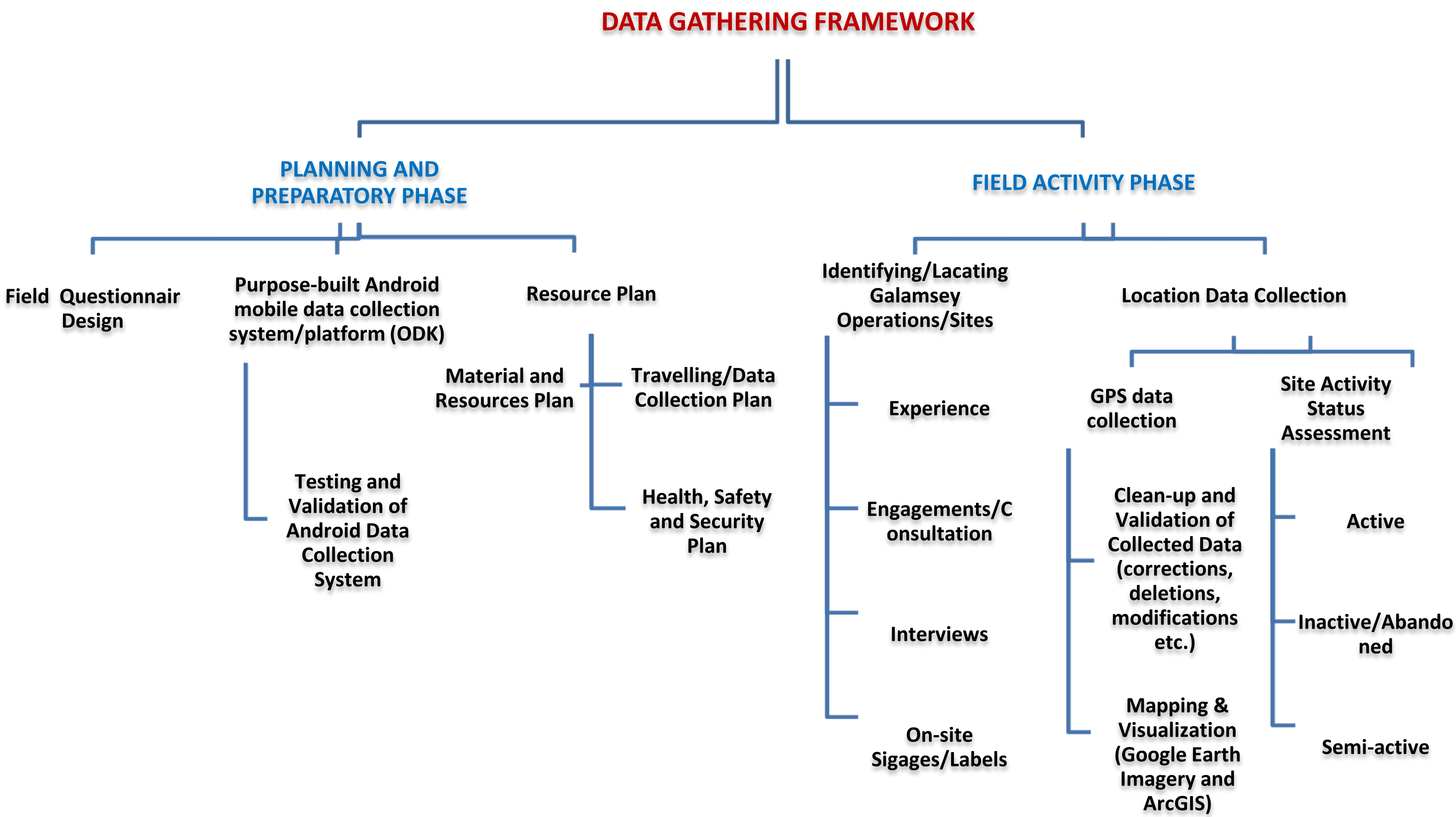


Figure 18: Summary of data collection framework

2.6 Land Area Estimation for closure liability estimation

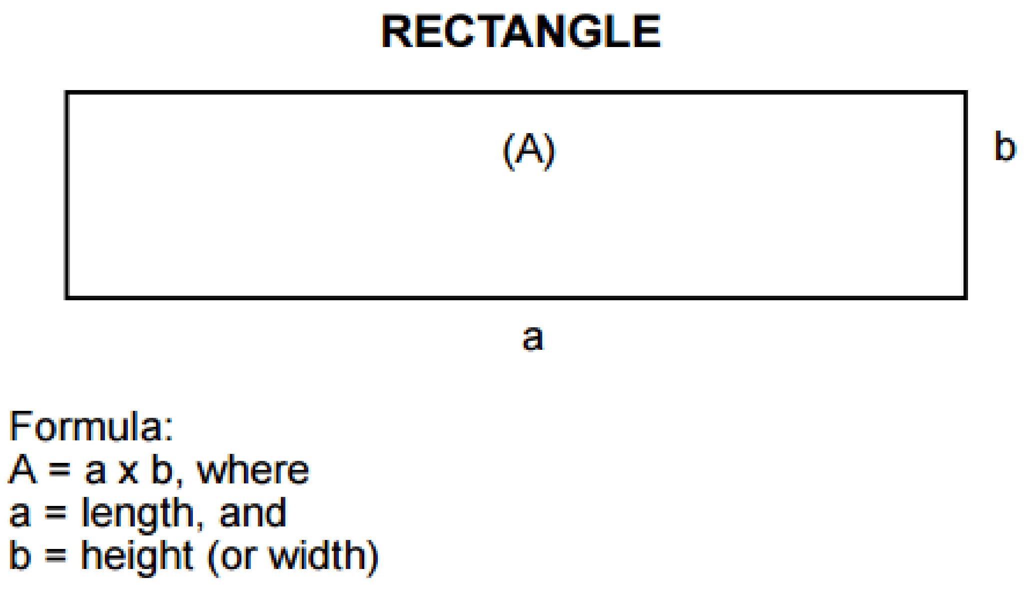
How permission is gained and who to contact at a galamsey site is very key to the success of the investigations and had to be done is a cunning manner to avoid failures. It was ensured that traditional and socio-cultural conditions within visited sites are respected and adhered to. Constraints such as religious, cultural days or superstitious data (Fridays, Sundays or adiim etc.), taboos, national days (including Independence Day celebrations, etc.) or specific weather conditions (seasons) were all noted and observed **[4]**. Due to the violent and radical nature of some galamseyers, it is possible to encounter a number of security risks when undertaking the study and was prepared to anticipate in advance and circumvent any potential security pitfalls **[41, 9].**

The enumerators used in this study were mostly locals, including females, from the various galamsey communities with some level of experience in galamsey and appreciable level of education. They were trained on how to use ODK Collect on the phones and how to download new surveys from ODK Aggregate while in the field. Given the widespread familiarity with mobile phones in developing countries **[42, 43],** the enumerators were quickly able to navigate the phones and within only a few trials they had cut in half the time required to conduct interviews or gather data.

Where entry permission is received, galamsey operators were asked questions concerning their personal and site histories, type of operation, activity status, and resource use inventory and land size estimation made. One questionnaire took approximately 5-10 minutes to complete. Where limited or no entry access is granted, it was still possible to rapidly estimate land size visually and collate core information needed from the peripheries of the site and from inhabitants of the community and engaged locals.

In estimating the footprint (area) of the galamsey operation, it was ensured that where related or similar types of operations of galamsey (e.g. all sample holes/pits) are found to be concentrated or clustered at a particular area (often separated by a few meters or so), the estimate is done for the entire site and the total number within the clusters recorded. However, in situations where galamsey operations are positioned apart, say approximately 100m and above, their land sizes are estimated individually, irrespective of their operational differences or similarities. Site activity status, be it active, semi-active or abandoned, information was also gathered.

Surveying irregular and large land tracts can be done by various methods. While some methods are simple and based on basic geometry, others are complex and may involve GPS, satellite imagery, using maps and planimeter, GPS, Aerial photography, using Google earth, using maps and graphs,. The method employed the use of a simple visual estimation, assuming all affected sites are rectangular in shape.



Shape area is estimated by simply measuring the length and width of the affected lands in meters. Multiply the length times the width to get the square meters of surface area. This value was converted to acres by dividing by xxx and kilometer square by xxx. On abandoned galamsey sites, the lengths and breadths of affected sites were obtained by pacing (where possible).

By the use of dip sticks, the pond, pits and river depths were estimated across all the sites for volume calculations. An average depth of 10m was estimated for all pits and dredging ponds encountered. The volume of water in the pits and ponds (in cubic meters) was calculated by simply multiplying the pond area (in square meters) by the average pond depth in meters.

The data collection was done in two phases; phase one was done over a 10 month period, starting from mid December 2014 to end of October 2015, to extensively gather position data within the eleven (11) selected districts. A mop-up exercise and data processing was thereafter carried out until the end of April 2016 to ensure operations that fell on the 'blind side" of the first exercise or perhaps due to access restriction was picked up (where possible).

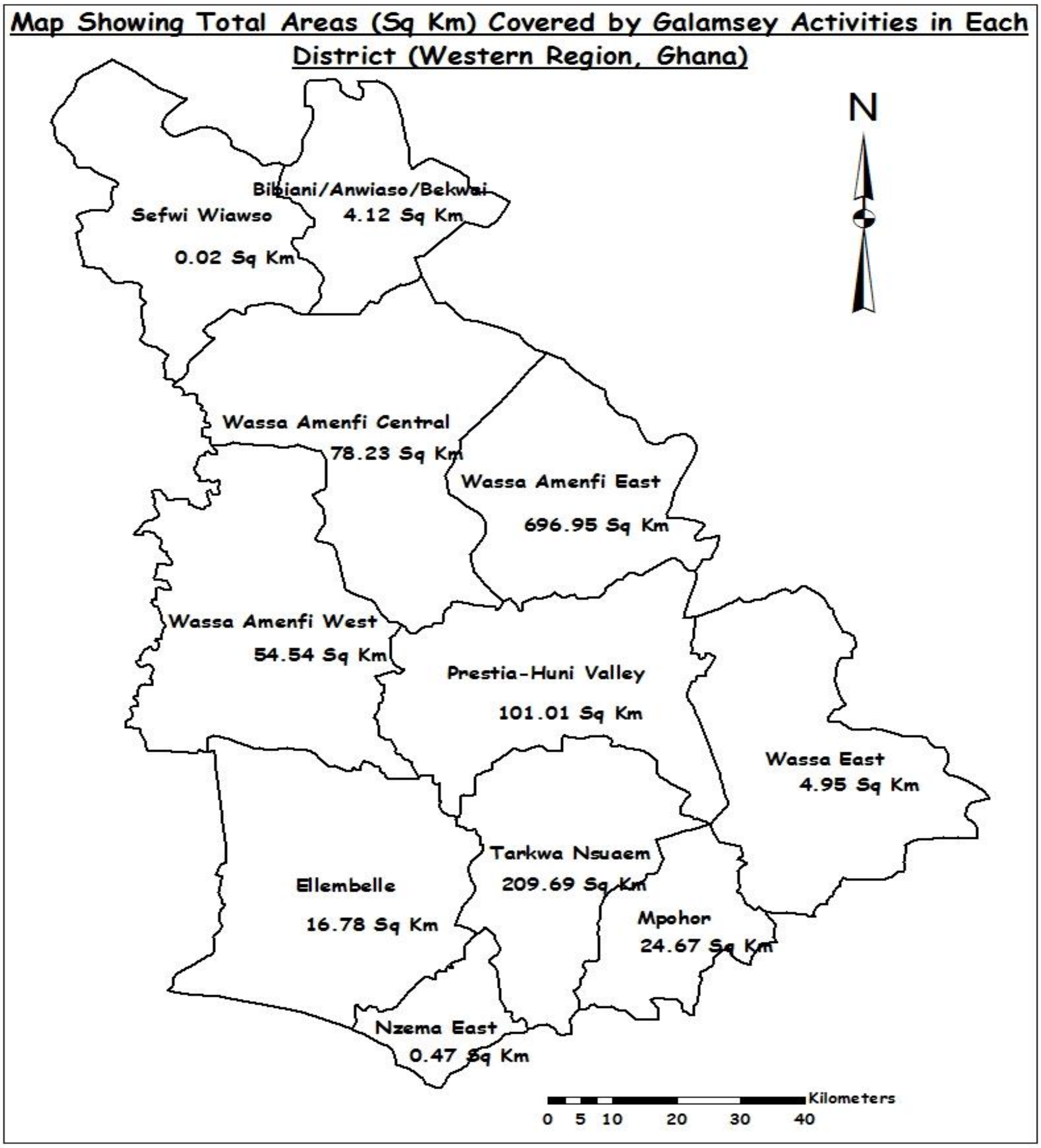


Figure 19: Estimated footprint of the 9 galamsey types within the 11 selected MDAs

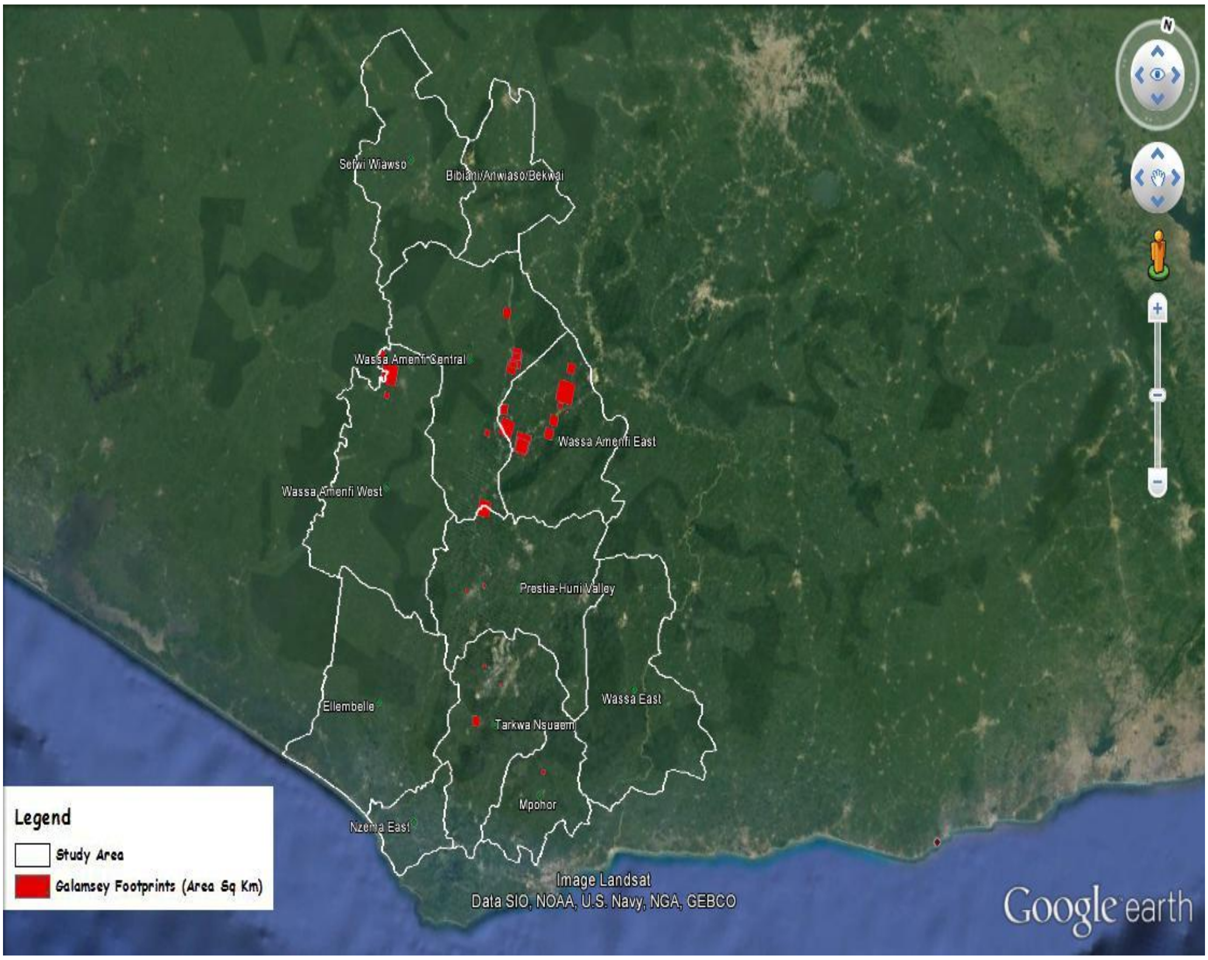


Figure 22: Visualization and validation of estimated land sizes on Google Earth Imagery

2.6.1 Land-take Trend per MDAs

Per Table 8, the three most impacted districts, in terms of land-take or operational footprint, are the Amenfi East (58.272%), Tarkwa Nsuaem (17.532%) and Prestea Huni Valley (8.452%). This is due to the fact that these districts host the highest percentage of chamfi and alluvial (washing board) operations, which generally requires a large area of land to profitably operate.

Although the Tarkwa Nsuaem (276 sightings with approximately 3,628 individuals), Amenfi East (223 sightings and 1,397 individuals) and Prestea Huni-Valley Districts (153 sightings and 1,114 individuals) were earlier on noted as the three main galamsey hotspots, their land-take information did not follow the same pattern. Generally, underground and mill house operations have very limited land sizes compared to the chamfi and alluvial washing board; hence the footprint trends recorded in **Tables 8-12 and figure 19**. The Sefwi Wiawso (0.002%), Bibiani-Anhwiaso-Bekwai (0.344%), Wassa East (0.414%) and Nzema East Districts (0.416%) are the four MDAs least proliferated by galamsey operators.

Table 8: estimated footprint of galamsey operations across the 11 MDAs

MDAs	Total footprint of MDA	Land-take for galamsey operation		Percentages	
	Area (sq.km)	Area (Ha)	Area (sq.km)	% (galamsey)	% (in relation
Amenfi Central	1,845.9	7,822.52	78.23	**6.540**	4.24
Amenfi East	1,558.0	69,695.33	696.95	**58.272**	44.73
Amenfi West	1,448.56	5,454.23	54.54	**4.560**	3.77
Bibiani Anhwiaso Bekwai	833.7	412.03	4.12	0.344	0.49
Ellembelle	995.8	1,678.00	16.78	1.403	1.69
Mpohor	524.533	2,467.46	24.67	2.063	4.70
Nzema East	1084.0	498.00	4.98	0.416	0.46
Prestea Huni Valley	1,809.0	10,108.92	101.09	**8.452**	5.59
Sefwi Wiawso	1,101.6	2.29	0.02	0.002	0.00
Tarkwa Nsuaem	905.2	20,968.87	209.69	**17.532**	23.17
Wassa East	1,651.9	495.35	4.95	0.414	0.30
Grand Total	**13,758.29**	**119,603.00**	**1,196.03**	**100.000**	**100.000**

2.6.2 Land-take Trend per Operations

The chamfi (45.47%), alluvial washing board (43.4%) and river/stream dredging (4.94%) galamsey are the three operations with most extensive footprint. According to Mantey et al., 2016, the chamfi and alluvial washing board galamsey are only next to the underground sample pit as the galamsey types with the highest number of individuals within clusters. The chamfi operation, having the third highest number of sightings made and second highest number of individuals within clusters (sightings), operates using the Chan Fa engine for simultaneous mining and gold extraction. It has since its introduction over a decade ago in Ghana by the Chinese enjoyed much popularity among galamsey operators. It requires a small parcel of gold-laden land and a relatively low start-up cost. It is a highly efficient, easy to use, mobile or potable and can handle both alluvial and lode/vein deposits with ease. The low feeding rate or loading capacity is compensated for by having many set-ups per an area; thus having them in clusters. See **Tables 8-12 and figure 19** for details.

Table 9: estimated footprint of the 9 galamsey operational types across the 11 MDAs

Types of Galamsey	Area (Hac)	Area (sq.km)	%
Alluvial washing board	51,909.66	519.10	**43.40**
Alluvial washing plant	1,275.71	12.76	1.07
Anwona	144.33	1.44	0.12
Chamfi	54,380.00	543.80	**45.47**
Dig and wash	3,270.15	32.70	2.73
Mill/processing house	245.10	2.45	0.20
River/stream dredging	5,912.00	59.12	4.94
Underground old abandoned shaft	104.40	1.04	0.09
Underground sample pit	2,361.65	23.62	1.97
Grand Total	**119,603.00**	**1,196.03**	**100**

Table 10: Summary table of galamsey operations and their respective footprint across the 11 MDAs

	AWB			AWP			Anwona			Chamfi			D&W			MH			Dredg.			UAS			USP			Total Area (Ha)	Total cluster Ind.	Total sightings
MDAs	*Area (sq.km)*	*Clustered*	*Sightings*	*Area (sq.km)*	*Clustered*	*Sightings*	*Area (sq.km)*	*Clustered*	*Sightings*	*Area (sq.km)*	*Clustered*	*Sightings*	*Area (sq.km)*	*Clustered*	*Sightings*	*Area (sq.km)*	*Clustered*	*Sightings*	*Area (sq.km)*	*Clustered*	*Sightings*	*Area (sq.km)*	*Clustered*	*Sightings*	*Area (sq.km)*	*Clustered*	*Sightings*			
Amenfi Central	31.29	104	36							43.80	92	7	0.95	43	7	0.01	6	3							2.18	382	7	**7822.52**	**627**	**60**
Amenfi East	428.49	374	109	7.98	32	9	0.24	14	5	234.05	703	61	22.72	105	15	0.02	21	15							3.44	148	9	**69695.33**	**1397**	**223**
Amenfi West	44.16	151	34	0.00			0.03	1	1	10.00	18	1	0.03	15	1	0.32	3	1										**5454.23**	**188**	**38**
Bibiani Anhwiaso Bekwai	3.89	95	29	0.15	6	2										0.06	12	12				0.007	6	6	0.02	25	5	**412.03**	**144**	**54**
Ellembele										16.70	25	5	0.08	4	1													**1678.00**	**29**	**6**
Mpohor										20.82	52	9	0.53	11	2		1	1	3	1	1				0.32	25	3	**2467.46**	**90**	**16**
Nzema East										4.63	16	5	0.35	4	1													**498.00**	**20**	**6**
Prestea Huni Valley	4.17	25	6	3.16	9	3				85.17	254	29	2.61	78	12	0.17	83	67				0.530	9	6	5.28	656	30	**10108.92**	**1114**	**153**
Sefwi Wiawso	0.01	2	2													0.01	2	2										**2.29**	**4**	**4**
Tarkwa Nsuaem	6.75	63	7	1.46	6	3	0.71	46	5	128.63	583	35	5.42	173	25	1.86	155	111	52.74	162	38	0.507	15	10	11.61	2425	42	**20968.87**	**3628**	**276**
Wassa East	0.34	23	11	0.01	1	1	0.46	55	10				0.00			0.01	4	4	3.38	13	4				0.76	40	2	**495.35**	**136**	**32**
Grand Total	**519.10**	**837.00**	**234.00**	**12.76**	**54.00**	**18.00**	**1.44**	**116.00**	**21.00**	**543.80**	**1,743.00**	**152.00**	**32.70**	**433.00**	**64.00**	**2.45**	**287.00**	**216.00**	**59.12**	**176.00**	**43.00**	**1.04**	**30.00**	**22.00**	**23.62**	**3,701.00**	**98.00**	**119,603.00**	**7,377.00**	**868.00**

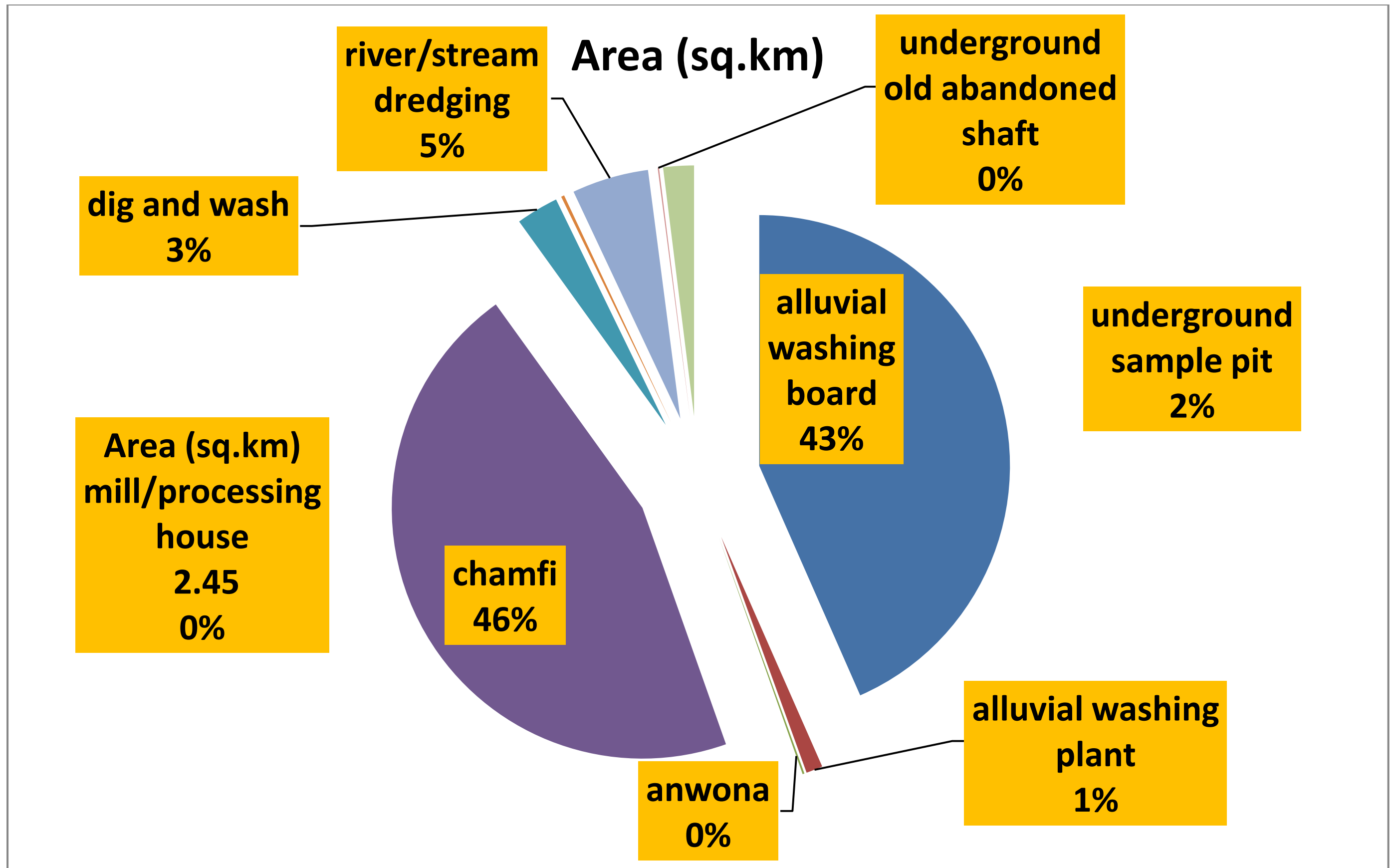


Fig. 23: Footprint (km^2) by galamsey operations in square kilometers

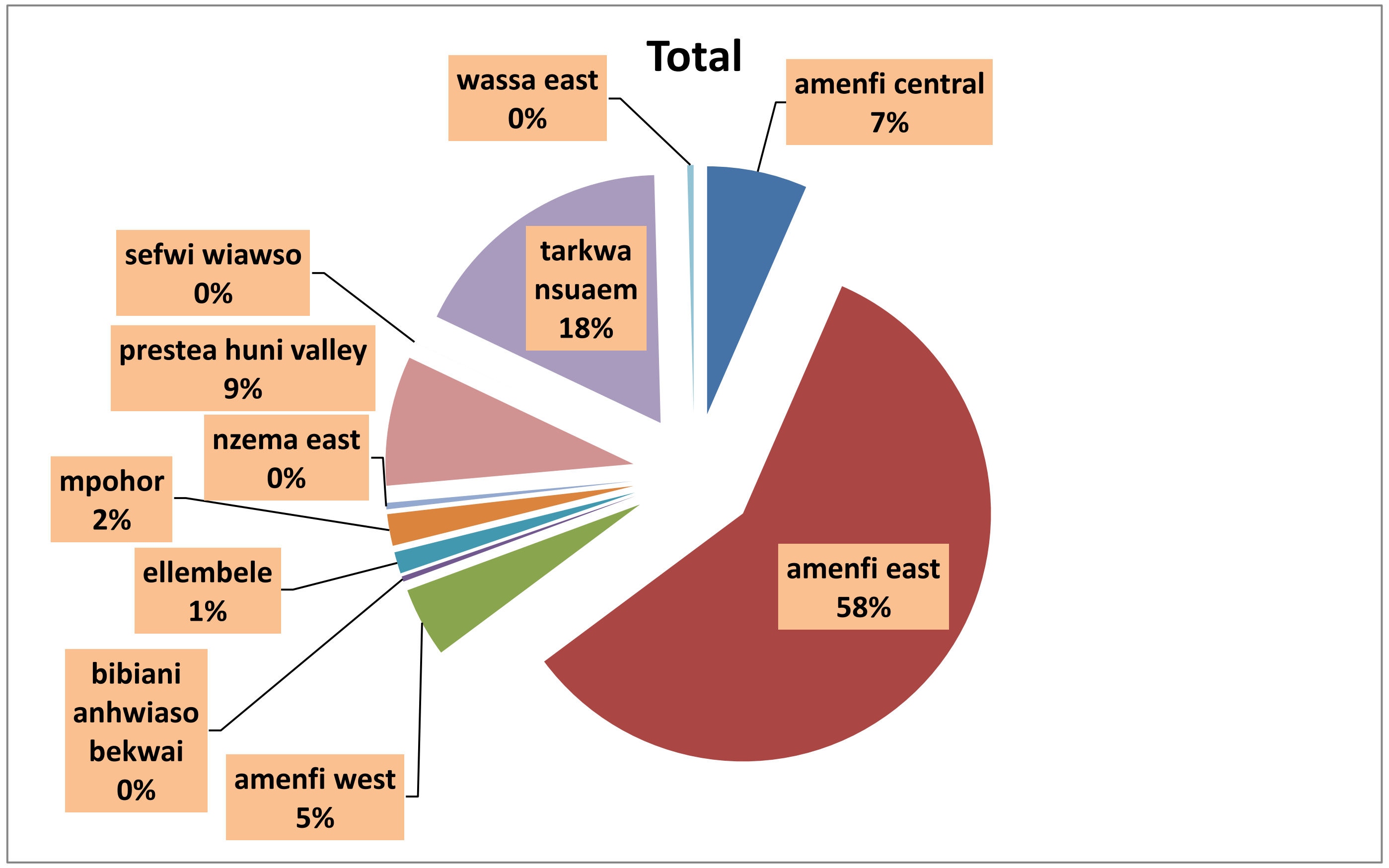


Fig. 24: Footprint of galamsey operations (in square kilometers) within the 11 MDAs

The washing board galamsey is the most sighted and comes after the underground sample pit and chamfi as the operations with highest number of individuals within clusters due to the abundance of alluvial deposits and water bodies across the entire stretch of the Wassa Amenfi East district and some vast portions of the Tarkwa Nsuaem and Prestea Huni Valley districts (which are identified as the three main washing board MDA hotspots). The washing board also represents the most economical way or profitable means of commercially extracting low grade and alluvial deposits. It is the galamsey type most practiced by foreigners, especially the Chinese. It is also very popular within all three Amenfi Districts (East, Central and West) considered due to the very rural certain they present, their alluvial deposits and drainage networks, low level of law enforcement and limited activity of LSMs. With the exception of the Nzema East, Mpohor and Ellembelle, the eight remaining MDAs considered in the research were found to be hosting alluvial washing board galamsey.

Mantey et al [1] explains that, in terms of their organization, the alluvial washing board, chamfi and underground sample pit are respectively the three main operations usually found in clusters or having more than one operation on the same piece of land. These operations are commercially driven and are testaments of the high intensity involved the clustered operations recorded. The most stand-alone operation is that of the mill-house galamsey.

Alluvial dredging galamsey was found to be very popular in the Tarkwa Nsuaem, Wassa East and Prestea Huni Vally districts, mostly along the channel of the Bonsa River, Ankobra River and their numerous tributaries including Buri, Anoni, Sumin, Ayiasu, Huni, Oppon, Bogo, Peme, Subri, Bonsa and Mansi. The Ankobra River is also dredged heavily by illegal miners and has left large sections of the water very turbid; hence the relatively large footprint occupied by this type of galamsey.

Table 11: Estimated footprints of galamsey operations within the 11 MDAs

MDAs	**Total footprint of MDA**	**Land-take for galamsey operation**		**Percentages**	
	Area (sq.km)	**Area (Ha)**	**Area (sq.km)**	**% (galamsey)**	**% (in relation to overall MDA size)**
Amenfi Central	1,845.90	7,822.52	78.23	**6.54**	4.24
Amenfi East	1,558.00	69,695.33	696.95	**58.272**	44.73
Amenfi West	1,448.56	5,454.23	54.54	**4.56**	3.77
Bibiani Anhwiaso Bekwai	833.7	412.03	4.12	0.344	0.49
Ellembelle	995.8	1,678.00	16.78	1.403	1.69
Mpohor	524.533	2,467.46	24.67	2.063	4.7
Nzema East	1084	498	4.98	0.416	0.46
Prestea Huni Valley	1,809.00	10,108.92	101.09	**8.452**	5.59
Sefwi Wiawso	1,101.60	2.29	0.02	0.002	0
Tarkwa Nsuaem	905.2	20,968.87	209.69	**17.532**	23.17
Wassa East	1,651.90	495.35	4.95	0.414	0.3
Grand Total	**13,758.29**	**119,603.00**	**1,196.03**	**100**	**100**

Table 12: Estimated footprints of galamsey operations

Types of Galamsey	**Area (Hac)**	**Area (sq.km)**	**%**
Alluvial washing board	51,909.66	519.1	**43.4**
Alluvial washing plant	1,275.71	12.76	1.07
Anwona	144.33	1.44	0.12

Chamfi	54,380.00	543.8	**45.47**
Dig and wash	3,270.15	32.7	2.73
Mill/processing house	245.1	2.45	0.2
River/stream dredging	5,912.00	59.12	4.94
Underground old abandoned shaft	104.4	1.04	0.09
Underground sample pit	2,361.65	23.62	1.97
Grand Total	**119,603.00**	**1,196.03**	**100**

2.7 Geochemical Characterization or site investigation of galamsey sites

This section present an extract of the attached paper entitled "Assessing the levels of water and soil contaminants across the various operational forms of galamsey within selected hotspot districts of the Western Region, Ghana". It present an overview of the levels of contaminants across the various galamsey types encountered in the 11 MDAs.

Studies were carried out within the three galamsey hotspot districts assemblies to ascertain the levels or extent of geochemical and radiological contaminations for the nine main types of galamsey operations encountered within the Western Region of Ghana. Geochemical analysis involved the physico-chemical examination of surface waters, determination of the metal, naturally occurring radioactive materials (NORMs) and oil and grease concentrations in soils, slurry/sludge and mine wastes from two randomly selected host sites across the selected districts.

The levels of physico-chemical parameters for water samples were generally below the Ghana EPA Effluent discharge guideline, except for pH, Ammonia as N, Turbidity and total suspended solids where exceedances were recorded. The average and ranges of values obtained for Total Dissolved Solids (33-607mg/kg), Conductivity (51-905), Dissolved Oxygen (6.9-9.5), Nitrite as NO2- (<0.001-0.579), Nitrate as NO3- (0.1-0.258), Phosphate as PO43- (0.01-0.45), chloride (4.3-130.5), Sulphate as SO_4^{2-}, the cyanide species (free, WAD and Total) were all below the EPA threshold and recorded no exceedances for all the sampling sites investigated.

The pH readings for the various galamsey types generally ranged from 4.81-8.15. With the exception of slightly acidic levels recorded at Boppoh (5.10 and 5.39-alluvial washing plant operation), Gyapa (5.24 and 5.94-Chamfi) and Esikuma (4.81 and 5.76 - Dig and wash operation), all other values obtained were well within the Ghana EPA effluent discharge guide of 6-9. With the exception of results obtained for the reference samples (8.0-29.0) and those from the underground abandoned shaft galamsey sites (**44-67**), elevated levels of Turbidity and total suspended solids were recorded for all the eight remaining types of galamsey investigated, generally ranging between 8.0-87,800.0. The levels of Ammonia as N generally ranged from 0.02- 5.69 and compared to Ghana EPA's standard of 1.0, there were exceedance in chamfi at Gyapa (1.01 and 3.12), dig and wash at Kedadwen and Esikuma (1.74, 1.06 and 1.04), underground abandoned shaft at Tarkwa Tarsco Top (5.15 and 5.69) and mill house at both Green Compound and Bogoso Junction operational sites (5.20, 5.20, 5.20 and 4.94).

Oil & Grease values recorded for surface water samples ranged from 2.0 to 35,564mg/L. Exceedance in the following galamsey types were recorded: anwona (11,462.5-16,717 mg/L), chamfi (10452-24211 mg/L), washing board (11850-35564 mg/L) washing plant (10315-12325 mg/L) and mill house (12850-15564 mg/L) were recorded. There were no exceedances for the reference samples, underground sample pit, abandoned shafts, dig and wash and dredging galamsey types.

With the exception of mercury and arsenic, no exceedances were recorded for all other metals considered at the 9 galamsey types studied. Sodium (3.93-107.41 mg/L), Chromium (<0.01-0.47 mg/L), Nickel (0.01-0.29 mg/L), Copper (0.01-0.74 mg/L) Zinc (0.01-1.34 mg/L), Cadmium (0.002-0.006), Lead (<0.01-0.17 mg/L) and Arsenic (1-28.6mg/L) recorded no exceedances. With the exception of reference points and the underground sample pit locations where levels of arsenic were generally far below the EPA threshold of 0.5mg/L, the anwona galamsey (1.5-3.8), chamfi (10.1-24.5), dig and wash (1.0-1.7, washing board (2-18.70), Washing plant (1.0-20.2), shaft (1.0-1.6),dredging (1-2.4) and mill house (2.6-28.6) experienced exceedances.

The levels of mercury ranged from 0.004-215.25mg/L. There were exceedance in six out of the nine galamsey operations analyzed except for underground sample pit, abandoned shafts and reference/control points with values all below detection levels of <0.001. The levels recorded for dredging were slightly elevated with an average of 0.005mg/L. The mill house galamsey recorded the highest levels of mercury (149.51-215.25mg/L), followed by chamfi (76.5-88.9 mg/L) and then the alluvial washing board (39.8-55.4 mg/L). The washing plant (16.500-19.30 mg/L) and anwona galamsey (10.3-15.2 mg/L) also followed suit in order which corresponds with their operational intensity, scale and commerciality.

For the soils, slurry and mine wastes, all trace metals considered, except mercury and arsenic, recorded that falls below the IAEA optimum and action levels; thus the average and ranges obtained are within acceptable levels and poses no or limited threats to the environment. Elevated levels of mercury were recorded across slurries, soils and mine wastes sampled for mill house, anwona, chamfi, mill house, alluvial washing board, alluvial washing plant and dig and wash and dredging galamsey types. No exceedance was recorded for control samples, underground sample pit and abandoned shaft operations. The levels of mercury were very high for the very commercial galamsey operations like chamfi, mill house, alluvial washing board and alluvial washing plant; the values recorded for the subsistence operations like dredging and dig and wash galamsey operations only showed slight exceedances.

The Oil and grease levels recorded for the all the galamsey types and at the various sampling stations for soils, slurry and mine wastes were generally found to be below the Wisconsin (US) interim criteria for sediment of 1000ppm.

The radiological analysis of soil, mine waste and slurry matrices was assessed based on direct gamma ray spectrometry to quantify the radionuclides of interest namely; ^{238}U, ^{232}Th and ^{40}K in heap pads/soils and water samples. The activity concentrations of ^{238}U (Ra-226), ^{232}Th and K in all the soil, slurry and mine wastes samples had values below the World Health Organisation (WHO) recommended guideline levels of 10.0 Bql^{-1} for ^{238}U and 1.0 Bql^{-1} for ^{232}Th in drinking water. The values of the hazard indices from the soils, slurry and wastes are less than the ICRP annual effective dose of 1.0 mSv recommended for public exposure control. Human health risk assessment indicated no alarming situation within the study areas.

As a way of summary, the four main pollution concerns requiring attention in galamsey are high TSS or turbidity levels, oil and grease, arsenic and mercury; most especially for the commercially driven alluvial operations and mill house galamsey. The underground operations employ the use of diesel and petrol for water discharges but rarely use mercury since virtually any form of gold extraction takes place at the mining sites. The radiological and chemical analysis of water and soil matrices at the various galamsey sites revealed that the illegal mining and or processing activities have minimally impacted on the soil and surface water resources and does not pose an immediate environmental hazard to the human population, wildlife and the surrounding ecosystem.

2.8 Environmental and resource use inventory

Due to the dynamic and ever-changing nature of the galamsey operation, the approach employed here for the environmental assessment and resource inventory was aimed at rather providing a rapid overview on environmental impacts in the galamseyed area than provide a proper technically extensive analysis of any environmental impact that may occur. Thus, the data gathered was aimed helping readers understand basic environmental impacts in respective galamasey operations and might give guidance on where one need to follow up with more comprehensive environmental research.

The ODK mobile system was very instrumental in the collection of key environmental inventory information for effective interpretation and the costing estimation. Prominent among the solicited information are: Terrain Classification (Ground Condition, Ground Roughness, Slope), machinery and equipment inventory, chemical, water and energy use, waste generation and other environmental inventorying (surface water impacts, soil impacts, ground contaminations, vegetation, wild animals etc.). Table xx provides details on the resource use and environmental inventory questionnaire.

2.9 Stakeholder Consultation and analysis

Informal discussions with local community members, galamsey operators and some opinion leaders revealed that the two most popular end land use preferred most is agricultural and forest land.

2.10 Reclamation Planning and Costing

The key closure issues considered are:

- As soon as practicable the government of Ghana must:
  - Stop all galamsey activities, both surface and underground types, and restrict access to the various sites;
  - Engage with district assemblies and traditional rulers of affected communities to discuss synergies for reclamation of impacted facilities;
  - Commit funds or budget for galamsey management programs
- Conducting site specific geochemical studies and field trials to understand and optimise re-reclamation and vegetation methodologies for the affected lands
- Estimating the sizes of lands taken by galamsey operations
- Building resource and environmental impact inventory for the various operations
- Working with the local communities to establish sustainable land uses for and management of the reclaimed site facilities e.g. Pit lakes, infrastructure

Battery limits

The battery limits situated at are listed in Table 13;

Table 13: Galamsey operation battery limits

Component	Aspects
Infrastructure components	
Mill House	■ Mostly a wooden structure with concrete base with average dimensions of 25m by 15m ■ Crushers ■ Sluice board and washing sumps ■ Smoothing machine ■ Chan Fa ■ Electrical connection ■ Water pumps and hoses ■ Sacs (filled or empty) ■ Retorts, charcoal, coal pot and other gold extraction/refinement instruments ■ Mercury ■ Fuel (diesel and petrol) ■ "Shump"/processed waste pile ■ Dozer (for loading shump/process waste into trucks for sale) ■ Littered surroundings
Sample Pits	■ Water pumps ■ Hoses ■ Pits with average width or entrance of 1.5m

Component	Aspects
	■ Pit with varying depth (normally dependent on water table) ■ Fuel (diesel and petrol) ■ Waste rocks and soils ■ Erected shelters/structures ■ Adjacent receptacle (river/stream) for discharged waters ■ Littered surroundings
Abandoned Shafts	■ Generators ■ Pumping/dewatering stations ■ Adjacent receptacle (river/stream) for discharged waters ■ Hoses/pipes ■ Shafts with varying entrance dimensions and depth ■ Fuel (diesel and petrol) ■ Waste rocks and soils ■ Erected shelters/structures ■ Littered surroundings
Alluvial washing board	■ Washing board/metallic sluice boards ■ Water pumps ■ Hoses/pipes ■ Pits with average depths of 10m ■ Pit with varying width ■ Fuel (diesel and petrol) ■ Waste rocks/soils dumps ■ Erected shelters/structures ■ Excavators ■ Dozers ■ Muddy grounds ■ Pool of waters/turbid ponds ■ Littered surroundings
Alluvial washing plant	■ Washing plant/trommel ■ Water pumps ■ Hoses/pipes ■ Pits with average depths of 10m ■ Pit with varying width ■ Fuel (diesel and petrol) ■ Waste rocks/soils dumps ■ Erected shelters/structures ■ Excavators ■ Dozers ■ Muddy grounds ■ Pool of waters/turbid ponds ■ Littered surroundings
Anwona	■ Suction dredge/Tototooto ■ Water pumps/pumping machine ■ Hoses/pipes ■ Pits with average depths of 10m ■ Pit with varying width ■ Fuel (diesel and petrol) ■ Waste rocks/soils dumps

Component	Aspects
	■ Erected shelters/structures ■ Excavators/Dozers ■ Muddy grounds ■ Littered surroundings
Dredging	■ Suction dredge/Totototo ■ Water pumps/pumping machine ■ Hoses/pipes ■ Pits with average depths of 10m ■ Pit with varying width ■ Fuel (diesel and petrol) ■ Waste rocks/soils dumps ■ Erected shelters/structures ■ Excavators ■ Dozers ■ Muddy grounds ■ Littered surroundings
Chamfi	■ Chan Fa diesel powered engine ■ Erected shelters ■ Water pumps/pumping machine ■ Hoses/pipes ■ Pits with average depths of 10m ■ Pit with varying width ■ Fuel (diesel and petrol) ■ Waste rocks/soils dumps ■ Excavators ■ Dozers ■ Muddy grounds ■ Littered surroundings

Reclamation and Closure Scenario

The closure scenario for galamsey impacted lands describes and summarizes the operational site as it would appear at different stages during the closure process;

- A view of the galamsey site as it would appear at the last day of operations;
- Key activities/actions expected to take place during the decommissioning and closure period; and,
- A description of anticipated post closure activities/actions to be implemented, to progress the site to a stable and self-sustaining state for eventual site relinquishment.

Summarised in Table 14 are the various closure scenarios for the 9 galamsey types.

Table 14: Overall closure scenario for galamsey operations

Reclamation Scenarios and Assumptions	
Abandoned Shafts:	
	o Drive galamsey operators away and leave all facilities intact until ownership concerns are sorted out.
	o Removal of dewatering pipelines and infrastructure

	o Place under care and maintenance
	o Provide security/Restrict access
	o Revegetate surroundings
	o Undertake cleanup exercise
	o Water and soil Monitoring (post closure)
	o Underground water pumping and discharge management (will continue for approximately 10yrs before government conclude decisions on its ownership concerns)
Sample Pits/Holes	
	o Cleanup of oil and grease on surroundings
	o Removal of dewatering pipelines and infrastructure
	o Backfill pits/holes
	§ average depth of 50m
	§ Average entrance width of 2m
	§ Average width of working area of 5m
	§ Average number of dries (working branches/ghettos) of 3
	o Dewatering of pits
	o Revegetation
	§ Spot planting
	§ Tree Planting
	§ Fertilizer application
	§ Care and maintenance
	o Access restriction to site
	o Water and soil Monitoring
	o Geotechnical assessments
	NB: Approximately 50% of affected areas contain pits/holes
Dredging	
	o Halt dredging and drive galamsey operators away
	o Average length of River to be desilted/dredged is 20km, width of River is 20m
	o Average length of stream to be desilted/dredged is 20km, width of River is 5m
	o All rivers/streams affected to be desilting
	o Removal of abandoned suction dredges/floats, pipes and other equipments (it is assumed at least one suction dredged and related equipments will be seen on every 1Ha
	o Oil films on surface of water bodies
	o Revegetation of banks
	o Access restriction
	o Care and maintenance
	o Water and soil Monitoring
	NB: Due to high dilution from waters, it is assumed contaminants will be reduced over a period of time
Alluvial Washing Board	
	o Clean up of oil and grease on surface of waters and surroundings
	o Earthworks
	§ Leveling
	§ Backfilling
	o Drainage channel construction
	o Phytoremediation (Treatment) of Oil/grease, Hg and As in impacted soils and sludges/sediments

	o Revegetation
	o Cleanup of litter
	o Removal and disposal of abandoned equipments (excavators, trucks etc.)…washing board and submerged excavator will be encountered
	o Water and soil Monitoring
	o Pump and treat waters contaminated with Hg, Arsenic, turbidity and oil/grease
	NB: Assume that for every affected area having a size of 50Ha and above, at least one abandoned
Washing Plant	
	o Clean up of oil and grease on surface of waters and surroundings
	o Earthworks
	§ Leveling
	§ Backfilling
	o Drainage channel construction
	o Revegetation
	o Clean up of litter
	o Removal and disposal of abandoned equipments (excavators, trucks etc.)…assume that for every affected area having a size of 50Ha and above, at least one abandoned washing plant and submerged excavator will be encountered
	o Water and soil Monitoring
	o Pump and treat waters contaminated with Hg, AS, high TSS/turbidity and oil/grease
Dig and Wash	
	o Earthworks
	o Reinstatement of drainage channels
	o Revegetation
	o Water and soil Monitoring
	o Pump and treat waters contaminated with Hg, AS, high TSS/turbidity and oil/grease
Anwona	
	o Clean up of oil and grease on surface of waters and surroundings
	o Backfilling of pits
	§ Average dimensions of 30m by 20m
	§ Average depth of 1.8m
	o Reinstatement of drainage channels
	o Phytoremediation (Treatment) of oil/grease and Toxic trace metals (Hg, As etc.) impacted soils and sludges/sediments
	o Revegetation
	o Removal and disposal of abandoned equipments (excavators, trucks etc.)…assume that for every affected area having a size of 1Ha and above, at least one abandoned suction dredge will be encountered
	o Water and soil Monitoring
	o Pump and treat waters contaminated with Hg, AS, high TSS/turbidity and oil/grease
Chamfi	
	o Removal of dewatering pipelines and infrastructure
	o Backfilling of pits and leveling of site
	o Clean up of oil and grease
	o Phytoremediation (Treatment) of oil/grease and Toxic trace metals (Hg, As etc.) impacted soils and sludges/sediments
	o Reinstatement of drainage channels

	o Revegetation
	o Clean up of litter
	o Removal and disposal of abandoned equipments (excavators, trucks etc.)…assume that for every affected area having a size of 20Ha and above, at least one abandoned Chan Fa machine and excavator will be encountered
	o Water and soil Monitoring
	o Pump and treat waters contaminated with Hg, AS, high TSS/turbidity and oil/grease
Mill House	
	o Clean up of oil and grease around surroundings
	o Demolition of mill house
	o Demolition of concrete structures
	o Removal of electrical facilities
	o Phytoremediation (Treatment) of oil/grease and Toxic trace metals (Hg, As etc.) impacted soils and sludges/sediments
	o Disposal of wastes
	o Disposal of wastes
	o Site general clean up
	o Earthworks
	o Revegetation
	o Clean up of mercury contaminated soils
	o Water and soil Monitoring
	o Pump and treat waters contaminated with Hg, As and oil/grease
	Mostly with concrete platform
	Wall erected up to a point and continued up with metallic wire mesh
	Average dimensions of 15m by 25m
	Roofed with iron sheets
	Mostly connected to ECG (legally or illegally)
	Washing pits (averagely 2) mostly concreted with dimensions of 2x3x2 (2m length, 3m width and 2m deep)
	Mostly have crushers, smoothening machine, Chan Fa diesel powered engine, retort, bottled mercury and other accessories for repairs
Labour for tasks	
	Labour to be sourced locally for all tasks
	A by-day rate will be paid out to labourers
	An experienced and competent Civil Engineer, Reclamation and Environmental Expert should be fine for the tasks
Equipment Hire	
	Dozer (D9) Dozer will be hire for all heavy duty tasks
	CAT 325 Excavator (with a long boom will be hired for the desilting)
	Dozer (D7) Dozer will be hire for all light tasks
	Dozer (D8) will be hire for medium duty tasks
	A 20 cubic metre truck will be hire for all loading and haulage tasks
	A lowbed shall be used where required
Planting Stock and Implements	
	Seedlings shall be sourced from the Forestry Commission
	Average cost of tree seedling (including transport) is pegged at GHs 5
	Planting will be done by by-day labourers

	Fertilizers, weedicides, insecticides and other agrochemicals shall be obtained from the Forestry Commission
	Price of agrochemicals shall be approximately GHs 30/bottle
	Cutlasses (100) each at a price of GHs 35
	Earth Chisels (100) each at a price of GHs 90
	Wheel barrows (100) each at a price of GHs 300
	Wellington Boots (200 pairs) each at a price of GHs 80
	Head pans (50) each at a price of GHs 120
	Spade/shovels (100) each at a price of GHs 70
	Knapsack sprayers (100) each at a price of GHs 40
	Nose mask (each a price of GHs 15)
Phytoremediation (Treatment) of ARD and Toxic trace metals (Hg, Cd, As etc.) impacted soils and sludges/sediments	
	This will involve the planting of very common aquatic macrophytes as per below:
	Grasses and legumes: Cattails/typher species, Paspalum. vaginatum, Cyno don.dactylon, Pueraria. phaseoloides, Centrosema. pubescens, Panicum. maximum, Schrankia. leptocarpa, Eclipta. alba (Linn.), Cyperus. haspen (Linn.), Melastromastrum. capitatum, Acreceras. zizanoides Dandy, Pteridum aquilinum (Linn), Ludwigia.decurrens Walt,Setaria longiseta P.Beauv., Physalis angulata (Linn.), and Desmodium scorpiurus.
	Tree species: Xylopia aethiopica (Hwentia), Pityrogramma calomelanos (Fern), Chromolaena odorata (Acheampong weed), Leucaena leucocephala (Leucaena), and Terminalia superba (Ofram)
Pump and treats surface waters impacted upon by high TSS, trace toxic metals and ARD	
	Cost of pumping (pump/fuel plus labour) is approximately **GHs 20,000**
	Assuming the average depth of pits in alluvial mine sites is approximately **10m**. Therefore a hectare (10,000 sq met) of land will have approximately **100,000 cubic meters** of water to be pumped and treated.
	Hg, Arsenic and other trace metals: depends very much of concentration and each element. I would say roughly 0.60-1.00 USD/m3.
	Oil and grease: as above, but when combined to the previous additionally 0.50 USD/m3 (?)
	TSS/turbidity: as above, but when combined to the previous additionally 0.10-0.30 USD/m3
	ARD (you mean "Acid Rock Drainage"?): as above, but when combined to the previous additionally 0.30-0.60 USD/m3
	NORMs (you mean "Naturally Occurring Radioactive Material"?): AQM has experience only of uranium, treatment like in the first point by specific adsorbents **0.60-1.00** USD/m3.
	NB: All things being equal, approximately USD 1 will be required to treat contaminated waters on galamsey sites
	Overall cost of pumping and treating contaminated waters per day per hectare approximately
Backfilling, plugging and sealing	
	Approximately it will take 8 hrs (1 day) to complete the backfilling/earthworks for an **hectare** of an affected land
Surface Grading, reprofiling and Leveling	

	Approximately it will take 16hrs (2 days) to grade/level and reprofile a land to a gentle rolling landscape
Demolition/dismantling Tasks	
	Approximately it will take 4hrs (half day) to demolish facilities (mill house, concrete etc.) per a hectare
Clean up and Housekeeping	
	Approximately it will take 4 hrs (half day) to complete clean-up for an **hectare** of an affected land
	NB: Approximately 2% of the total land areas shall require clean up
Salvaging of abandoned equipments	
	Approximately it will take 8 hrs (1 day) to complete salvaging and housekeeping for an **hectare** of an affected land
	NB: Approximately 2% of the total land areas shall require clean up
Phytoremediation of contaminated soils and waters	
	Chromolaena odorata, Typha domingensis, Lantana camara, Typher Spp., Brassica Spp. and vetiver grass

Reclamation Objectives and Measures

The reclamation objectives and measures were identified bearing in mind the site specific conditions of each galamsey type at the time of closure and the closure scenario as described in Summarised in Table 14 are the various closure scenarios for the 9 galamsey types.

Table 15. This section identifies the reclamation objectives for those aspects/components in line with best practice that will be adapted to manage impacts and risks identified for each galamsey type.

Alluvial Washing Board Galamsey Types

Reclamation objectives

The reclamation objectives for alluvial washing board galamsey are:

- Facilitation and transfer of infrastructure (pumps, dozers, excavators etc.) that could be of beneficial use to third parties;
- Remove superfluous surface infrastructure not transferred to third parties that could fall into a state of disrepair causing health and safety threats and/or compromise post reclamation beneficial land use; and,
- To create stable and productive land on rehabilitated disturbed areas from which surface infrastructure has been removed.

Table 15: closure measures

Aspect / component	Reclamation and closure measures
■ Washing board or engineered (metallic) sluice board ■ Dug-out Pits (mostly filled with water if abandoned and dry where active) ■ Impacted Wetlands ■ Muddy floors	■ Halt all on-going active galamsey activities and restrict access to sites ■ Identify and salvage all active and abandoned heavy equipments (for reuse at legalised sites) ■ Decommission and reclaim the sluice board, its accessories and general areas affected as follows: ▪ Demolish and remove all washing board equipments and

Aspect / component	Reclamation and closure measures
■ Contaminated soils/floors (from mercury and liquid hydrocarbons) ■ Heavily littered surroundings ■ Abandoned heavy duty equipments for mining (dozers, excavators) ■ Pumps and pipes ■ Contaminated waters (TSS, TDS, Conductivity, metals, ARD, NORMs, oil and grease) generally found at the site	available shelters for salvaging or disposal ▪ Remove all superfluous pipelines and pumps together with clean-up of all associated material ▪ Identify, clean and dispose of redundant and / or scrap washing board/sluice plant and related equipment which was in contact with chemical solutions ▪ Remove all piping, valves, litter or wastes and related infrastructure/equipment from the sites ▪ Reprofiles, grade, reshape and rip all access roads, pipeline corridors, pipe bunds and trenches, stockpile footprint areas, hard standings and lay-down areas where required in preparation for re-establishment of vegetation ▪ Backfill all voids or pits created as a result of the mining project ▪ Undertake a contaminated land assessment of the plant site area to determine potential soils and water contamination by chemicals and/or hydrocarbons ▪ Remove any contaminated soils as required, transport and bury in a dedicated and approved in pit waste cell prior to its rehabilitation ▪ Demolish and remove foundations or bury with adequate soil / subsoil cover for vegetation establishment ▪ Establish vegetation on rehabilitated areas using grasses, shrubs, and trees without (over-reliance) topsoil/subsoil placement ▪ Undertake phytoremediation exercise for contaminated by establishing aquatic macrophytic vegetation on rehabilitated areas using grasses, shrubs, and trees without (over-reliance) topsoil/subsoil placement ▪ Route contaminated (mercury, hydrocarbons, metals, NORMs, ARD etc.) waters collected in ponds and other wetlands to the water treatment plant and ensure appropriate treatment as required to satisfy effluent discharge standards and discharge. ▪ Reinstate water or drainage lines ▪ Undertake post closure surface water and soil monitoring programs
Closure liability	■ *See Table xx for details*

Alluvial Washing Plant Galamsey Types

Reclamation objectives

The reclamation objectives for alluvial washing board galamsey are:

- Facilitation and transfer of infrastructure (pumps, dozers, excavators etc.) that could be of beneficial use to third parties;
- Remove superfluous surface infrastructure not transferred to third parties that could fall into a state of disrepair causing health and safety threats and/or compromise post reclamation beneficial land use; and,
- To create stable and productive land on rehabilitated disturbed areas from which surface infrastructure has been removed.

Table 16: closure measures

Aspect / component	Reclamation and closure measures

Aspect / component	Reclamation and closure measures
■ Trommel or washing plant ■ Dug-out Pits (mostly filled with water if abandoned and dry where active) ■ Impacted Wetlands ■ Muddy floors ■ Contaminated soils/floors (from mercury and liquid hydrocarbons) ■ Heavily littered surroundings ■ Abandoned heavy duty equipments for mining (dozers, excavators) ■ Pumps and pipes ■ Contaminated waters (TSS, TDS, Conductivity, metals, ARD, NORMs, oil and grease) generally found at the site	■ Halt all on-going active galamsey activities and restrict access to sites ■ Identify and salvage all active and abandoned heavy equipments (for reuse at legalised sites) ■ Decommission and reclaim the sluice board, its accessories and general areas affected as follows: ▪ Demolish and remove all washing board equipments and available shelters for salvaging or disposal ▪ Remove all superfluous pipelines and pumps together with clean-up of all associated material ▪ Identify, clean and dispose of redundant and / or scrap washing board/sluice plant and related equipment which was in contact with chemical solutions ▪ Remove all piping, valves, litter or wastes and related infrastructure/equipment from the sites ▪ Reprofiles, grade, reshape and rip all access roads, pipeline corridors, pipe bunds and trenches, stockpile footprint areas, hard standings and lay-down areas where required in preparation for re-establishment of vegetation ▪ Backfill all voids or pits created as a result of the mining project ▪ Undertake a contaminated land assessment of the plant site area to determine potential soils and water contamination by chemicals and/or hydrocarbons ▪ Remove any contaminated soils as required, transport and bury in a dedicated and approved in pit waste cell prior to its rehabilitation ▪ Demolish and remove foundations or bury with adequate soil/subsoil cover for vegetation establishment ▪ Establish vegetation on rehabilitated areas using grasses, shrubs, and trees without (over-reliance) topsoil/subsoil placement ▪ Undertake phytoremediation exercise for contaminated by establishing aquatic macrophytic vegetation on rehabilitated areas using grasses, shrubs, and trees without (over-reliance) topsoil/subsoil placement ▪ Route contaminated (mercury, hydrocarbons, metals, NORMs, ARD etc.) waters collected in ponds and other wetlands to the water treatment plant and ensure appropriate treatment as required to satisfy effluent discharge standards and discharge. ▪ Reinstate water or drainage lines ▪ Undertake post closure surface water and soil monitoring programs
Closure liability	***Costing and other assumptions:*** ■ *See Table xx for details*

Anwona (pit dredging) galamsey

Reclamation objectives

The reclamation objectives are;

- Facilitation and transfer of infrastructure (suction dredges, pumps, excavators etc.) that could be of beneficial use to third parties;

- Remove superfluous surface infrastructure not transferred to third parties that could fall into a state of disrepair causing health and safety threats and/or compromise post reclamation beneficial land use; and,
- To create stable and productive land on rehabilitated disturbed areas from which surface infrastructure has been removed.

Table 17: closure measures

Component / aspect	Reclamation and closure measures
■ Open pits filled with water for dredging ■ Suction dredging machine (totototo) composed of sluice board, chan fa diesel powered engine, pumps and pipes ■ Contaminated soils/floors (from mercury and liquid hydrocarbons) ■ Contaminated waters (TSS, TDS, Conductivity, metals, ARD, NORMs, oil and grease) generally found at the site	■ Halt all on-going active galamsey activities and restrict access to sites ■ Identify and salvage all active and abandoned heavy equipments (for reuse at legalised sites) ■ Decommission and reclaim the sluice board, its accessories and general areas affected as follows: ▪ Demolish and remove all suction dredge machines and its accompanying set up or accessories for salvaging or disposal ▪ Remove all superfluous pipelines and pumps together with clean-up of all associated material ▪ Identify, clean and dispose of redundant and / or scrap equipment which was in contact with chemical solutions ▪ Remove all piping, valves, litter or wastes and related infrastructure/equipment from the sites ▪ Reprofiles, grade, reshape and rip all access roads, surrounding areas, etc. where required in preparation for re-establishment of vegetation ▪ Pump or route contaminated waters (mercury, hydrocarbons, metals, NORMs, ARD etc.) collected in dredged ponds to the water treatment plant and ensure appropriate treatment as required to satisfy effluent discharge standards and discharge. ▪ Dewater all created pits and backfill ▪ Undertake a contaminated land assessment to determine potential soils and water contamination by chemicals and/or hydrocarbons used ▪ Remove any contaminated soils as required, transport and bury in a dedicated and approved in pit waste cell prior to its rehabilitation ▪ Establish vegetation on rehabilitated areas using grasses, shrubs, and trees without (over-reliance) topsoil/subsoil placement ▪ Undertake phytoremediation exercise for contaminated by establishing aquatic macrophytic vegetation on rehabilitated areas using grasses, shrubs, and trees without (over-reliance) topsoil/subsoil placement ▪ Reinstate water or drainage lines ▪ Undertake post closure surface water and soil monitoring programs
Closure liability	***Costing assumption:*** ■ See section 0

Dig and Wash galamsey

Reclamation objectives

The reclamation objectives are;

- Remove superfluous surface infrastructure not transferred to third parties that could fall into a state of disrepair causing health and safety threats and/or compromise post reclamation beneficial land use; and,
- To create stable and productive land on rehabilitated disturbed areas from which surface infrastructure has been removed.
- Create long term stable landforms that can be productively used post reclamation as far as possible;

Table 18: closure measures

Component / aspect	Reclamation and closure measures
■ Sluice board (wooden and traditional) ■ Dug-out Pits (mostly filled with water if abandoned and dry where active) ■ Impacted water bodies (wetlands, creeks, streams etc.)	■ Halt all on-going active galamsey activities and restrict access to sites ■ Decommission and reclaim the sluice board, its accessories and general areas affected as follows: ▪ Demolish and remove all sluice boards and their accompanying set up or accessories for salvaging or disposal ▪ Remove all piping, litter or wastes and related infrastructure/equipment from the sites ▪ Reprofiles, grade, reshape and rip all access paths, surrounding areas, etc. where required in preparation for re-establishment of vegetation ▪ Pump or route contaminated waters (mercury, hydrocarbons, metals, NORMs, ARD etc.) collected in pits or land surface to the water treatment plant and ensure appropriate treatment as required to satisfy effluent discharge standards and discharge. ▪ Dewater all created pits and backfill ▪ Undertake a contaminated land assessment to determine potential soils and water contamination by chemicals and/or hydrocarbons used ▪ Remove any contaminated soils as required, transport and bury in a dedicated and approved in pit waste cell prior to its rehabilitation ▪ Establish vegetation on rehabilitated areas using grasses, shrubs, and trees without (over-reliance) topsoil/subsoil placement ▪ Undertake phytoremediation exercise for contaminated by establishing aquatic macrophytic vegetation on rehabilitated areas using grasses, shrubs, and trees without (over-reliance) topsoil/subsoil placement ▪ Reinstate water or drainage lines ■ Undertake post closure surface water and soil monitoring programs
■ Closure liability	***Costing assumption:*** ■ See section 0

Dredging (river/stream) galamsey

Reclamation objectives

- To remove remnant “relics” of dredging that could compromise post reclamation beneficial land use of the water system;
- To create a functioning and productive water system
- To rehabilitate the water body and its banks in a manner that reduces its visual impact;

Table 19: closure measures

Aspect / component	Reclamation measures
■ Contaminated water bodies (rivers and streams) ■ Open pits filled with water for dredging ■ Suction dredging machine (totototo) composed of sluice board, chan fa diesel powered engine, pumps and pipes ■ Contaminated soils/floors (from mercury and liquid hydrocarbons) ■ Contaminated waters (TSS, TDS, Conductivity, metals, ARD, NORMs, oil and grease) generally found at the site	■ Halt all on-going active galamsey activities and restrict access to sites ■ Decommission and reclaim the affected water body and general areas affected as follows: ▪ Demolish and remove all suction dredge machines and its accompanying set up or accessories for salvaging or disposal ▪ Remove all superfluous pipelines and pumps together with clean-up of all associated material ▪ Identify, clean and dispose of redundant and / or scrap equipment which was in contact with chemical solutions ▪ Undertake a contaminated land assessment to determine potential soils and water contamination by chemicals and/or hydrocarbons used ▪ Undertake desilting or dredging of water bodies ▪ Establish vegetation on banks of water bodies using grasses, shrubs, and trees without (over-reliance) topsoil/subsoil placement ▪ Reinstate water or drainage lines ■ Undertake post closure surface water and soil monitoring programs
■ Closure liability	■

Chamfi

Reclamation objectives

- Facilitation and transfer of infrastructure (pumps, dozers, excavators etc.) that could be of beneficial use to third parties;
- Remove superfluous surface infrastructure not transferred to third parties that could fall into a state of disrepair causing health and safety threats and/or compromise post reclamation beneficial land use; and,
- To create stable and productive land on rehabilitated disturbed areas from which surface infrastructure has been removed.

Table 20: closure measures

Aspect / component	Reclamation measures
■ Chan fa diesel powered engines ■ Dug-out pits (mostly filled with water if abandoned and dry where active) ■ Impacted water bodies and muddy floors ■ Contaminated soils/floors (from mercury and liquid hydrocarbons) ■ Heavily littered surroundings ■ Abandoned heavy duty equipments for mining (dozers, excavators) ■ Pumps and pipes ■ Contaminated waters (TSS, TDS, Conductivity, metals, ARD, NORMs, oil and grease) generally found at the site	■ Halt all on-going active galamsey activities and restrict access to sites ■ Identify and salvage all active and abandoned heavy equipments (for reuse at legalised sites) ■ Decommission and reclaim the sluice board, its accessories and general areas affected as follows: ▪ Demolish and remove all washing board equipments and available shelters for salvaging or disposal ▪ Remove all superfluous pipelines and pumps together with clean-up of all associated material ▪ Identify, clean and dispose of redundant and / or scrap washing board/sluice plant and related equipment which was in contact with chemical solutions ▪ Remove all piping, valves, litter or wastes and related infrastructure/equipment from the sites ▪ Reprofiles, grade, reshape and rip all access roads, pipeline corridors, pipe bunds and

Aspect / component	Reclamation measures
	trenches, stockpile footprint areas, hard standings and lay-down areas where required in preparation for re-establishment of vegetation ▪ Backfill all voids or pits created as a result of the mining project ▪ Undertake a contaminated land assessment of the plant site area to determine potential soils and water contamination by chemicals and/or hydrocarbons ▪ Remove any contaminated soils as required, transport and bury in a dedicated and approved in pit waste cell prior to its rehabilitation ▪ Demolish and remove foundations or bury with adequate soil / subsoil cover for vegetation establishment ▪ Establish vegetation on rehabilitated areas using grasses, shrubs, and trees without (over-reliance) topsoil/subsoil placement ▪ Undertake phytoremediation exercise for contaminated by establishing aquatic macrophytic vegetation on rehabilitated areas using grasses, shrubs, and trees without (over-reliance) topsoil/subsoil placement ▪ Route contaminated (mercury, hydrocarbons, metals, NORMs, ARD etc.) waters collected in ponds and other wetlands to the water treatment plant and ensure appropriate treatment as required to satisfy effluent discharge standards and discharge. ▪ Reinstate water or drainage lines ▪ Undertake post closure surface water and soil monitoring programs.
■ Closure liability	■

Abandoned shafts galamsey

Reclamation objectives

- Facilitation and transfer of infrastructure (pumps, dozers, excavators etc.) that could be of beneficial use to third parties;
- Remove superfluous surface infrastructure;
- To create stable land around shafts; and
- Place facility under care and maintenance

Table 21: closure measures

Aspect / component	Reclamation measures
Underground shafts Adjoining sample holes Pumping station/dewatering systems Hoses Compressors Fans and blowers	■ Drive galamseyers away and place facility under care and maintenance; restrict access
	■ General Clean ups and housekeeping (manual litter clean ups, removal of compressors, dewatering pumps, electrical cables, oil spills clean ups etc.)
	■ Cap, fill or seal holes, tunnels, “dries” and excavations leading into shafts through a cut to fill action ■ Shape and profile disturbed surface areas to be free draining

Aspect / component	Reclamation measures
	and emulating the natural surface topography as far as possible ■ Stabilise disturbed areas to prevent erosion and sediment mobilisation in the short to medium term until a suitable vegetation cover has been established
	■ Establish vegetation (60% legumes and 40% local spp. and grasses) on available surface. Spot planting shall be used with borrowed topsoil material from surrounding areas ■ Post-Closure Aspects (Water Discharge Management and Monitoring) ■ Post-Closure Aspects (Reclamation Monitoring-Supply and place fertilizers, beating-up and repair erosion damage as necessary for a period of three year to ensure establishment of vegetation cover)
	■ Undertake post closure dewatering of shafts/underground ***not costed at this point)*** ■ Continue with groundwater monitoring for to confirm that the there is no contamination of the groundwater system decommissioning and post closure
	■ Undertake a geotechnical, stability and hydrogeological investigations for the shafts (***not costed at this point)***

Dredging galamsey

Reclamation objectives

- Ensure River and stream restoration to ensure ecological, physical, spatial and management measures and practices. These are aimed at restoring the natural state and functioning of the river system in support of biodiversity, recreation, flood management and landscape development;
- To remove remnant "relics" of equipments/equipments that could compromise post reclamation beneficial land use; and
- To create stable and productive land and water resources.

Table 22: closure measures

Aspect / component	Reclamation measures
Dredging machines/totototo Hydrocarbons Highly turbid water bodies Oil-films on surface of water bodies	■ Halt all on-going active galamsey activities and restrict access to sites ■ Removal of abandoned dredges and general housekeeping ■ Desilting of rivers and streams
	■ Oil-film clean up on surface of water bodies
	■ Establish vegetation of river banks (60% legumes and 40% local spp. and grasses) on available surface. Spot planting shall be used with borrowed topsoil material from surrounding areas ■ Post-Closure Aspects (surface Water Quality, soils and sludge/slurry Monitoring) ■ The establishment of vegetation on the banks of river or water bodies; ■ Obtain native species, local species, and commercial species for use

Aspect / component	Reclamation measures
Dredging machines/totototo Hydrocarbons Highly turbid water bodies Oil-films on surface of water bodies	■ Halt all on-going active galamsey activities and restrict access to sites ■ Removal of abandoned dredges and general housekeeping ■ Desilting of rivers and streams
	in reclamation;
	■ Identify possible obstructions/impediments to surface water flows and correct to be free-draining. ■ Identify possible interception and/or ponding areas of surface water flows. ■ Desilt or dredge water bodies to ensure free-draining and if not possible isolate these areas from drainage paths by routing surface water flow past these areas

Mill House galamsey

Reclamation objectives

- To remove remnant "relics" of mill house processing galamsey that could compromise post reclamation beneficial land use; and
- To create stable and productive lands

Table 23: closure measures

Aspect / component	Reclamation measures
Mill or processing house Sluice board and sumps Smoothing machines Crushers Pumps Chan fa machines Sacs Retorts Ponds Electricity supply "Shumps"/tailings stockpiles Waste dumps/piles	■ Halt all on-going active galamsey activities and restrict access to sites ■ Decommission and reclaim the mill house facility, its accessories and general areas affected as follows: ▪ Demolish and remove all mill house foundations, equipments and available shelters for salvaging or disposal ▪ Remove electrical installations; ▪ Remove all superfluous pipelines and pumps together with clean-up of all associated material ▪ Identify, clean and dispose of redundant and / or scrap washing board/sluice plant and related equipment which was in contact with chemical solutions ▪ Remove all piping, valves, litter or wastes and related infrastructure/equipment from the sites ▪ Reprofiles, grade, reshape and rip all access roads, pipeline corridors, pipe bunds and trenches, stockpile footprint areas, hard standings and lay-down areas where required in preparation for re-establishment of vegetation ▪ Undertake a contaminated land assessment of the plant site area to determine potential soils and water contamination by chemicals and/or hydrocarbons ▪ Remove any contaminated soils as required, transport and bury in a dedicated and approved in pit waste cell prior to its rehabilitation ▪ Establish vegetation on rehabilitated areas using grasses, shrubs, and trees without (over-reliance) topsoil/subsoil placement ▪ Undertake phytoremediation exercise for contaminated by establishing aquatic macrophytic vegetation on rehabilitated areas using grasses, shrubs, and trees without (over-reliance)

Aspect / component	Reclamation measures
	topsoil/subsoil placement ▪ Route contaminated (mercury, hydrocarbons, metals, NORMs, ARD etc.) waters collected in ponds and other wetlands to the water treatment plant and ensure appropriate treatment as required to satisfy effluent discharge standards and discharge. ▪ Reinstate water or drainage lines ▪ Undertake post closure surface water and soil monitoring programs.

2.11 Closure Liability Cost Estimate

The Approach

The approach to developing the reclamation and closure costing is as follows:

- Sites visit and took a tour of the operational sites for respective galamsey types;
- Completion of footprint estimations, resource and environmental impact inventory for respective types of galamsey;
- Review of relevant and historic information
  - operational dynamics of galamsey operations;
  - MDAs and host villages for galamsey;
- Completion of geochemical analysis/site characterization;
- Derivation of site-specific unit rates (see **Table 24 for** details) for the reclamation of disturbed surface areas, as well as dedicated rates for demolitions/dismantling, earthworks, revegetation, water treatment, pumping, clean ups and housekeeping informed by third party rates obtained from local contractors and labourers in Ghana Cedis;
- Devising, in collaboration with best practice reclamation plan, closure scenario and reclamation measures for ASM and LSM operations;
- Quantifying closure and reclamation costs for the above items, utilising the available information; and
- Compiling a dedicated closure and reclamation costing spread sheet for all nine (9) types of galamsey within the 11 MDAs selected.

Table 24: Unit Rates

UNIT RATES FOR DEMOLITION, EARTHWORKS, REHABILITATION AND RELATED WORK, AS AT OCTOBER 2016					
Ref nr			**Unit Rate**	**Unit**	**Comment**
A	**Concrete**	**Column1**	**Column2**	**Column3**	**Column4**
A1	**Demolition of Concrete floors, bases and foundations**				
A1.1	Very heavy concrete with thickness greater than 750 mm	GHs	3200	Per day (8hrs)/Ha	A dozer 8 or 9 (D8 or D9) can be used for this task. The cost includes machine hiring fee of GHs 2,200, chop money of GHs 200 and fuel fee of GHs 800. Rates gathered from galamsey operators and hiring services
A1.2	Heavy concrete with thickness 500 - 750 mm	GHs			
A1.3	Medium concrete with thickness between 250 and 500 mm	GHs			
A1.4	Light concrete thickness less than 250 mm	GHs			
B	**Steel structures and**				

	equipment demolition				
B1	**Steel buildings and related infrastructure (Including Sheeting)**				
B1.1	Light plant or structures	GHs	800	Per day (8hrs)/normal boys room/Ha	A skilled and experienced welder will be used in dismantling manually. Assumed the 10 people per hectare for every 8 hours…each given an amount of GH80.
B1.2	Light/medium plant or structures	GHs			
B1.3	Medium plant or structures	GHs			
B1.4	Medium/heavy plant or structures	GHs			
B1.5	Heavy plant structures	GHs			
B1.6	Very heavy plant structures	GHs			
C	**Brick buildings and structures demolition**				
C1	Normal one storey brick buildings	GHs	2500	Per day (8hrs)/Ha	A dozer 7 (D7) is ideal for this task. The cost include machine hiring fee of GHs 1800, chop money of GHs 200 and fuel fee of GHs 500
C2	Normal double storey brick buildings	GHs			
C3	Single brick wall (110mm)	GHs			
C4	Double brick wall (220mm)	GHs			
C5	Prefabricated Buildings	GHs			
C6	Fiber reinforced walls	GHs			
C8	Removal of timber structures	GHs			
D2	**Overland and electric power lines disconnection and removal**				
D2.1	Minor power lines	GHs	2500	Per day (8hrs)/Ha	A dozer 7 (D7) is ideal for this task. The cost include machine hiring fee of GHs 1800, chop money of GHs 200 and fuel fee of GHs 500
D2.2	Major power lines	GHs			
D3	**Abandoned excavator/dozer removal and handling**				
D3.1	Excavator and other heavy duty machines	GHs	5500	Per day (8 hrs)/Ha	This will done using hired crane or suitable equipment
D3	**Abandoned washing board, washing plant, sluices, pumps and pipelines/hoses removal**				
D3.1	Abandoned washing board, washing plant, sluices, pumps and pipelines/hoses	GHs	360	Per day (8 hrs)/Ha	This will done manually by hired locals. Assumed 6 persons with each given an amount of GHs 60 per hectare per day.
E	**Backfilling/Sealing of pits, sink holes, subsidence, adits, excavations and ponds**				
E1	Access creating, material gathering and cleanup of the site	GHs	2500	Per day (8hrs)/Ha	A D7 Dozer and 4 locally hired assistants
E7	Pushing wastes materials into pits/holes/adits	GHs			
G	**Rehabilitation of disturbed/affected areas**				
G1	**Profiling/Leveling/Regrading of land surfaces**				
G1.1	Shaping/levelling of infrastructural footprint areas	GHs	2500	Per day (8hrs)/hac	A dozer 7 (D7) is ideal for this task. The cost include machine hiring fee of GHs 1800, chop money of GHs 200 and fuel fee of GHs 500
G1.2	Reshaping / profiling of dumps (general)	GHs			
G1.3	Import cover material (from surrounding areas) and spread	GHs			
G1.4	Profiling of general disturbed areas	GHs			
G2	**Establishment of vegetation**				

G2.1	Establishment of vegetation (general)	GHs	6000	Per day (8hrs)/Hac	Local labour hire. Assume 1000 saddling's per hectare (at a planting distance of 3m by 3m). GHs 3000 required for tree 1000 seedlings purchase (average price of seedling pegged GHs3). Planting shall also entail planting erosion control cover crops or grass such as peuraria, brachiara, vetiver etc. Assumed the cost of grass or cover crop is GHs 2000/hac. Assumed a crew of 10 required to complete planting on a hectare of land per day with each paid a by-day rate of GH80.
G2.2	Establishment of vegetation on dumps	GHs			
G2.3	Establishment of vegetation along river/stream banks	GHs			
G2.4	Stabilize PH levels of soil with lime	GHs			
G3	**Water management (riparian areas, re-instatement of drainage lines)**				
G3.1	Reinstatement of drainage lines	GHs	1500	Sum/Hac/8hrs	Manual construction of trenches, use of sand bags etc. Assuming 15 labourers are used per day at a rate of GHs 100 per each
G3.2	Storm water routing along pit toe	GHs			
G3.3	Storm water routing along outer slopes/upper surface	GHs			
G3.4	Reinstatement of wetlands	GHs			
G3.6	**Plug and seal of boreholes**				
G3.6.1	Surface plug (5m)	GHs	3000	sum/8hrs/Ha	The rate includes site establishment and related costs, all plug material and labour.
G3.6.2	Full depth plug (35m)	GHs	5000		
H	**Site Characterization exercise**				
H1	**Site assessment**				
H1.1	Soils	GHs	15000	sum/ha	Sampling and lab analysis (physicochemical)…metals, ARD, physicals (field parameters), NORMs, oil and grease etc. At least two samples each of water, soil, slurry/sludge and mine waste expected to be collected for physicochemical analysis.
H1.2	Surface Water	GHs			
H1.4	Groundwater	GHs			
H1.5	Sediment/Slurry	GHs			
H1.6	Mine Waste	GHs			
H2	**Housekeeping Exercise**				
H2.1	**Manual clean up and landfilling**				
H2.1.1	Litter	GHs	500	sum/8hrs/Ha	
H2.1.2	Toilet facilities	GHs			
H2.2	**Clean up of oil-contamination**				
H2.2.1	Scraping and disposal at designated landfill	GHs	1000	sum/8hrs/Ha	Using local labour (assuming 10 locals each at a by-day rate of GHs 80) to scrape and dispose waste off at an adjacent municipal engineered landfill. Transport fare for disposal assumed to be GHs 200
H2.2.5	Degreasing of items	GHs			
H3	**Clean up and treatment of of Mercury wastes in soils**				
H3.1	General ripping	GHs	30000	sum/8hrs/Ha	
H3.2	Deep ripping (heavy)	GHs			
H3.3	Ripping for alleviation of compaction and gathering of mercury wastes	GHs			
H3.4	Decontamination of items	GHs			
H3	**Clean up of oil on surface of**				

	water bodies				
H3.1	General ripping	GHs	12000	sum/8hrs/Ha	
H3.2	Deep ripping (heavy)	GHs			
H3.3	Ripping for alleviation of compaction and gathering of mercury wastes	GHs			
H3	**Removal of abandoned dredges on rivers**				
H3.1	General ripping	GHs	1500	sum/8hrs/Ha	
H3.2	Deep ripping (heavy)	GHs			
H3.3	Ripping for alleviation of compaction and gathering of mercury wastes	GHs			
H3	**Phytoremediation of TSS, ARD and Toxic metals (Hg, Cd, Pb, As) in waters**				
H3.1	Pumping and treatment of turbid waters	GHs	6000	sum/Ha	Assuming 20% of available lands contains contaminated waters that requires some form of treatment
H3.1	Pumping and treatment of waters with elevated levels of toxic metals (Hg, As, Cd etc.)	GHs			
H3.1	Pumping and treatment of waters with high ARD and low pH	GHs			
J	**Post-closure aspects**				
J1	Reclamation monitoring	GHs	4200	sum/Ha/yr	3 years monitororing
J2	Care and maintenance (High intensity)	GHs			On annula basis for as period of 3 years. 10 labourers each are charging a by-day of GH80. 200 tree seedlings (legumes and local spp.) at a cost of GHs 600 for beating-up (replacement of dead seedlings).
J3	Care and maintenance (Low intensity)	GHs			Weeding and beating-up done on quarterly basis (4 times a year)
K	**Post-closure monitoring (Site Specific)**				
K1.1	Surface water	GHs	1200	Sum/Ha/yr	Physicochemical parameters on biannual basis (2 samples each per hac)
K1.2	Soils	GHs			Physicochemical parameters on biannual basis (2 samples each per hac)
K1.2	Slurry and sludge	GHs			Physicochemical parameters on biannual basis (2 samples each per hac)
K3.3	Subsidence and geotech monitoring	GHs			On annual basis
K	**Desilting of River Bodies**				
K1.1	Silt removal and handling	GHs	2600	Day (8hrs)/Ha	Physicochemical parameters on biannual basis
O.4	**Equipment Rates**				
O.4.1	D9 Dozer	GHs	3200	Day (8hrs)	Rates gathered from galamsey operators
O.4.2	D8 Dozer	GHs	3000	Day (8hrs)	Rates gathered from galamsey operators
O.4.2	D7 Dozer	GHs	2800	Day (8hrs)	Rates gathered from galamsey operators
O.4.3	325 Excavator	GHs	2600	Day (8hrs)	Rates gathered from galamsey operators
O.4.4	Truck (20 cubic metre)	GHs	1500	Day (8hrs)	Rates gathered from galamsey operators
O.4.5	Grader	GHs	2600	Day (8hrs)	Rates gathered from galamsey operators

O.4.6	Lowbed	GHs	5500	Day (8hrs)	Rates gathered from galamsey operators
O.4.6	Crane	GHs	5500	Day (8hrs)	Rates gathered from galamsey operators
O.4.7	Long boom excavator (for dredging/desilting)	GHs	3500	Day (8hrs)	Rates gathered from galamsey operators
L	**Post-Closure Aspects (Water Pumping and Discharge Management)-Underground Operations**				
K3.3	Groundwater pumping, discharge management and geotech monitoring	GHs	5500	Day (8hrs)	Rates gathered from galamsey operators
L	**Pumping and treatment of contaminated waters**				
K3.3	Pumping cost (hiring cost of pump and labour)	GHs	500	Day (8hrs)	Rates gathered from galamsey operators
K3.3	Treatment cost	GHs	3.582	per cubic meter	Using rates (USD 0.9/m3) gathered from Aquaminerals, Finland (USD 0.6/m3 of water), P2W (USD 1.25/m3) and Viola (USD 0.86/m3). A hectare of land is assumed to contain approximately 100,000 cubic meters of water…assuming each created pits has a depth of 10m. Using Dollar to Cedi rate of US1=GHs 3.98

Assumptions

- The scenarios and assumptions made for each type of galamsey type can be found in **Table 14.**

Unit rates and basis for costing

The basis for costing was;

- A compilation of unit rates for various closure activities (decommissioning and reclamation activities) from galamsey operators and vehicle hiring or renting service providers. All costs are presented in Ghana cedi terms.
- The Unit rates for general reclamation and closure measures and activities were obtained from galamsey operators and local hiring service providers. **Table 24** provides details on the Unit rates gathered.

Table 25 provides a summary table for the estimated closure cost for the nine galamsey types encountered in the 11 MDAs within the Western Region of Ghana. The estimated reclamation and closure costing spread sheet for the various galamsey types are attached as an appendix to this report**.**

Table 25: Closure cost summary spreadsheet

	Closure components	CLOSURE SCHEDULES-2016									
		Washing Plant (GHS)	Washing Board (GHS)	Anwona (GHS)	Dig and Wash (GHS)	Dredging (GHS)	Sample Pit (GHS)	Abandoned Shafts (GHS)	Chamfi (GHS)	Mill House (GHS)	Total (GHS)
1	Infrastructural, Mining Reclamation and Monitoring Aspects										
	Sub-Total 1	**108,825,266.30**	**700,104,768.03**	**2,254,054.95**	**45,559,485.38**	**8,946,963.20**	**63,568,801.09**	**1,179,707.57**	**49,645,467.59**	**7,622,650.43**	**987,707,164.53**
	Additional Allowances										
1	Preliminary and general										
2	Contingencies										
	Sub-Total 2										
	Grand Total Excl. VAT. (Sub-total 1 +2)	**108,825,266.30**	**700,104,768.03**	**2,254,054.95**	**45,559,485.38**	**8,946,963.20**	**63,568,801.09**	**1,179,707.57**	**49,645,467.59**	**7,622,650.43**	**987,707,164.53**

CONCLUSION

The illegal artisanal mining cycle is well known: discovery, migration, and relative economic prosperity are followed by resource depletion, outmigration and economic destitution. Drugs, prostitution, disease, gambling, alcohol abuse, and degradation of moral standards are frequent consequences of the chaotic occupation at galamsey sites. It is apparent that the economic benefits obtained by the miners do not compensate for the deplorable socio-economic conditions left to surrounding communities. After depletion of easily exploitable gold reserves, sites are abandoned, and those who remain contend with a legacy of environmental devastation and extreme poverty. These people have little opportunity to escape their circumstances. Thousands of abandoned artisanal mines can be found in the Western Region of Ghana, and those currently operating will undoubtedly experience the same fate.

This paper focuses on an important consequence of galamsey: closure and reclamation. By better understanding the magnitude of impacts caused, closure, decommissioning and costing principles relating to the various types of galamsey generally found within the Western Region of Ghana, effective measures for prevention and mitigation of pollution are more likely to be developed and implemented. Key information gathered included; types of galamsey, their spatial distribution pattern, their land-take estimation, stakeholder consultations and contaminant levels measurements.

The chamfi (45.47%), alluvial washing board (43.4%) and river/stream dredging (4.94%) galamsey are the three operations with most extensive footprint. According to Mantey et al., 2016, the chamfi and alluvial washing board galamsey are only next to the underground sample pit as the galamsey types with the highest number of individuals within clusters. The chamfi operation, having the third highest number of sightings made and second highest number of individuals within clusters (sightings), operates using the Chan Fa engine for simultaneous mining and gold extraction. It has since its introduction over a decade ago in Ghana by the Chinese enjoyed much popularity among galamsey operators. It requires a small parcel of gold-laden land and a relatively low start-up cost. It is a highly efficient, easy to use, mobile or potable and can handle both alluvial and lode/vein deposits with ease. The low feeding rate or loading capacity is compensated for by having many set-ups per an area; thus having them in clusters.

The washing board galamsey is the most sighted and comes after the underground sample pit and chamfi as the operations with highest number of individuals within clusters due to the abundance of alluvial deposits and water bodies across the entire stretch of the Wassa Amenfi East district and some vast portions of the Tarkwa Nsuaem and Prestea Huni Valley districts (which are identified as the three main washing board MDA hotspots). The washing board also represents the most economical way or profitable means of commercially extracting low grade and alluvial deposits. It is the galamsey type most practiced by foreigners, especially the Chinese. It is also very popular within all three Amenfi Districts (East, Central and West) considered due to the very rural certain they present, their alluvial deposits and drainage networks, low level of law enforcement and limited activity of LSMs. With the exception of the Nzema East, Mpohor and Ellembelle, the eight remaining MDAs considered in the research were found to be hosting alluvial washing board galamsey.

The three most impacted districts, in terms of land-take or operational footprint, are the Amenfi East (58.272%), Tarkwa Nsuaem (17.532%) and Prestea Huni Valley (8.452%). This is due to the fact that these districts host the highest percentage of chamfi and alluvial (washing board) operations, which generally requires a large area of land to profitably operate. Although the Tarkwa Nsuaem (276 sightings with approximately 3,628 individuals), Amenfi East (223 sightings and 1,397 individuals) and Prestea Huni-Valley Districts (153 sightings and 1,114 individuals) were earlier on noted as the three main galamsey hotspots, their land-take information did not follow the same pattern. Generally, underground and mill house operations have very limited land sizes compared to the chamfi and alluvial washing board; hence their footprint trends recorded. The Sefwi Wiawso (0.002%), Bibiani-Anhwiaso-Bekwai (0.344%), Wassa East (0.414%) and Nzema East Districts (0.416%) are the four MDAs least proliferated by galamsey operators.

From the geochemically perspective, the four main pollution concerns requiring attention in galamsey are high TSS or turbidity levels, oil and grease, arsenic and mercury; most especially for the commercially driven alluvial operations and mill house galamsey. The underground operations (sample pit and abandoned shaft) employ the use of diesel and petrol for water discharges but rarely use mercury since virtually any form of gold extraction takes place at the mining sites. The radiological analysis of water and soil matrices at the various galamsey sites revealed that the illegal mining and or processing activities have minimally impacted on the soil and surface water resources and does not pose an immediate environmental hazard to the human population, wildlife and the surrounding ecosystem.

This reclamation and closure plan is prepared for the nine galamsey types that generally exist within the Western Region with the objective of returning the site to a suitable state which would support pre-mining land use activities such as small-scale agriculture, hunting, and artisanal forestry. In addition, the intent is to leave the site at closure with better water quality in available drainage system downstream than existed when the galamsey businesses were in operation.

The closure plan includes driving away galamsey operators and restricting access to the general public; long-term drainage management; the demolition, dismantling and removal of the galamsey infrastructures (mill houses, washing board sluices, washing plant/trommel, electrical installations, chan fa diesel engines, smoothing machines, concrete platforms, roofing systems, compressors, blowers etc.); the filling of open pits and holes; housekeeping and general clean-up of sites; salvaging of abandoned heavy duty equipments (dozers, excavators, graders, Toyota Pick-ups/Tundras etc.); conduct of site characterization/geochemistry exercises; pumping and treatment of polluted waters; phytoremediation of affected land and wetlands; the revegetation of disturbed areas with native seedlings grown; and the monitoring of surface water quality, rehabilitated sites and general care and maintenances of facilities until parameters meets the Ghanaian EPA and Best Management Practices.

An estimated total amount of ***GHS 987,707,164.53*** is required for returning galamsey affected lands to states close to originality. The closure details or spreadsheets can be found in attached appendices. Due to the very high dynamisms within galamsey, it is recommended that periodic environmental impact and inventory is undertaken. A much more detailed consultation and stakeholder engagement processes should be observed for a collaborative approach to closure to be achieved. Detailed site characterization and geochemical studies, which includes acid rock drainage (ARD), screening of galamsey operators, groundwater quality assessments and geotechnical and hydrogeological modeling for the various types of galamsey.

REFERENCES

1. Mantey, J., Owusu-Nimo, F., Nyarko, K.B. and Aubynn, A., 2016. The Operational Dynamics of "Galamsey" Within Eleven (11) Selected Districts of the Western Region, Ghana. Journal of Mining and Environment.
2. GEF/UNDP/UNIDO, 2006. Manual for Training Artisanal and Small-Scale Gold Miners/Veiga, M.M. et al./Vienna, Austria: GEF/UNDP/UNIDO, 2006, 144p. (http://www.responsiblemines.org/attachments/221_training%20manual%20for%20miners%20GMP%20Marcelo%20Veiga.pdf?phpMyAdmin=cde87b62947d46938306c1d6ab7a0420)
3. Salim-Nuhu, A., (2013). An assessment of an environmental problem in Ghana and proposed solutions based on environmental economic principle. htm lhttp://www.ghanaweb.com/GhanaHomePage/features/artikel.php?ID=294578 (accessed on 8th May 2015)
4. 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. http://www.profor.info/sites/profor.info/files/docs/Methodological%20Toolkit.pdf
5. Hilson, G.H., 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

6. Tom-Aba D, Olaleye A, Olayinka AT, Nguku P, Waziri N, Adewuyi P, et al. (2015) Innovative Technological Approach to Ebola Virus Disease Outbreak Response in Nigeria Using the Open Data Kit and Form Hub Technology. PLoS ONE 10(6): e0131000. doi:10.1371/journal.pone.0131000.
7. UNHCR, 2010. Material for data collection with Android:ODK. http://www.parkdatabase.org/files/documents/2010_How-to-Use-an-Emulator_UNHCR.pdf
8. http://www.ghanaweb.com/GhanaHomePage/NewsArchive/Illegal-mining-a-threat-in-Ghana-67451 (accessed on 13th May 2016)
9. http://www.nytimes.com/2013/06/07/world/africa/ghana-arrests-chinese-in-gold-mining-regions.html?_r=0 (accessed on 13th May 2016)
10. http://vibeghana.com/2013/02/11/chinese-illegal-miner-shoots-three-intruders-in-ghana/ (accessed on 13th May 2016)
11. 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)
12. Griffis, R.J., Barning, Kwesi, Agezo, F.L., and Akosah, F.K., 2002, Gold Deposits of Ghana, Minerals Commission, Accra Ghana. www.ghanamincom.gsf.fi
13. **http://www.ghanadistricts.com/Region-Links.aspx?s=3077&r=10**
14. Chaudhri, et al 2015. R. Chaudhri, et al. (2013). Decentralized Human Milk Banking with ODK Sensors. Proceedings of the 3rd ACM Symposium on Computing for Development, Article No. 4.
15. ICMM & Ghana Chamber of Mines (GCM), 2015. Mining in Ghana –What future can we expect? http://www.tabforestmines.com/wp-content/uploads/2015/10/Ghana-Chamber-of-Mines-report.pdf (accessed on 10th April 2016
16. Ghana Statistical Services (GSS), 2014. District Analytical Report- Ellembele District Assembly, 2010 Population and Housing Census; http://www.statsghana.gov.gh/docfiles/2010_District_Report/Western/Ellembelle.pdf
17. Ghana Statistical Services (GSS), 2014. District Analytical Report- Tarkwa Nsuaem Municipal Assembly, 2010 Population and Housing Census;
18. Deo Shao, 2012. A Proposal of a Mobile Health Data Collection and Reporting System for the Developing World. Master Thesis Project 30p, Spring 2012. Malmö University, Department of Computer Science. School of Technology Department of Computer Science.
19. http://www.statsghana.gov.gh/docfiles/2010_District_Report/Western/Tarkwa%20Nsuaem.pdf
20. Ghana Statistical Services (GSS), 2014. District Analytical Report- Mpohor District Assembly, 2010 Population and Housing Census; http://www.statsghana.gov.gh/docfiles/2010_District_Report/Western/Mpohor.pdf
21. http://ghanalocalassemblies.gov.gh/districts/?news&r=5&_=178
22. Ghana Statistical Services (GSS), May 2015; Ghana Poverty Mapping Report. http://www.statsghana.gov.gh/docfiles/publications/POVERTY%20MAP%20FOR%20GHANA-05102015.pdf (accessed on 4th July 2016)
23. http://www.ghanadistricts.com/regional.aspx?Western&r=10 (accessed on 11th April 2016)

24. Ghana Statistical Services (GSS), 2014. District Analytical Report- Axim Municipal Assembly, 2010 Population and Housing Census; http://www.statsghana.gov.gh/docfiles/2010_District_Report/Western/NZEMA%20EAST.pdf
25. Ghana Statistical Services (GSS), 2014. District Analytical Report- Sefwi Wiawso Municiap Assembly, 2010 Population and Housing Census; http://www.statsghana.gov.gh/docfiles/2010_District_Report/Western/Sefwi%20Wiawso.pdf
26. Ghana Statistical Services (GSS), 2014. District Analytical Report- Bibiani-Anwhiase-Bekwae District Assembly, 2010 Population and Housing Census; http://www.statsghana.gov.gh/docfiles/2010_District_Report/Western/Sefwi-%20Bibiani%20Ahwiaso%20Bekwai.pdf
27. Ghana Statistical Services (GSS), 2014. District Analytical Report- Amenfi East District Assembly, 2010 Population and Housing Census; http://www.statsghana.gov.gh/docfiles/2010_District_Report/Western/Wassa%20Amenfi%20East.pdf
28. Ghana Statistical Services (GSS), 2014. District Analytical Report- Prestea Huni-Valley District, 2010 Population and Housing Census; http://www.statsghana.gov.gh/docfiles/2010_District_Report/Western/Prestea%20Huni-Valley.pdf
29. **Ghana Minerals Commission, Small Scale Mining database 2014.**
30. Ghana Statistical Services (GSS), 2014. District Analytical Report- Amenfi Central District Assembly, 2010 Population and Housing Census; http://www.statsghana.gov.gh/docfiles/2010_District_Report/Western/Wassa%20Amenfi%20Central.pdf
31. Ghana Statistical Services (GSS), 2014. District Analytical Report- Amenfi West District Assembly, 2010 Population and Housing Census http://www.statsghana.gov.gh/docfiles/2010_District_Report/Western/Amenfi%20West.pdf
32. Ghana Statistical Services (GSS), 2014. District Analytical Report- Wassa East District Assembly, 2010 Population and Housing Census
33. Chaudhri, et al 2015. R. Chaudhri, et al. (2013). Decentralized Human Milk Banking with ODK Sensors. Proceedings of the 3rd ACM Symposium on Computing for Development, Article No. 4.
34. Anokwa, Y., Hartung, C., Brunette, W., Borriello, G. and Lerer, A. 2009. Open source data collection in the developing world, Computer, Vol. 42, pp. 97-99, 2009.
35. Francis Smart 2015. Open Data Kit: Making it Work; For you. MSU and USAID.
36. Hartung, C., Anokwa, Y., Brunette, W., Lerer, A., Tseng, C. and Borriello, G. 2010. Open data kit: Building information services for developing regions, Proc. ICTD, 2010.
37. http:// opendatakit.org (accessed on 3rd April 2016)
38. https://opendatakit.org/help/training-guides/ (accessed on 23rd April 2016)
39. A. Raja, A. Tridane, A. Gaffar, T. Lindquist, and K. Pribadi , 2014. Android and ODK based data collection framework to aid in epidemiological analysis. Online J Public Health Inform. 2014; 5(3): 228. Published online 2014 Feb 5. doi: 10.5210/ojphi.v5i3.4996. PMCID: PMC3959915
40. University of Notre Dame, 2014. Introduction to Open Data Kit; A suite of tools to collect data and build information services; Workshop sponsored by: Center for Social Research, Eck Institute for Global Health, Initiative for Global Development, Kellogg Institute for International Studies, mobileND, O_ce of Information Technologies
41. https://www.highbeam.com/doc/1P3-3704531581.html (accessed on 13th May 2016)
42. Anokwa, Y., Hartung, C., Brunette, W., Borriello, G. and Lerer, A. 2009. Open source data collection in the developing world, Computer, Vol. 42, pp. 97-99, 2009.
43. Hartung, C., Anokwa, Y., Brunette, W., Lerer, A., Tseng, C. and Borriello, G. 2010. Open data kit: Building information services for developing regions, Proc. ICTD, 2010.
44. Ghana Statistical Services (GSS), 2014. District Analytical Report- Amenfi West District Assembly, 2010 Population and Housing Census http://www.statsghana.gov.gh/docfiles/2010_District_Report/Western/Amenfi%20West.pdf

APPENDIX A: Summary of Mineral Output and Revenue (2013 and 2014)

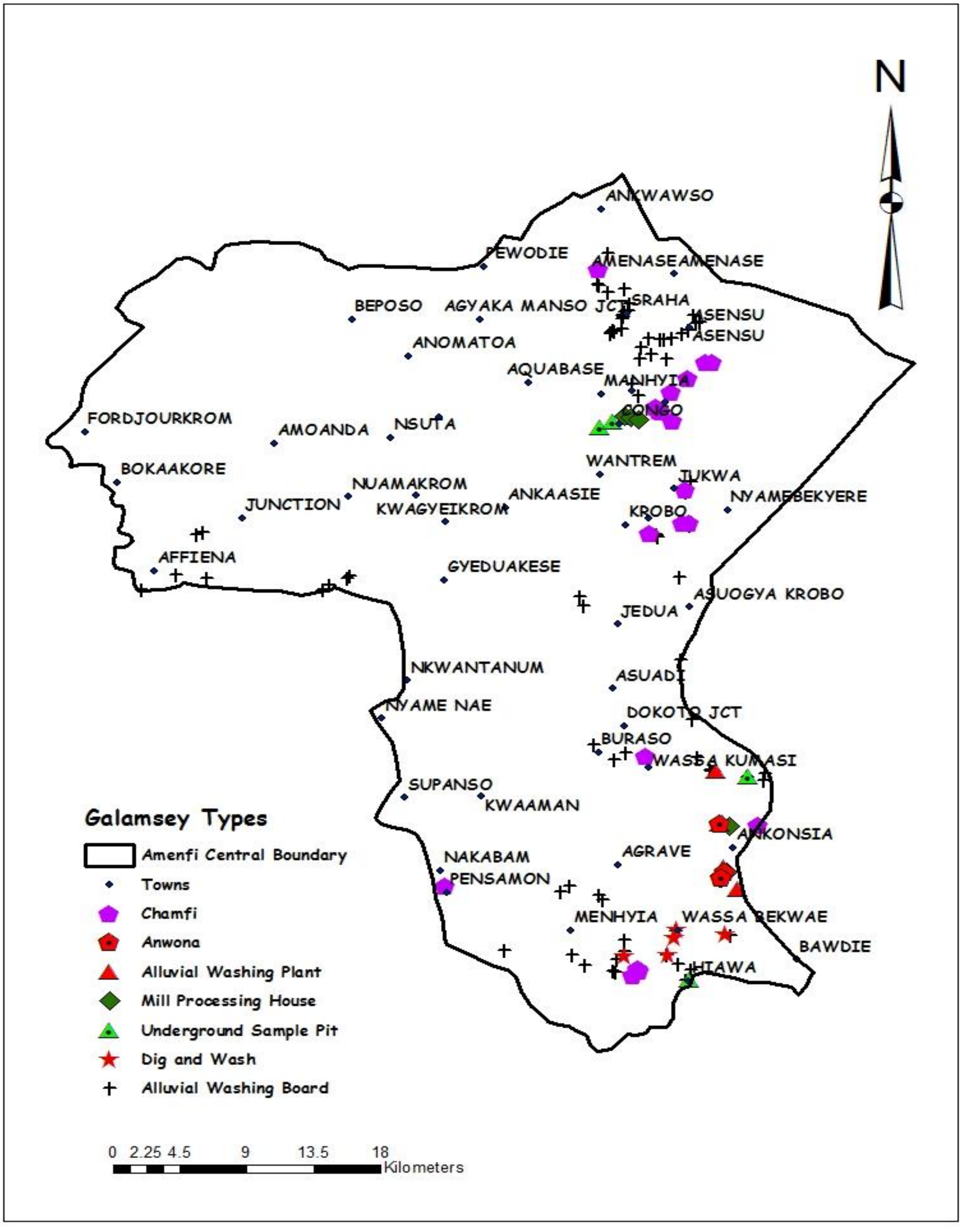
COMPANY	2013		2014	
	PRODUCTION	REVENUE (US $)	PRODUCTION	REVENUE (US$)
AGA- OBUASI	239,052	414,794,330	243,223	313,666,710
AGA- IDUAPRIEM	220,658	301,112,215	176,930	234,604,046
GFG- TARKWA	632,244	893,149,334	558,222	590,393,835
GFG- DAMANG	153,117	216,444,000	177,741	224,652,540
GSBPL	144,997	204,743,250	147,957	186,181,634
GSR- WASSA	185,808	263,072,401	112,835	142,734,191
CHIRANO	274,683	385,457,028	286,326	354,691,899
NEWMONT- AHAFO	570,155	793,670,767	442,020	565,732,824
NEWMONT- AKYEM	129,211	163,888,151	471,658	595,474,578
ADAMUS	105,215	143,205,706	88,476	144,592,629
PERSEUS	198,608	279,883,073	187,363	238,110,562
PMMC - GOLD	216,381	387,601,517	265,350	238,110,562
ASAP VASA	122,518	163,262,284	9,652	12,633,028
PMMC - DIAMOND	159,074	8,030,808	241,120	10,700,962
GHANA MANGANESE COMPANY	1,997,911	135,475,951	1,353,486	91,147,458

APPENDIX B: NUMBER OF SIGHTINGS MADE

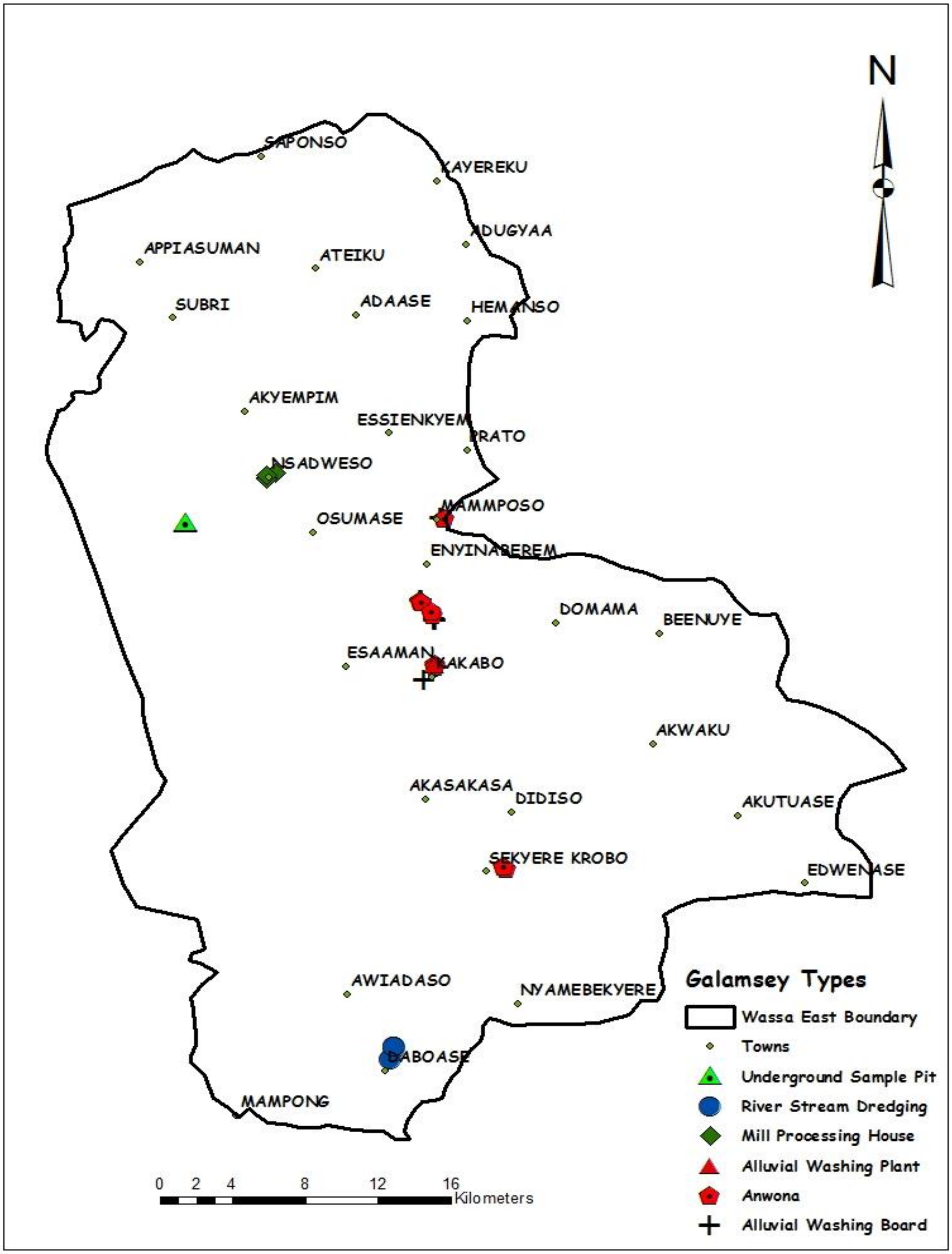
MDAs	GALAMSEY TYPES																			
	AWB		AWP		ANW		CHAM		D&W		MHP		R/S DRE		UOAS		USP		Cluster Totals	Total Sightings
	Cluster	*Sightings*	*Cluster*	*Sightings*	*Cluster*	*Sightings*	*Cluster*	*Sightings*	*Cluster*	*Sightings*	*Cluster*	*Sightings*	*Cluster*	*Sightings*	*Cluster*	*Sightings*	*Cluster*	*Sightings*		
WAC	104	*36*					92	*7*	43	*7*	6	*3*					382	*7*	**627**	**60**
AE	374	*109*	32	*9*	14	*5*	703	*61*	105	*15*	21	*15*					148	*9*	**1397**	**223**
AW	151	*34*			1	*1*	18	*1*	15	*1*	3	*1*							**188**	**38**
BAB	95	*29*	6	*2*							12	*12*			6	*6*	25	*5*	**144**	**54**
ELL							25	*5*	4	*1*									**29**	**6**
MPOR							52	*9*	11	*2*	1	*1*	1	*1*			25	*3*	**90**	**16**
NE							16	*5*	4	*1*									**20**	**6**
PHV	25	*6*	9	*3*			254	*29*	78	*12*	83	*67*			9	*6*	656	*30*	**1114**	**153**
SW	2	*2*									2	*2*							**4**	**4**
TNM	63	*7*	6	*3*	46	*5*	583	*35*	173	*25*	155	*111*	162	*38*	15	*10*	2425	*42*	**3628**	**276**
WE	23	*11*	1	*1*	55	*10*					4	*4*	13	*4*			40	*2*	**136**	**32**
Total	**837**	***234***	**54**	***18***	**116**	***21***	**1743**	***152***	**433**	***64***	**287**	***216***	**176**	***43***	**30**	***22***	**3701**	***98***	**7377**	**868**

- WAC: Wassa Amenfi Central;
- AE: Amenfi East
- AW: Amenfi West
- BAB: Bibiani-Anwhiase-Bekwai
- ELL: Ellembelle
- MPOR: Mpohor
- NE: Nzema East
- PHV: Prestea Huni Valley District
- SW: Sefwi Wiawso
- TNM: Tarkwa Nsuaem Municipality
- WE: Wassa East (Daboase)

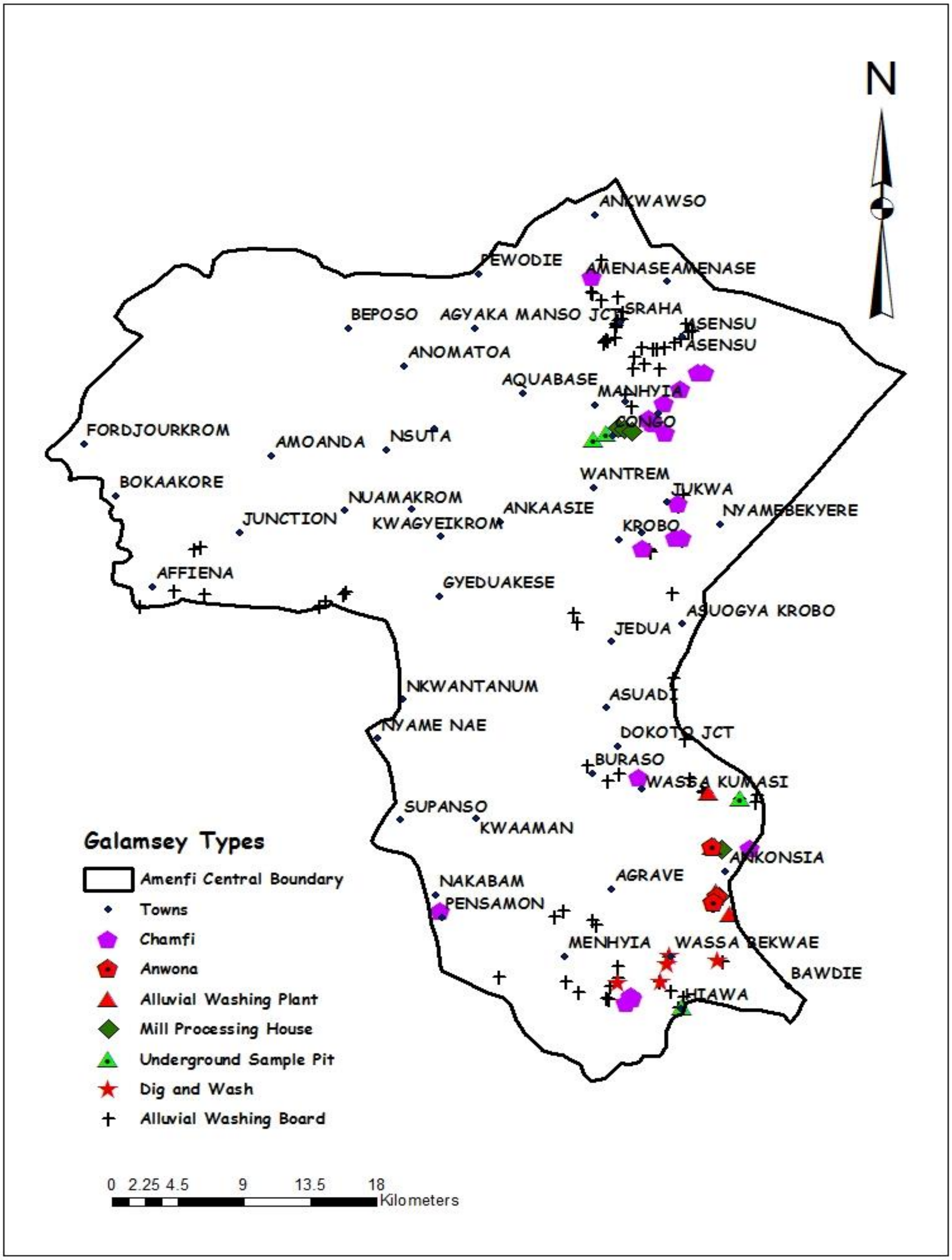
APPENDIX C: Galamsey Distribution Maps for less proliferated MDAs



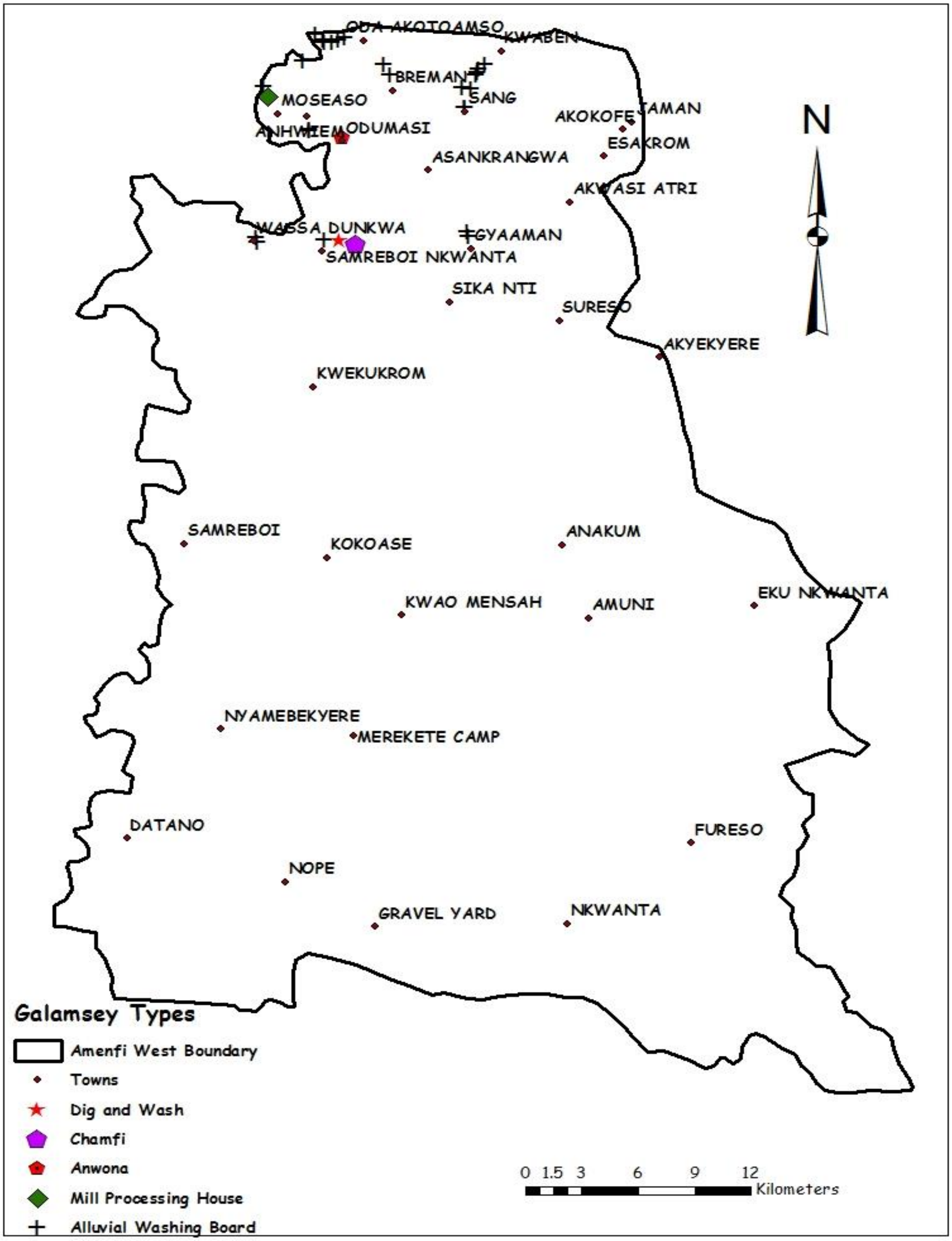
C1: Distribution of galamsey types within the ***Amenfi Central***



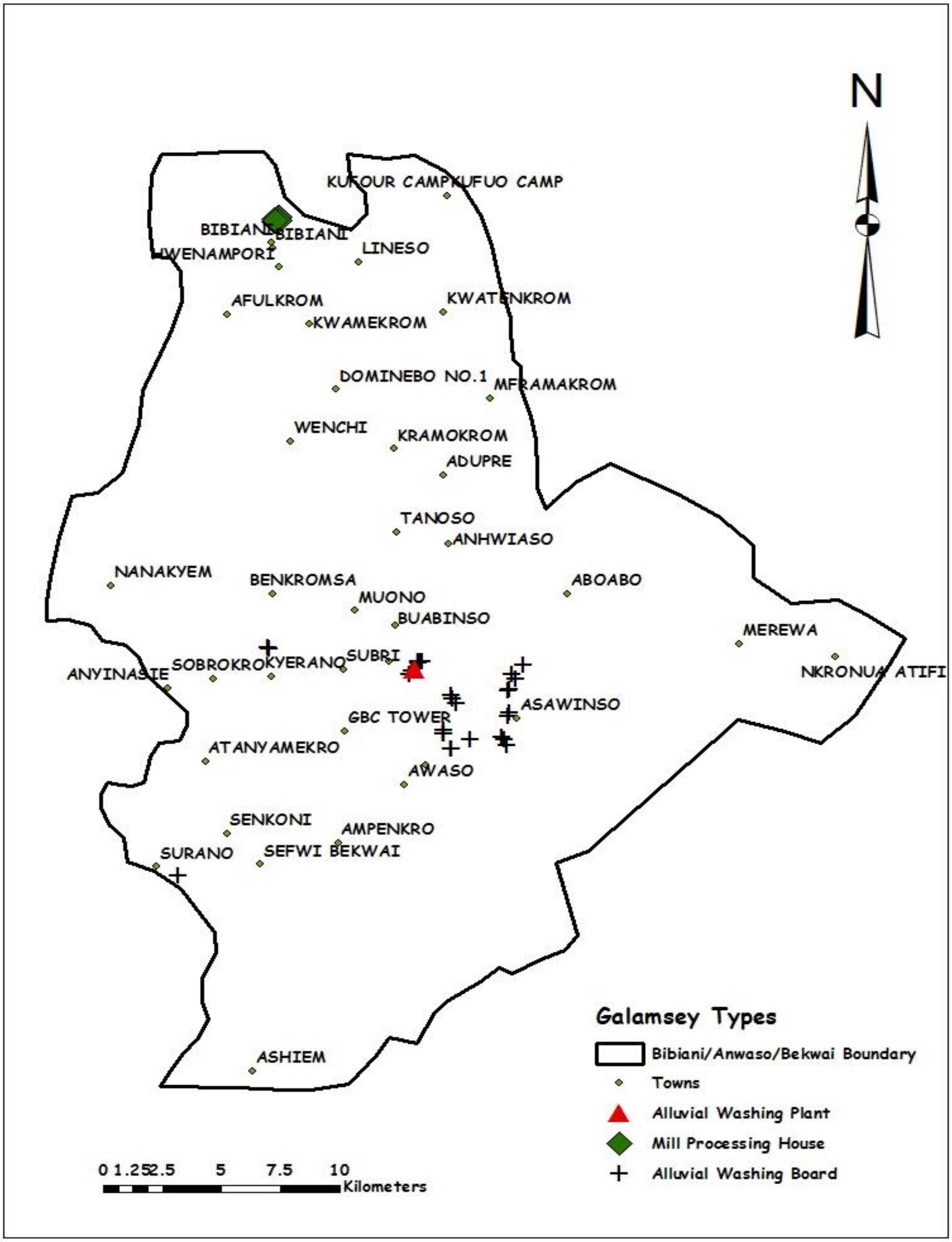
C2: Distribution of galamsey types within the ***Wassa East***



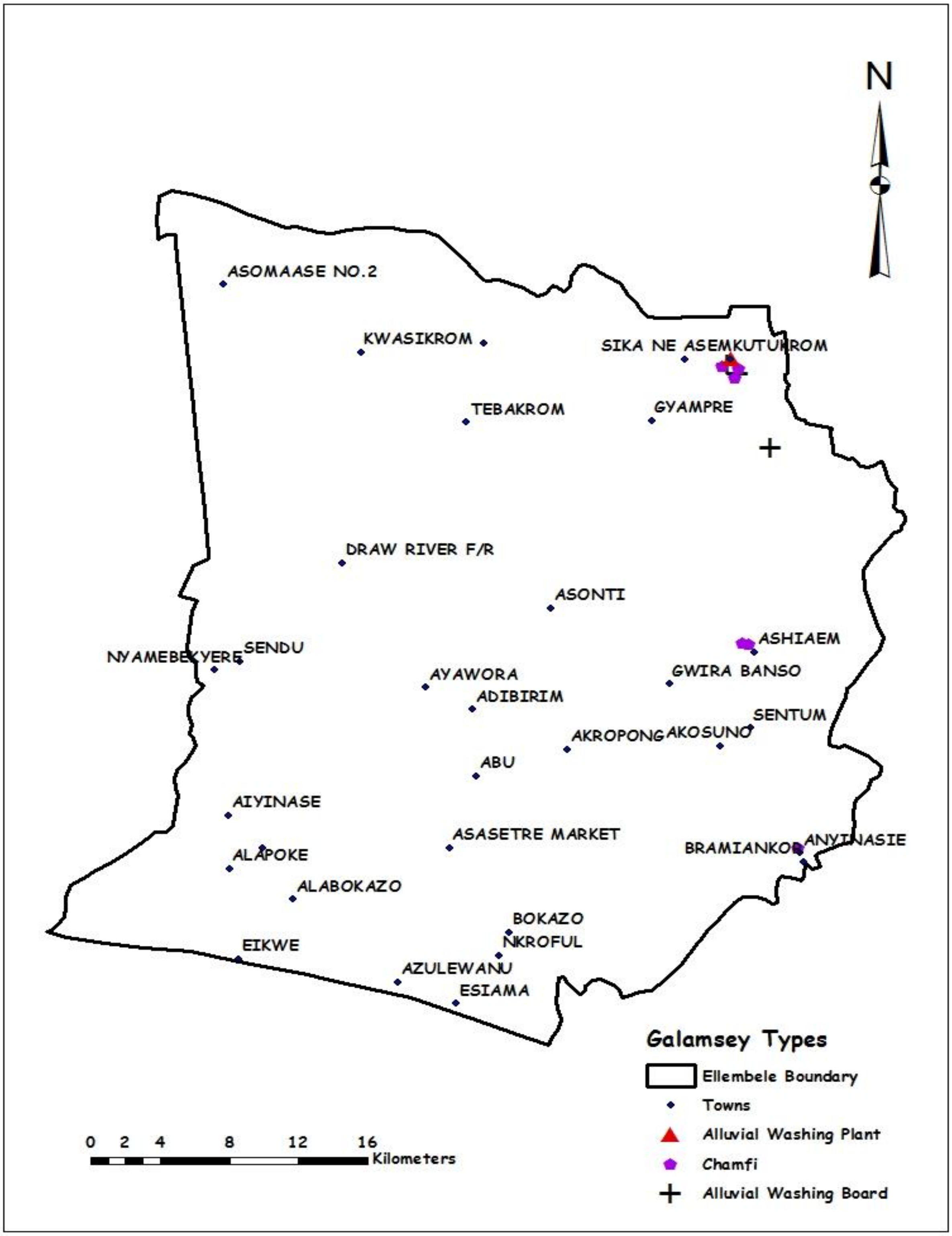
C3: Distribution of galamsey types within the ***Amenfi Central***



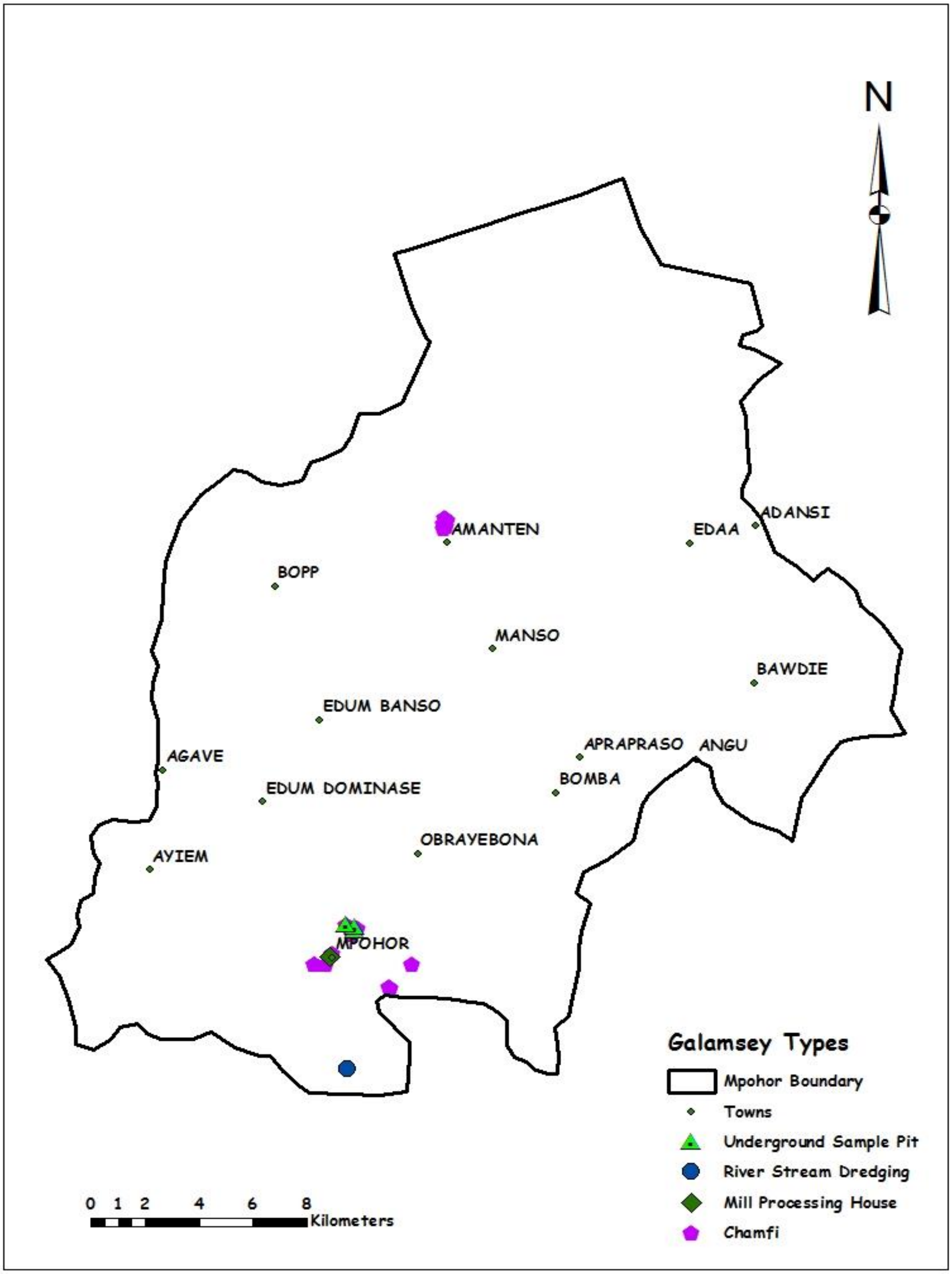
C4: Distribution of galamsey types within the ***Amenfi West***



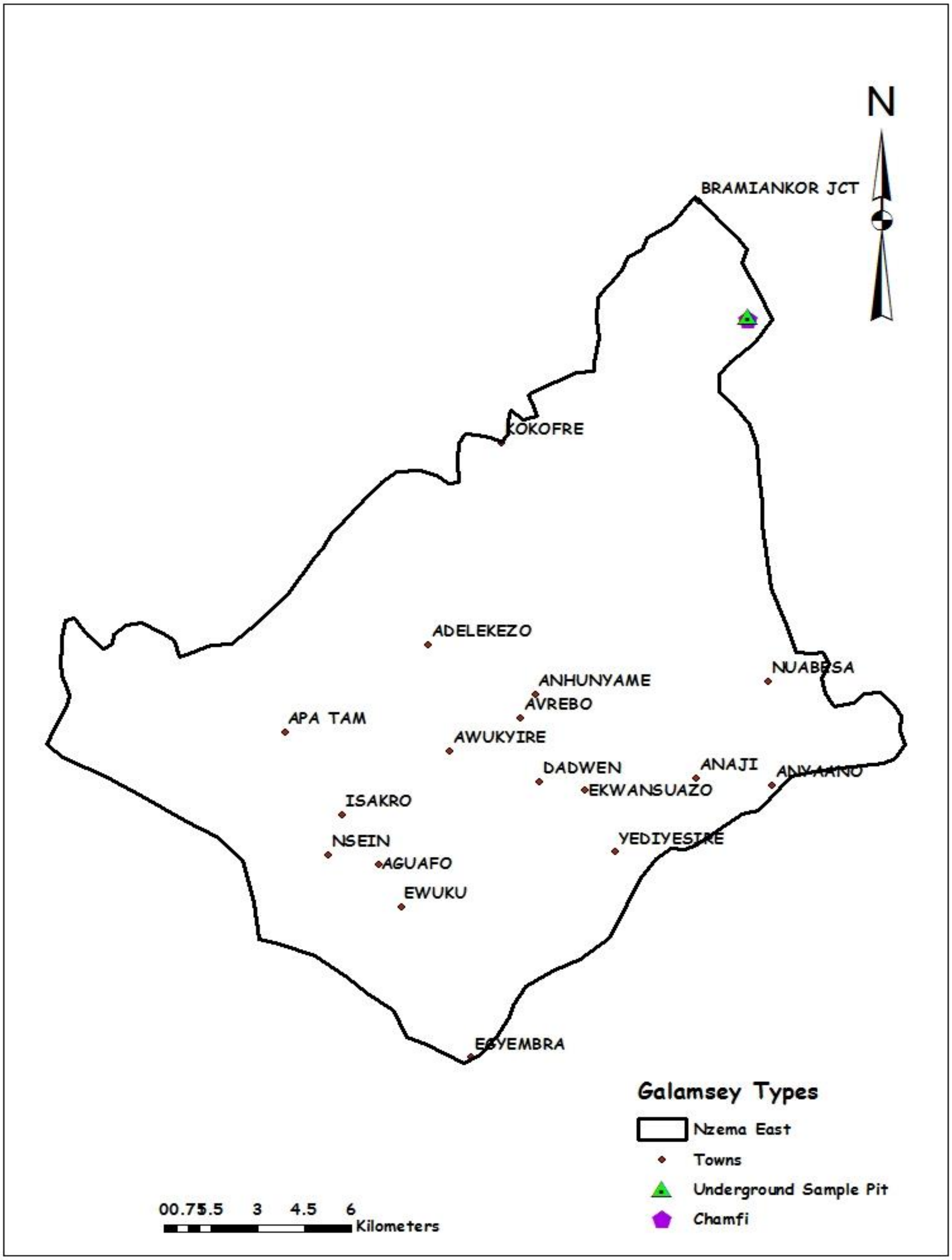
C5: Distribution of galamsey types within the ***Bibiani-Anwiase-Bekwai***



C6: Distribution of galamsey types within the ***Ellembelle***



C7: Distribution of galamsey types within the ***Mpohor***



C8: Distribution of galamsey types within the ***Nzema East***

APPENDIX D: Overview of the ODK Questionnaire

ITEMS		
A. FUNDAMENTALS	**DETAILS/FINDINGS**	
Date:		
Time:		
Municipality/District:		
Town/Village:		
Type of galamsey mining/processing:		
Galamsey Site Code/Number:		
GPS Coordinates for galamsey site:		
Age of galamsey operation:		
Weather condition at time of visit ***(Select all that apply):***		
• Windy:		
• Sunny:		
• Rainy:		
• Cloudy		
• After a raining event:		
B. SITE FEATURES/MACHINERY/MATERIALS	**TERRAIN CLASS**	
Terrain Classification (*Select all that apply):*		
Ground Condition		
• Very good		
• Good		
• Average		
• Poor		
• Very Poor		
Ground Roughness		
• Very even		
• Slightly Even		
• Uneven		
• Rough		
• Very Rough		
Slope		
• Level		
• Gentle		
• Moderate		
• Steep		
• Very Steep		
Machinery & Equipment Use (*Select all that apply):*	**QUANTITY**	**DIMENSIONS/DESCRIPTIONS**
• Excavators		
• Pumps		
• Sacks (empty)		

• Sacks (filled with load)		
• Bowls/Vats		
• Half-cut drums (metallic)		
• Half-cut drums (rubber/plastic)		
• Earth Chisels		
• Guns		
• Gensets/generators		
• Light vehicles (e.g. Toyota Tundra, Nissan, Kia etc.)		
• Motor bikes		
• Bicycles		
• Cutlasses/machetes		
• Stools/Chairs		
• Buckets/ Basins		
• Iron bars or pry bars		
• Wheel barrows		
• Compressor		
• Shovels/spades		
• Sieves		
• Morta and pestle		
• Blowers (tunnels and underground use)		
• Sledge hammers		
• Washing plant (Chinese)		
• Washing board (Chinese)		
• Fans		
• Shanking tyres (sample tyres)		
• Drying felt/tarpaulin		
• Touch lights/Lamps		
• Furnace		
• Charcoal		
• **Others**		
C. CHEMICAL/REAGENTS USE		

Chemicals used for operation ***(Select all that apply):***	**ESTIMATED MONTHLY CONSUMPTION**
• Cyanides	
• Mercury	
• Diesel	
• Kerosene	
• Grease	
• Bollas	
• Acids	
• Engine oil	
• Petrol/Gasoline	
• Other Lubricants	
• **Others**	

D. WATER USE & DISPOSAL PATTERN	ESTIMATDED MONTHLY CONSUMPTION	
Raw Water Sources ***(for processing):***		
• Stream/River (provide name of water body)		
• Standing pipe/Tap from Ghana Water		
• Groundwater/Bore hole		
• Adjacent Wetland		
• Pond		
• Rainwater collection		
• Lake (provide name of Lake)		
• **Others**		
Waste Water/Effluent Discharges ***(Select all that apply):***	**DISCHARGE POINTS**	**MEANS OF DISCHARGE**
• Into adjacent Stream/River		
• Into Groundwater/Bore hole		
• Into Adjacent Wetland		
• Into Pond		
• Into surrounding environment		
• **Others**		
E. USE OF ENERGY/POWER	**YES/NO**	
Source of Power/Electricity ***(Select all that apply):***		
• ECG		
• IPP (From an Independent Power Producer)		
• Self-generating		
Use of Power ***(Select all that apply):***	**YES/NO**	
• Houses/Offices		
• Processing/Milling House		
• Underground operation		
• Blowers		
• Pumps		
• Mining site		
• Others		
F. ENVIRONMENTAL ASSESSMENT (VISUAL)	**YES/NO**	**COMMENTS/OBSERVATIONS**
Water Impacts ***(Select all that apply):***		
• Name(s) of water body:		
• Water is emanating from facility?		
• Water is passing through facility?		
• Standing/stagnant?		
• Fully Filled?		
• Partially filled		
• Flowing?		
• Silted?		

• Turbid?		
• Oil-film on surface?		
• Others		
Observed water colour ***(Select all that apply):***		
• Brown		
• Green		
• Yellow		
• Yellow-orange		
• Orange		
• Grey-black		
• Others		
Vegetation Assessment ***(Select all that apply):***		
• Healthy		
• Unhealthy/Sick		
• Full revegetation		
• Depleted/deforested		
• Others		
Soil/Ground Contaminations ***(Select all that apply):***		
• Diesel		
• Petrol		
• Grease		
• Kerosene		
• Other		
Housekeeping/Waste Management Practices ***(Select all that apply):***		
• Human excreta		
• Serious littering/waste		
• Landfills		
• Others		
ARD tell-tale signs ***(Select all that apply):***		
• Bright orange-colored water		
• Yellow-orange solid (yellow boy)		
• Low pH waters		
• Others		
Mine Waste disposal facilities ***(Select all that apply):***		
• Piles/Heaps		
• Pit/excavation/pit		
• Above ground		
• Underground		
• Away from operational site		
• Collection by ASM/LSM (provide names)		
• **Others**		
Processing Waste disposal ***(Select all that apply):***		
• Shumps (solid)		
• Shumps (Liquid)		

• Pit/excavation/pit		
• Above ground/piled on ground surface		
• Underground		
• Adjacent operational site		
• Away from operational site		
• Collection by ASM/LSM (provide names)		
Wildlife Impacts *(Select all that apply):*		
• Signs of dead mammals		
• Dead Fishes		
• Dead Birds		
• Others		
Extent of Restoration/Reclamation *(Select all that apply):*		
• Earthworks/Landscaping		
• Natural Regeneration/Revegetation		
• Demolitions/dismantling		
• Unreclaimed/unrestored		
• Reclaimed/restored		
• Others		

G. SAMPLING	COMMENTS/OBSERVATIONS
Surface water sampling	
• Number of samples	
• Sample code	
• Sample location (GPS Coordinates)	
Ground/sub-surface water sampling	
• Number of samples	
• Sample code	
• Sample location (GPS Coordinates)	
Soil sampling	
• Number of samples	
• Sample code	
• Sample location (GPS Coordinates)	
Sediments sampling	
• Number of samples	
• Sample code	
• Sample location (GPS Coordinates)	

The International Growth Centre (IGC) aims to promote sustainable growth in developing countries by providing demand-led policy advice based on frontier research.

Find out more about our work on our website www.theigc.org

For media or communications enquiries, please contact mail@theigc.org

Subscribe to our newsletter and topic updates www.theigc.org/newsletter

Follow us on Twitter @the_igc

Contact us
International Growth Centre,
London School of Economic and Political Science,
Houghton Street,
London WC2A 2AE

International Growth Centre

DIRECTED BY

FUNDED BY

Designed by soapbox.co.uk