GeoJournal (2023) 88:789–810
https://doi.org/10.1007/s10708-022-10642-3

Geospatial characterisation and distribution of Illegal gold mining (galamsey) operations in Upper West Region, Ghana

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Accepted: 28 March 2022 / Published online: 16 April 2022

Abstract Recent interest by governmental, non-governmental and civil society organisations in monitoring, tracing, tracking and flushing out illegal mining activities in Ghana has intensified due to the fact that large tracts of arable lands, forests and water resources are destroyed by this group of illegal miners. Yet, the scale of operation, types, characteristics and spatial distribution of illegal mining activities across the 16 regions of Ghana remain inadequate in the scientific literature. This study investigates the types, characteristics and spatial distribution of galamsey activities in Upper West Region. Cross-sectional spatial data were sourced using Garmin GPS extre 30 and corroborated with key informant interviews in Wa East, Wa West and Nadowli-Kaleo Districts. From the results, a total of 2505 individual sightings under 6 major galamsey types (underground pit, dig and check, dig and wash, chamfi, mill house and shormp) were uncovered. The results showed that Wa West District is dominated by the dig and check galamsey while Wa East District hosts the large majority of the underground pits. In addition, Nadowli-Kaleo District is dominated by the underground pit galamsey. Wa East District was the hotspot of illegal mining activities (1644 sightings) in the region. Based on the characterisation, this study, argued that galamsey activities in Upper West Region are still at the rudimentary stage as compared to other geographies in Ghana. Constant monitoring of the where and how ASM activities are being carried out in the region is pertinent in eradicating and reclaiming galamsey degraded lands.

Keywords Artisanal and small-scale mining · Galamsey · Spatial distribution · Land degradation

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Introduction

The mining sector is a major economic fulcrum for many countries in the developing world (Hirons, 2020; Tuokuu et al., 2020; Zolnikov, 2020). Precious minerals such as gold, manganese, diamond and bauxite are extracted on a large-scale and artisanal and small-scale basis in these geographies. However, artisanal and small-scale mining (ASM),

particularly gold mining dominates in most societies in sub-Saharan Africa (Hilson, 2010, 2016). Sub-Saharan Africa exclusively hosts about 20 million artisanal and small-scale miners and associated dependents of about 100 million (Hilson, 2017). In Ghana, the research focus, recent reports revealed that approximately a million and 4.5 million people directly and indirectly engage in artisanal and small-scale mining operations, respectively (McQuilken & Hilson, 2016). In fact, artisanal and small-scale mining activities have proliferated the entire geographic landscape of Ghana, and in spite of the fact that ASM activities were previously fixed to Southern Ghana (Ofosu-Mensah, 2010), Northern Ghana (Upper West Region) have recorded substantial numbers of illegal small-scale mining activities in recent times (Baddianaah et al., 2021; Hilson et al., 2013; Osumanu, 2020).

The surge in ASM activities largely result in conflicts between large-scale mining groups and the small-scale miners over access to mineralised lands. Large-scale mining groups are recognised and certified by the responsible state institutions such as the Minerals Commission, Environmental Protection Agency (EPA) and the host Metropolitan, Municipal and District Assemblies (MMDAs) to operate within designated concessions (Hilson, 2002). On the contrary, a majority of the artisanal and small-scale mining groups engage in illegal manoeuvrings, and on most occasions, invade large-scale mining concessions with impunity to mine, often resulting in conflict between the two groups of miners (Hilson, 2002; Hilson & Yakovleva, 2007; Yakovleva & Vazquez-Brust, 2018; Yankson & Gough, 2019). Besides, other land use conflicts involving the miners and farmers as a result of the degradation of arable lands by the illegal mining operators are highlighted (Nicholls et al., 2020). Moreover, recent studies have argued that artisanal and small-scale mining activities have a greater positive effect on the local economy (Guenther, 2018; Yankson & Gough, 2019). Specifically, Guenther (2018) found that the existence of an artisanal mining pit in a local community results in an increase in household income by 0.2% accrued from non-farm and associated ASM activities. The artisanal mining sector contributes about 30–31% of the total quantity of Ghana's gold productive resources and about 11.9% of Gross Domestic Product (GDP) in 2016 (Bebbington et al., 2018; Eduful et al., 2020).

Artisanal and small-scale mining operations are no new livelihoods sources to indigenous communities in Ghana. As of the fourth century, the indigenous settlers were extracting their mineral wealth by employing traditional methods and simple tools (Ofosu-Mensah, 2010, 2011). Conversely, the formalization regimes under colonial rule have criminalised all forms of minerals prospecting and/or mining outside the legal framework. This gave birth to two forms of artisanal and small-scale miners in the country—the legal artisanal and small-scale miners (operating under well codified legal framework) and the illegal miners (operating outside the legal framework) and commonly referred to as "galamsey" in the country. Galamsey is jargon in the local context implying "gather and sell" (Aryee et al., 2003; Ofosu-Mensah, 2010). Invariably, there is a wide debate as to whether the registration of a small-scale mining project limits its adverse environmental, social and economic ramifications. Proponents of this notion have argued that the operational characteristics of both legal and illegal artisanal and small-scale mining activities are similar (Debrah et al., 2014).

Artisanal miners employ rudimentary technologies and tools such as buckets, pickaxes, wheelbarrows, shovels and pans in their operations. This results in low output, poor recovery, and a vicious cycle of poverty among the operators (Hilson & Maconachie, 2020a, 2020b; McQuilken & Hilson, 2016). That aside, ASM is advantageous because it requires low investment capital (Hilson & Maconachie, 2020a). Another common characteristic of artisanal mining operations is the high demand for manpower and the low educational attainment of the actors (Hilson, 2016; Nyame & Grant, 2014). The use of rudimentary technologies by artisanal and small-scale miners comes with a plethora of negative ramifications such as frequent deaths associated with pit collapse, mercury contamination and other physical injuries (Gonzalez et al., 2019; Ottenbros et al., 2019). Correspondingly, recent studies have argued that the mechanisation of the ASM sector by the Chinese intruders involving the use of chan fa, excavators and other heavy-duty machines is the main cause of the massive environmental destruction going on in the Ghanaian ASM sector (Afriyie et al., 2016; Aidoo, 2016; Botchwey & Crawford, 2018; Hess & Aidoo, 2016; Hilson, 2017; Hilson et al., 2014). Additionally, ASM activities are associated with increasing social cost,

child labour, human trafficking, sexual exploitation of women and tax evasion (Azumah et al., 2020; Veiga & Marshall, 2019; Werthmann, 2009).

The aforementioned adverse ramifications of illegal mining operations in Ghana have increased government's expenditure towards cleaning the mess. According to Frimpong-Boateng (2018), the government needs about US$ 29 billion to reclaim a land area of approximately 2.4 million hectares caused by galamsey activities annually, and in line with this submission, about US$ 100 million was set aside under the Multi-Sectoral Mining Integrated Project (MSMTP) to reclaim galamsey degraded lands in 2017 (CSIR-Forestry Research Institute of Ghana, 2017). However, the government's attention towards reclaiming the galamsey degraded lands appears to focus on the southern part of Ghana compared to Northern Ghana including Upper West Region. The first attempt by the government to reclaim galamsey degraded lands in the country commenced in Eastern Region in November 2017 (Baddianaah et al., 2021). This notwithstanding, the environmental cost associated with the ASM sector such as land degradations, deforestation, acid mine drainage, siltation and diversion of river channels and chemical pollution of water bodies are daily challenges that Ghanaians are facing and Upper West Region is no exception. In recourse to addressing the aforementioned challenges of ASM activities in Ghana, relevant policy interventions were formulated alongside, the existing reforms such as the Small-Scale Mining Law [Provisional National Defence Council Law (PNDCL) 218, 1989], Mercury Law (PNDCL 217, 1989) and the Precious Minerals Marketing Corporation Law (PNDCL 219, 1989) (Akabzaa & Darimani, 2001; Bebbington et al., 2018). The Small-Scale Mining Law (PNDCL 218) was later incorporated into the Minerals and Mining Act of 2006 (Act 703).

Notably, the government renewed interest in putting a stop to galamsey operations in the country was championed by Media Coalition against Galamsey in 2017, prompting the government to ban all ASM activities in the country in July 2017. Following this, a 400 combined police and military anti-galamsey taskforce known as 'Operation Vanguard' was constituted to enforce the ban (Eduful et al., 2020; Owusu et al., 2019). Again, through the media and other social media platforms, public education, awareness creations and anti-galamsey slogans were disseminated in an effort to help curb the galamsey menace in Ghana (Biney, 2019). Yet, the aforementioned strategies put in place to help curb galamsey activities in the country could not address the associated menace although reports of some rivers and lands regaining their natural statuses in recent times have been indicated (Eduful et al., 2020). As result, some scholars suggested the application of models concerning behavioural change to understand the underlying factors responsible for the growing illegality among local miners (Tweneboah-Koduah et al., 2020).

Moreover, the intention and mandate to fight galamsey activities by the government appear to depend largely on the use of the military and other anti-galamsey operatives. And fast forward in March 2021, another group of the anti-galamsey taskforce (Operation Halt), consisting mainly of 200 military officers was formed to help put an end to galamsey operations across the country (Adu-Baffour et al., 2021). While these are positive steps towards ending illegal mining operations in Ghana, a major challenge faced by the military and related anti-galamsey taskforce groups has to do with how to locate the specific operational areas of the illegal miners and the types of activities they engage in.

Notwithstanding the fact that the ASM sector has received massive scholarly contributions, a chunk of the extant articles appears to focus on the adverse environmental effects (Bansah et al., 2018; Boadi et al., 2016; Rajaee et al., 2015), land use and land cover variations in the illegal mining areas (Abaidoo et al., 2019; Amproche et al., 2020; Ferring & Hausermann, 2019; Laari et al., 2015). The livelihood implications and coping strategies of artisanal miners have been explored (Hilson & Maconachie, 2020a; Mabe et al., 2021; Tuokuu et al., 2020) while issues of child labour, gender roles and sexual exploitation of women have been studied (Sovacool, 2020; Zolnikov, 2020). However, few studies have explored the spatial distribution of the types, characteristics and patterns of illegal mining activities in Ghana. Mantey et al. (2017) and Owusu-Nimo et al. (2018) explored the spatial distribution of ASM activities but with specific limitations to Western Region. Against this background, this study seeks to investigate the characteristics, types and spatial distribution of galamsey activities in Upper West Region.

This study is timely because of the recent interest by governmental, non-governmental (NGOs) and civil society organisations (CSOs) in monitoring, tracing, tracking and flushing out illegal mining activities in Ghana. The study will help governmental and other anti-galamsey organisations to design tailor-made policies to help curb galamsey activities in the country. It will guide the anti-galamsey taskforce groups such as 'Operation Halt' to monitor, trace and track the illegal miners onsite within convenient time frames. It will also enlighten the Government of Ghana on key areas of galamsey hotspots for reclamation purposes. Finally, the study has a wider scope of contributing to improving environmental quality and human wellbeing, a fundamental tenet of the United Nations Sustainable Development Goals. In order to achieve the study objective, the following research questions were raised:

1. What are the characteristics and types of ASM activities in Upper West Region?
2. How are ASM activities spatially distributed in Upper West Region?

Literature review

Ghana is by far one of the leading countries with mineral wealth in Africa. The country is endowed with several minerals, including gold, manganese, bauxite, diamond, kaolin, iron ore, crude oil, and salt (Akabzaa & Darimani, 2001; Darimani et al., 2013; Hilson, 2001). However, the gold mining sector has been vibrant since ancient times compared to the other minerals (Akabzaa & Darimani, 2001; Hilson, 2001; Hilson & Potter, 2005; Ofosu-Mensah, 2011). Thus, the dominance and abundance of gold earned Ghana its former name-the Gold Coast (Ofosu-Mensah, 2010). Traditional gold mining started in the Gold Coast largely on artisanal forms in the early part of the fourth century, and like other indigenous livelihood activities, local miners used to gather precious stones, crush, wash and grind them locally to obtain metallic gold using simple tools and indigenous technologies (Ofosu-Mensah, 2010, 2011). The narratives about traditional gold mining centred largely on the Akan traditional settlements since the middle belt of Ghana was found to have contained large deposits of precious gold (Ofosu-Mensah, 2010).

According to Dumett (1998), gold in the pre-colonial era was used to decorate the Akan traditional rulers' palaces, and also as regalia, with little attention on the monetisation of the mineral wealth. Subsequently, traditional mining served as the oasis of gold supply in the Trans-Saharan trade, including other European markets (Ofosu-Mensah, 2010). During this era, gold was mined and traded with the local people and perceived as supplementary to agriculture and other indigenous crafts (Ofosu-Mensah, 2010, 2011). These aforementioned contributions and characteristics of the local mining sector seem to suggest that traditional gold mining was not the most sought-after as witnessed in present-day Ghana but a secondary income-generating activity to agriculture. Additionally, all traditional mining activities during the pre-colonial regime were guided and regulated by the chiefs and fetish priests with strict compliance by the local miners (Ofosu-Mensah, 2010; Sarpong, 2015). It has been reported that the guarantee to mine gold during the pre-colonial period was strongly influenced by customs and tradition, of which mining enclaves were revered (Addei & Amankwah, 2011; Ofosu-Mensah, 2011; Sarpong, 2015). As reported by Addei and Amankwah (2011) and Awuah-Nyamekye and Sarfo-Mensah (2012), the gods were usually called upon to intervene and punish miners who deliberately cause massive destruction to the physical environment. Thus, the local miners and traditional rulers were cautious of the adverse environmental tragedies, and were, therefore, guided by the use of customs, taboos, and norms to streamline the sector.

Traditional methods were largely relied upon in mining gold in the Gold Coast and this has transitioned into local mining practices in present-day Ghana. These methods, according to Aryee et al. (2003), include shallow alluvial mining, deep alluvial mining, and hard rock mining methods. The choice of a particular mining method to be used by local miners was influenced by the topography of the mineralized enclave. Shallow alluvial mining involves prospecting for gold-bearing ore within gorges and related low-lying regions. Thus, local miners could prospect for gold up to a depth of one metre. This is considered the cheapest and easiest method of traditionally mining gold, and is locally referred to as dig and wash. The recovered ore is further refined through sluicing and amalgamation to obtain the real gold. Additionally, the deep alluvial mining method involves

prospecting and extracting the mineral-bearing ore within deep alluvial deposits occupying the banks of some prominent rivers such as the Ankobra, Densu, Offin and Volta. This technique of mining gold requires the opening of large and deep gullies underneath to a depth of approximately 7–12 m, which are supported with terrace (benches) side-by-side the mining pit to prevent it from collapsing. The miners succeed in recovering the gold-bearing ore, washed, and further process it to obtain the gold (Aryee et al., 2003).

The hard rock method of mining gold is employed in areas where the gold-bearing rock is deep-seated underneath. With this, indigenous miners employ the technology of sinking holes deep-down to reach the target; and with the aid of simple tools, such as chisels and hammers, the mineral-bearing rock is disaggregated to manageable sizes for conveyance. This notwithstanding, explosives in the form of dynamites are sometimes used in a situation whereby the rock is too hard to crack by human labour. Of recent, the literature is beginning to reclassify the types of ASM operations with respect to the types of tools and methods used in prospecting for the mineral (Mantey et al., 2016, 2017, 2020; Owusu-Nimo et al., 2018). These authors as guided by the existing literature classified the varied forms of tools, scope, scale and pattern, to classified ASM activities into nine: 1. Chamfi, 2. Alluvial Washing Plant, 3. Mill House, 4. River/Stream Dredging, 5. Underground Sample Pit/Hole, 6. Underground Shifts/Tunnels, 7. Alluvial Washing Board, 8. Anwona, and 9. Dig and Wash. The classification by these authors appears to move beyond the traditional classification by Aryee et al. (2003) to cover the multiplicity of activities that take place along the chain of ASM operations. However, the forgone discussion on indigenous methods applied in mining gold appears to suggest that the local miner is innovative and capable of adapting to sustainable methods of mining gold in Ghana.

Besides, the literature explored (e.g. Dumett, 1979, 1998; Ofosu-Mensah, 2010, 2011) showed local mining activities before colonialism appeared to have apportioned little attention and prominence to the destructive aspect of mining activities on the environment, probably, due to the massive use of simple tools in prospecting for gold at the time (Ofosu-Mensah, 2010). Artisanal mining activities continue to soar across local communities during colonial rule but witnessed a paradigm shift in the right to freely prospect for gold and other minerals by traditional miners around the 19th Century (Ofosu-Mensah, 2011). Traditional rulers lost power and full control over mineralized lands under their stools to the colonial authorities. Thus, the colonial government (The British) brought in legislation that created a monopoly and a strong preference for large-scale mining claimed to be geared towards the modernization of the mining sector as against indigenous mining. It has been reported that the agenda for modernization of mining activities in Ghana was championed by the colonial masters while local miners were scolded, marginalized, and tagged as illegal miners (Ofosu-Mensah, 2011). However, a large proportion (a million-plus) of the local people still earned their livelihood from the ASM sector (Hilson et al., 2014; McQuilken & Hilson, 2016; Zolnikov, 2020).

Consequently, artisanal and small-scale miners took lessons from large-scale mining companies, and thus, began to upgrade their activities by employing both rudimentary and highly mechanized activities (Zolnikov, 2020). A recent study by Yankson and Gough (2019) claimed job losses from the large-scale mining companies rather fuelled the proliferation of the diverse forms of ASM activities in Ghana. Once a miner is laid off by a large-scale mining company, the closest alternative is to join the ASM bandwagon. This sided well with Hilson's (2010) argument that a miner will always be a miner based on his observation of the Akwatia artisanal miners' resettlement penchants. Thus, these local miners are found to have now widened their coverage across many districts in Ghana, operating in several forms (Owusu-Nimo et al., 2018). This comes with its associated negative consequences of social, economic, and environmental ramifications (Owusu et al., 2019).

Materials and methods

The study area

The study was conducted in Upper West Region, located in the North-western part of Ghana (Fig. 1) The region shared a boundary with the Republic of Burkina to the north and the Republic of La Côte d'Ivoire to the southwest. The southern part of the region is bordered by Northern and Savannah

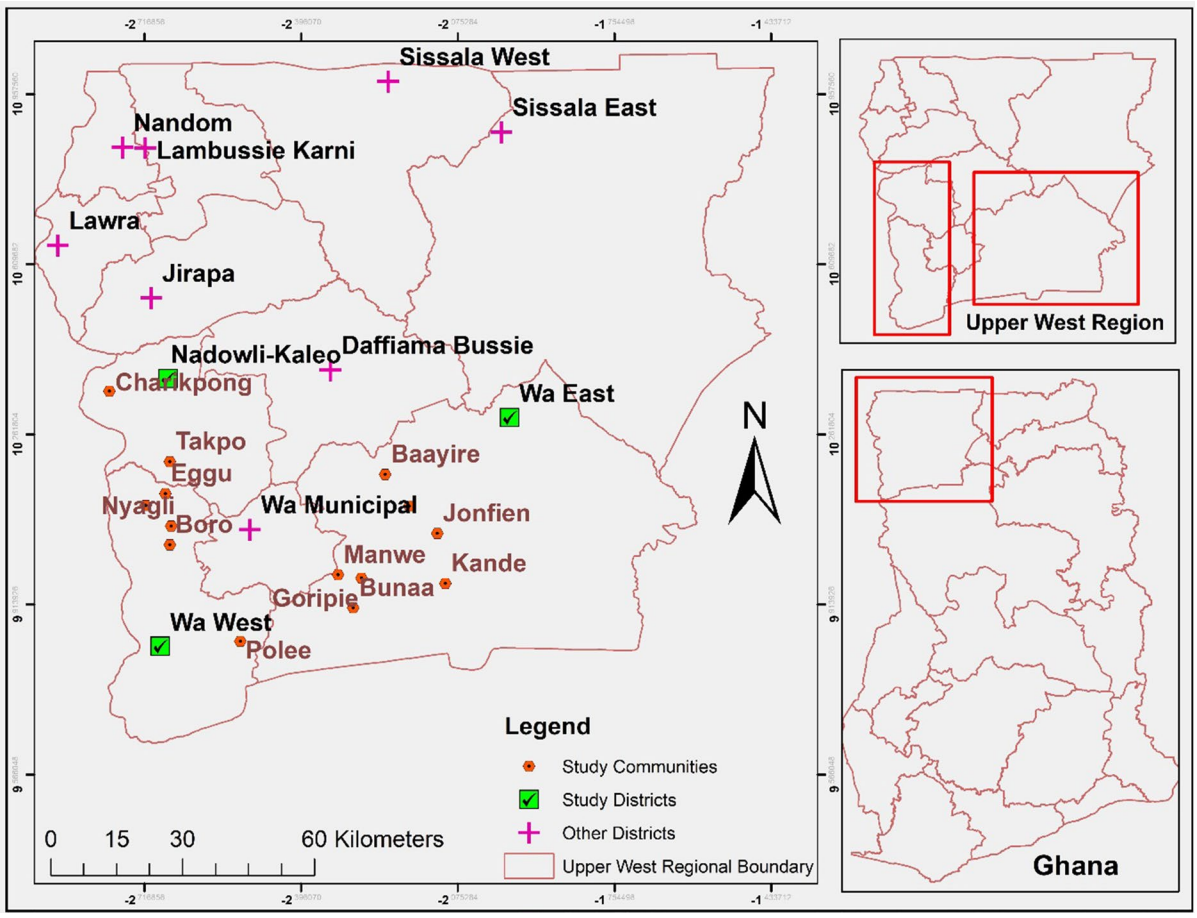

Fig. 1 Map of Upper West Region showing study communities. Source: Authors (2021)

Regions. Upper West Region covers a total land area of about 18,476 km^2 (12.7%) of the total area of Ghana. The 2010 population and housing census report revealed that about 702,110 of the 28 million Ghana's total population resides in the Upper West Region (Ghana Statistical Service (GSS), 2013). The majority (83.7%) are rural dwellers. Thus, the region is dominated by agriculture and other primary sector activities like lumbering, fishing and artisanal and small-scale mining (Baddianaah et al., 2022). Though the agriculture sector dominates, subsistence farming involving the cultivation of cereals like guinea corn, maize, millet, rice, sorghum and leguminous crops (e.g. beans, cowpea, soya beans, groundnuts and cotton is the main stay of the local economy. However, the industry and services sectors are steadily expanding. Pito brewing, woodcarving, pottery, blacksmithing, cotton spinning and weaving are dominant cottage industries in the region (GSS, 2013).

In addition, the region is dominated by the guinea savannah vegetation, hosting several economic trees such as the shea (Vitellaria paradoxa), neem (Azadirachta indica), baobab (Adansonia digitata) and Dawadawa (Parkia biglobosa). The topography is averagely flat with few isolated hills. The Pre-Cambrian rocks consisting of metamorphic and granite are rich in mineralized gold and has been a major source of attraction for exploring and mining of gold by artisanal miners across several communities in Wa East, Wa West and Nadowli-Kaleo Districts. The region also hosts an international mining company—Azumah Resource Limited operating under the JULIE Concession.

Data collection

The data collection for this study occurred in two phases—phase one covered the collection of spatial (geographically referenced) data while phase two involved the collection of qualitative data from relevant key informants to buttress the results from the spatial data. The entire data collection lasted for five months (May–September 2021). The study used a cross-sectional concurrent mixed methods design because it offers researchers the opportunity to collect data within a defined period on the prevailing phenomena (Creswell, 2014; Creswell & Plano Clark, 2011). Multiple sampling techniques were deployed systematically to reach out to the study communities and desired respondents. The first step of sampling involved clustering Upper West Region based on the delineation of administrative districts and municipal assemblies (MDAs). Of the 11 MDAs, three districts with records and current dynamics of ASM operations based on the extant literature (Agyemang & Okoto, 2014; Baddianaah et al., 2021; Bagah et al., 2016; Laari et al., 2015, 2016) were selected—Wa West District, Wa East District and Nadowli-Kaleo District were involved in the survey.

For the fact that the study seeks to explore and map the spatial distribution patterns, types and characteristics of ASM activities in the Upper West Region, all communities with records of galamsey operations in the aforesaid districts were covered for the spatial data. This enables the researchers to obtain a broader understanding of the occurrence and status of galamsey activities across the region. In Wa East District, seven communities (Danyuokura, Bunaa, Baayiri, Manwe, Goripie, Kande and Jonfien) were covered. Five communities (Boro, Nyagli, Eggu, Polee and Tandabore) were covered in Wa West District while in Nadowli-Kaleo District, only two communities (Takpo and Charikpong) were found to host galamsey activities and were covered. Moreover, at the time of the field data collection, Takpo was a very dominant galamsey community that attracts large numbers of galamseyers, increasing the number of galamsey activities particularly underground pits (ghettos) sighted in Nadowli-Kaleo District.

Prior to embarking on the field data collection, the researchers reviewed literature published in revered journals to acquire in-depth knowledge about the classification, types and operational dynamics of artisanal and small-scale miners in Ghana (see Mantey et al., 2016, 2017, 2020; Owusu-Nimo et al., 2018). As a result, the researchers commenced the field data collection with the foreknowledge of mapping the spatial distribution of nine galamsey types as uncovered by Owusu-Nimo et al. (2018) in Western Region of Ghana. However, six galamsey types were uncovered in this study. To map the identified galamsey types, a semi-structured questionnaire was developed of which five data collection assistants (Graduate Students of the Department of Environment and Sustainability Sciences, University for Development Studies, Tamale) were trained on how to pick the GPS coordinates with a Garmin etrex 30 GPS and as well, take stock of the galamsey types using the questionnaire. Furthermore, all the data collection assistants were informed of the difficulty, illusive and cunning nature of dealing with illegal miners. Besides, they were made to understand that picking data at the galamsey site is risky; one has to cross valleys, climb hills and in some cases cross rivers—most galamsey sites are largely inaccessible (Kwai & Hilson, 2010). As such, maximum security and safety precaution were detailed and through snowballing, the consent of a lead miner (gang leader) was sought with the help of the assembly member in each mining community before visits could be made to these sites.

In fact, consent forms were distributed to the assemble member and chief of each galamsey community and on their acceptance to allow for the research team to visit the site, they then led the team leaders (lead researchers) to engage the galamsey leaders in further deliberations to get their understanding and consent to participate in the study. The respondents were made aware that the research was purposely to contribute to knowledge and guide policymakers for a better engagement with the local miners. The decision to withdraw from the survey at any point in time on grounds of perceived disregard for ethical standards was assured the respondents. This safe the data collection team from physical and verbal assaults since any stranger at the galamsey site is easily identified and construed as an informant to the ant-galamsey taskforce. It is common knowledge that the workings of illegal miners are strongly associated with superstition and spiritual undertakings (Baddianaah et al., 2021; Ofosu-Mensah, 2010; Sarpong, 2015), therefore, the operational characteristics of galamseyers such as religious beliefs,

socio-cultural characteristics, spiritual inclinations, taboos and related practices were learned through the lead miners, respected and adhere to by all members of the data collection team. Some galamsey types particularly those associated with processing activities such as the mill house and shormp (a local name for a well-designed platform for washing and processing gold bearing sand) were located within the towns while the ghettos (pits), dig and wash, dig and Check and Chamfi were located far away from the mining communities.

Correspondingly, the gang leaders who served as entry facilitators into the mining sites helped the data collection team to identify, locate and differentiate the various types of operations. The galamsey types were observed to occur either in a cluster or standalone mode, that is approximately 100 m apart (Mantey et al., 2017; Owusu-Nimo et al., 2018). With this, GPS coordinates of standalone activities were mapped one after the other. However, in areas where the operations occur in clusters (e.g. underground pits), one or two points were picked at vantage intervals (approximately 20 m apart) while the total number is counted and recorded. With regards to galamsey types such as dig and wash, and dig and check, individual plot size of about 50 by 50 m was considered large enough to pick a point while the individual or group mining activities within these plots were counted and recorded. The status of the galamsey type in terms of abandoned, active or semi-active were ascertained and recorded.

The second phase of data collection involved in-depth interviews with key informants who are major actors and/or relevant parts of the galamsey operations in the local communities. Galamsey is more or less like a 'cabal' of which some of the key actors are hidden (Botchwey & Crawford, 2018). In this study, a chief and a landlord (*tendana)*, an assembly member, and a lead miner (gang leader) were interviewed in each study community. Chiefs and *tendanbas* (plural for the landlord) play significant roles in the ASM sector. They sometimes grant concessions based on the existing customary land tenure to the local miners and could regulate illegal mining activities in their respective communities as well (Andrews, 2015; Botchwey & Crawford, 2018; Crawford & Botchwey, 2016; Osei-Kojo & Andrews, 2016). Assembly members are direct representatives of the decentralized governance system and could play a role either in aiding or fighting illegal mining activities. Lead miners (gang leaders) were interviewed in connection with their operational characteristics, challenges and the way forward for galamseyers in their communities. As earlier stated, since the respondents consented to the study, their voices were taped-recorded in the local language (dagaare/waali) of which all the data collection assistants were native speakers, thereby, allowing them to probe further during the interviewing. Moreover, each interview session lasted between 30 minutes and one hour, and was finally transcribed into the English Language for presentation. Table 1 presents the total number of key informants that took part in the survey.

Data analysis

The spatial coordinates of the galamsey types were screened, cleaned and entered into excel statistical package and classified based on the latitudes and longitudes (XY coordinates) with the attributes and specific locations defined. Polygon shapefiles of Ghana Districts (Ghana Statistical Service, 2013) were used to overlay the GPS coordinates in ArcGIS 10.5. The results were generated using maps (figures) and supported with tables. This enables the researchers to explore and appreciate the spatial distribution patterns of ASM activities across the study districts. Furthermore, the in-depth interviews were screened and organised according to themes for further analysis. The dominant themes as suggested by the theoretical foundation of grounded theory (see Charmaz & Belgrave, 2012) were identified, analysed and presented in the form of direct and indirect quotes. The adoption of the grounded theory approach was deemed relevant in eliminating discussions that are not directly situated with the research focus but were gathered during interviews administration.

Results and discussion

Types and abundance of ASM activities

Of the 11 MDAs in Upper West Region, three districts consisting of Wa East District, Nadowli-Kaleo District and Wa West District were involved in the study. The aforementioned districts were found to be the hubs of galamsey in the region of which six

Table 1 Distribution of key informants

Region	District/Commu	Type of respondent	No. of respondents
Upper West	Nadowli-Kaleo (Tarkpo and Charikpong)	(a) Chiefs	2
		(b) Landlord(s)	2
		(c) Lead Miners	2
		(d) Assembly Members	2
	Wa East (Goripie, Manwe, Baayiri and Jonfien)	(a) Chiefs	3
		(b) Landlord(s)	4
		(c) Lead Miner(s)	4
		(d) Assembly Members	4
	Wa West (Nyagli, Eggu and Polee)	(a) Chiefs	3
		(b) Landlord(s)	3
		(c) Lead Miner(s)	3
		(d) Assembly Members	3
Total			35

Source: Authors (2021)

Table 2 ASM activities sighted in Wa East District

ASM pattern/type	Number of Sightings Per Community-Wa East District							Total
	Danyuokura	Bunaa	Baayiri	Manwe	Goripie	Kande	Jonfien	
1. Pit Mining (Ghetto)	192	59	31	44	47	28	177	578
2. Dig and Wash	67	13	19	40	18	8	12	177
3. Dig and Check	41	7	26	21	29	0	49	173
4. Chamfi	54	15	9	57	22	14	61	232
5. Mill House	44	12	7	33	28	7	33	164
6. Shormp	87	21	23	48	43	20	78	320
Total	485	127	115	243	187	77	410	1644

Source: Field Survey (2021)

major types of ASM activities were identified across 14 communities. Overall, 2505 artisanal gold mining activities (Wa East District = 1644, Nadowli-Kaleo District = 437, Wa West District = 424) were sighted across the 14 communities (see Tables 2, 3, 4 and Fig. 2). These activities occur on individual sites or in clusters. Thus, the artisanal miners work on an individual basis or in groups referred to as gangs, buttressing the nomenclature on the composition and conceptualisation of ASM activities (Akabzaa & Darimani, 2001; Hentschel et al., 2003; Owusu et al., 2019). Conversely, a group of miners working within an underground pit is best described as a ghetto (Baddianaah et al., 2021; Mantey et al., 2016; Owusu-Nimo et al., 2018).

Wa East District was found to hosts the majority of the individual galamsey operations; 1644 sightings

Table 3 ASM activities sighted in Nadowli-Kaleo District

ASM Pattern/Type	Number Sighting Per Community-Nadowli-Kaleo District		Total
	Takpo	Charikpong	
1. Underground Pit (Ghetto)	191	21	212
2. Dig and Wash	0	0	0
3. Dig and Check	23	0	23
4. Chamfi	57	15	72
5. Mill House	31	7	38
6. Shormp	67	25	92
Total	369	68	437

Source: Field Survey (2021)

Table 4 ASM activities sighted in Wa West District

ASM Pattern/Type	Number of Sightings Per Community-Wa West District					Total
	Boro	Nyagli	Eggu	Polee	Tandabore	
1. Pit Mining (Ghetto)	0	0	0	174	0	174
2. Dig and Wash	0	0	0	31	0	31
3. Dig and Check	15	31	18	21	37	122
4. Chamfi	0	0	0	34	0	34
5. Mill House	0	0	0	22	0	22
6. Shormp	0	0	0	41	0	41
Total	15	31	18	323	37	424

Source: Field Survey (2021)

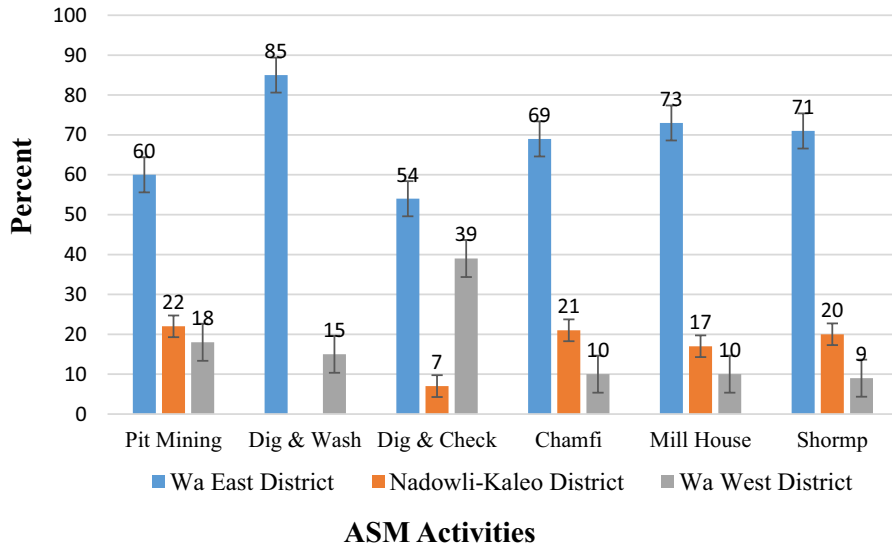

Fig. 2 Types of ASM activities in Upper West Region. Source: Field Survey (2021)

(Table 2) while Wa West District recorded the least, 437 sightings (Table 3) accentuating the literature highlighting the proliferation of galamsey activities and their implications in Wa East District (Agyemang & Okoto, 2014; Laari et al., 2015). Galamsey has become a major livelihood trajectory across local communities in Ghana, although the adverse environmental and social consequences are on the rise (Hilson & Maconachie, 2020a; Kwai & Hilson, 2010; Osumanu, 2020; Owusu et al., 2019; Owusu-Nimo et al., 2018; Zolnikov, 2020). The results (Table 2) further showed that Wa East District hosts all the six types of galamsey activities (underground pit/ghetto mining, dig and wash, dig and check, chamfi, mill house and shormp). Of the seven mining communities covered, it was only in Kande that the dig and wash type of mining was not sighted. Notably, underground pit (ghetto) mining was the most prevalent activity engaged in by a large majority of the artisanal miners (578 sightings). In Nadowli-Kaleo District, 121 underground pits were slighted with no records of the dig and wash type of galamsey (Table 3).

Furthermore, the results (Table 4) showed that the dig and check type of mining was prevalent across all the five mining communities in Wa West District. It was only in one community (Polee) that the underground pit/ghetto mining (174 sightings), dig and wash (31 sightings), chamfi (34 sightings), mill house (22 sightings) and shormp (41 sightings) were uncovered. However, the remaining four communities (Boro, Nyagli, Eggu, and Tandabore) host the dig and check galamsey only.

The dig and check type of galamsey is the most affordable and easy to operate compared to dig and wash and underground pit mining (Owusu-Nimo et al., 2018). With a pickaxe and a shovel, the

miner is ready to operate because the metal detection machine ("ambulance") can be hired or sourced through an agreed ratio of sharing. However, large areas of land are degraded by this type of mining since it is a surface mining method (Mantey et al., 2017; Owusu-Nimo et al., 2018). On the positive trajectory, the dig and check galamsey does not involve the use of mercury and is free from frequent deaths and injuries associated with the underground pit mining as a result of pits collapsing (Bansah et al., 2016, 2018; Ofosu-Mensah, 2011), making it a healthy mining method. Mercury contamination and pit caveins are major disincentives to galamsey activities in developing societies (Hilson, 2016; Ofosu et al., 2020). With this type of mining, the health of the miner is highly secured compared to either the underground pit or the dig and wash. An interview with a lead miner revealed that the absence of chamfi, mill house and shormp in some communities was due to the fact that the pre-Cambrian rock layer of Brimian and Post-Brimian granitic origin (Ghana Statistical Service, 2013) containing the gold is closer to the earth surface and occur in recognisable solid patches, and therefore, conditioned the application of the dig and check method in these communities. The dig and check method of extracting the gold does not involve further processing. According to a miner, the process is simple and thus, the easiest method of mining gold by the galamseyers. He explains the process as follows:

> *As explained, the dig and check method of extracting gold involves the use of a metal detection sensor machine popularly called ambulance. With this, the miners excavate the ground to about a foot or not more than two feet. The sand, gravel and stones are evenly spread and this handheld metal detection machine is used to run over the surface to detect and select the raw gold. The presence of raw gold within the working environment is often recognised by a loud sound from the metal detection machine. The raw gold is picked and does not require any further processing* (Source: Interview with a lead miner, Nyagli, June 10, 2021).

The aforementioned submission suggests that the nature of the gold-bearing ore greatly influence the type and methods used by galamseyers in extracting the gold and explained the sharp contrast in the types, patterns and characteristics of galamsey activities reported by previous studies particularly in Southern Ghana (Aryee et al., 2003; Andrews, 2015; Nyame & Grant, 2014; Mantey et al., 2017; Owusu-Nimo et al., 2018; Kumi-Boateng & Stemn, 2020). Wa East District alone accounted for about 85% of the dig and wash, 60% of underground pits and 54% of dig and check for the three main mineral extraction methods uncovered in Upper West Region. Similarly, 73% of the mill house, 71% of shormp and 69% of chamfi were recorded in Wa East District (Fig. 2).

Upper West Region appears to have less concentration of ASM activities (Table 5 and Fig. 3) compared to other geographies in Southern Ghana. For instance, in addition to the six galamsey types uncovered in this study, other types of galamsey in operation in southern Ghana (e.g. Western Region) include the Anwona (pit dredging), stream or river dredging, washing plant and panning (Mantey et al., 2017; Owusu-Nimo et al., 2018). These types of mining activities are broadly classified as alluvial or placer mining (Mantey et al., 2016; Owusu-Nimo et al., 2018). The topography of Upper West Region is undulating with highlands ranging between 275 and 300 m. Thus, isolated patches of inselbergs, streams and rivers dot across the region. The Black Volta, River Kulpong and its tributaries drained the region (Ghana Statistical Service, 2013). Generally, artisanal miners operate within the highland areas, explaining the absence of all forms of alluvial/placer mining (pit dredging, stream or river dredging, washing plant and panning) activities in the region. The results suggest that the types and forms of illegal mining activities thrived based on the nature of the gold-bearing rock. Thus, it is imperative to understand the types and forms of illegal mining operations in a specific geographic perspective in order to devise relevant, specific policy measures on them.

The ASM activities sighted in Upper West Region are purely labour intensive. Simple tools such as pickaxes, shovels, buckets, pans, wheelbarrows chisels and hammers are used by the miners. However, some wealthy miners were able to purchase chanfans, compressors, grinding mills and metal detectors to support their exploration. Moreover, no excavator or earth-moving machine was sighted in this study (Table 5). This revealed that ASM activities in the region are still in the crude forms involving the use of simple tools and

Table 5 Characteristics and types of ASM activities in Ghana

Types of ASM activities	Description	Tools and resources involved	Broad composition
1. Underground pit/ghetto	This involves manual dugout pits, associated with the blasting of the gold-bearing ore underground. An underground pit could measure up to 30 m deep. Miners engage in dewatering particularly in the rainy season to continually operate. After, every blast, the gold-bearing rocks are package in sacks and conveyed out of the pits for further processing at the mill house. Raw gold is sometimes picked by the miners (a process known as selection) depending on the mineral content of the rocks. Less water is used under this type of mining	Chisel, pickaxe, hammer, rope, blast (dynamite), water pullers and compressors (machines) Fuel (petroleum, diesel and oil/lubricant)	Mining only
2. Dig & Check	This involves manual excavation of the earth to a depth of one foot and therefore, it is classified as surface mining. The gold-bearing rocks are spread, and a metal detector ("ambulance") is used to detect the presence of gold. In areas of rich mineral content, manual selection of the gold is done by the miners	Pickaxe, shovels, metal detector ("ambulance")	Mining only
3. Dig & Wash	It involves excavating the mineralised sand, heaping and washing the sand to obtain the gold. This type of mining is commonly done in the rainy season. Water use is highly intensive under this type of mining	Pickaxe, chan fa, shovel, pan, bucket, wheelbarrow, sluice board and mercury	Both mining and processing
4. Mill House	It involves purely processing of gold—crushing, grinding and washing the mineralised earth materials/rocks to obtain the gold. Water use is highly intensive	Crusher, chan fa, wheelbarrow smoothing machine, pan, bucket, wash wooden board, mercury, fuel (petroleum, diesel and oil/lubricant)	Processing only
5. Chamfi	It involves grinding gold-bearing rocks using chan fa. The chan fa is mostly sited near a source of water (a self-created source, a dam or a river). Water use is highly intensive under this type of mining	Chan fa, pan, bucket, wash wooden board, mercury, fuel (petroleum, diesel and oil/lubricant)	Both mining and processing
6. Shormp	It consists of a well-designed platform along a watercourse or a self-created water source, a dam or a river. In other classification, the shormp is referred to as a washing board (Mantey et al., 2017; Owusu-Nimo et al., 2018). Water use is highly intensive under this type of mining	Wooden washing board, pan, bucket, shovel	Processing only

Source: Field Survey (2021)

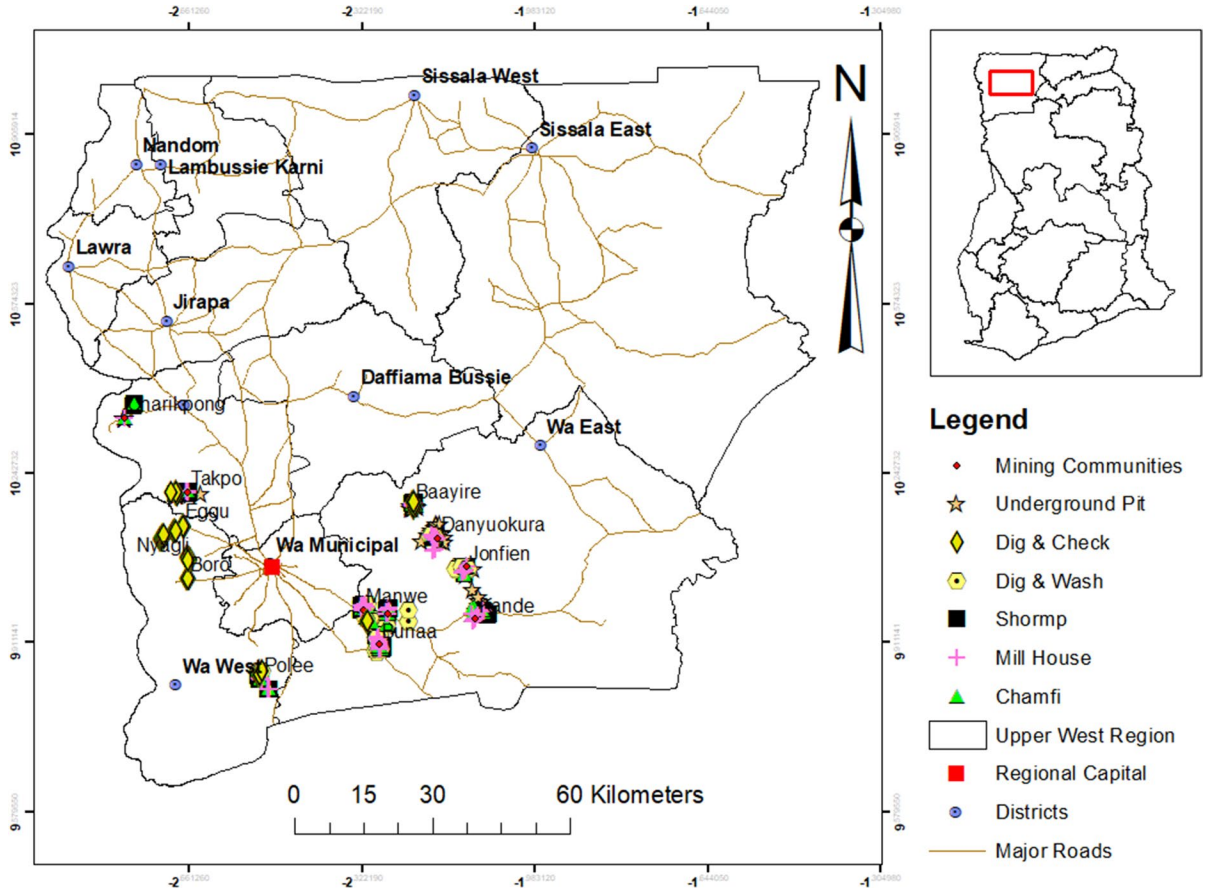

Fig. 3 Distribution of ASM activities in Upper West Region. Source: Field Survey (2021)

materials such as mercury in retrieving the gold and can easily be traced, tracked and regularised. The results align with the literature pointing to the use of basic tools by artisanal miners (Akabzaa & Darimani, 2001; Bansah et al., 2016; Boafo et al., 2019; Guenther, 2018; Hilson, 2001; McQuilken & Hilson, 2016; Owusu et al., 2019). The use of chanfans and excavators are innovations brought into the Ghanaian illegal mining landscape by the Chinese illegal miners as a way of mechanising galamsey activities in the country around the late 2000s (Boafo et al., 2019; Botchwey & Crawford, 2018; Hilson et al., 2014). However, the destructive effects of the use of chanfans and excavators on the physical environment have been highlighted (Adu-Baffour et al., 2021; Botchwey & Crawford, 2018; Hilson, 2017; Owusu-Nimo et al., 2018).

Distribution of ASM activities in Upper West Region

Spatially, galamsey activities occur in three districts, namely Wa East, Nadowli-Kaleo and Wa West in Upper West Region (Fig. 3). However, reports of illegal miners invading and prospecting for gold in Jirapa and other districts have been adduced. The results further showed that galamsey activities in the region are confined to the south-western half, showcasing variations in the types of galamsey activities across communities and districts. For instance, the dig and check type of mining dominates across communities in Wa West District while Wa East District hosts a multitude of the galamsey types—dig and wash, dig and check, underground pit mining (ghetto), shormp, chamfi and mill house). Nadowli-Kaleo District recorded few distributions of ASM activities because of the stringent measures put in place by Azumah Resource

Limited—an Australian mining company licensed to prospects for gold within the Wa-Lawra mining landscapes. Interviews with lead miners revealed that the Azumah Resource Limited has regulated the spread of galamsey activities in Nadowli-Kaleo District by employing the military in fighting galamsey activities. A lead miner intimated:

> *"galamsey activities used to boom in this community (Charikpong) until Azumah came in the mid-2000s and started fighting us. They (Azumah Resource Limited) succeeded in halting our activities by mounting a military post here. The barrier you saw before entering Charikpong is one and there is another one directly situated at the mining site"* (Key informant interview with a lead miner, Charikpong, June 2021).

A chief reported that his farmlands have been taken over by the Azumah Resource Limited of which he cannot even enter the whole enclave to harvest shea nuts. Moreover, the aforementioned results suggest that although the use of the military in fighting illegal mining activities have been criticized by several scholars (e.g. Boadi et al., 2016; Boafo et al., 2019; Hilson & Maconachie, 2020b; Owusu et al., 2019) their involvement, to some extent, has contributed to reducing illegal mining activities in the country.

Artisanal miners were observed to operate on a hit and run basis (Nyame & Grant, 2014), revealing vast areas of abandoned mining pits, dig and check, and dig and wash across all the mining communities. Thus, some galamsey activities were found to be active, semi-active, and/or abandoned (Fig. 4).

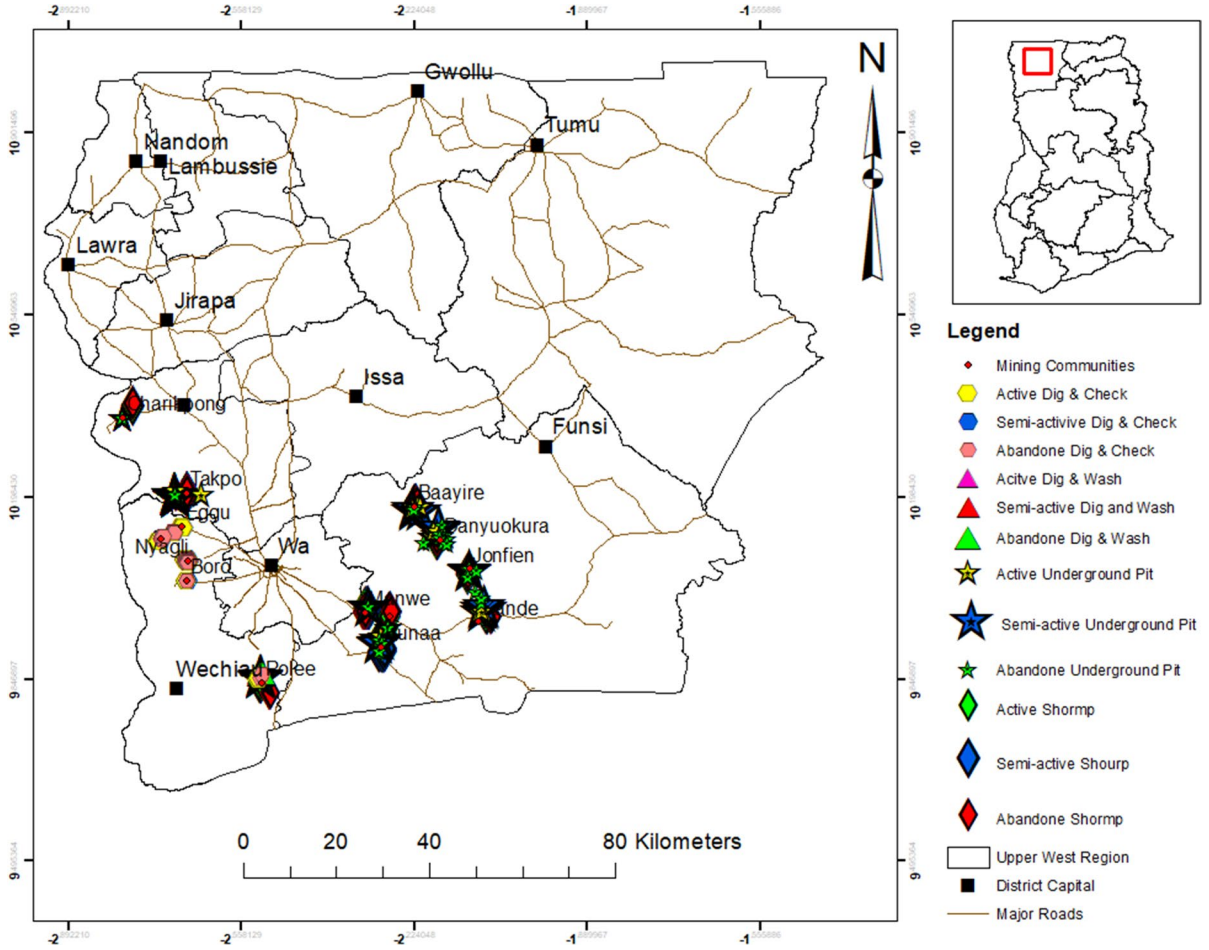

Fig. 4 Status of ASM activities in the Upper West Region. Source: Field Survey (2021)

The presence of unrecovered/abandoned pits, dig and check, and dig and wash ASM activities suggests that land reclamation has not been prioritized by the artisanal miners in their respective communities. The miners indicated they do not reclaim the land after mining because they are not under any regulation to do so. A lead miner retorted:

> *"Our interest is not about the aftermath environmental consequences but the gold. We know we are doing illegal mining under no regulation. It is more or less like hit and run, and so, what is the essence of going to reclaim the land? Even, if you are caught at the site in the name of reclaiming the land, you will be treated as an illegal miner and prosecuted"* (Source: Key informant interview with a lead miner, Charikpong, June 2021).

The aforesaid finding suggests that the lack of harmonisation between galamseyers and the regulatory institutions such as the Minerals Commission, Environmental Protection Agency (EPA) and the Metropolitan, Municipal and District Assemblies (MMDAs) (Adu-Baffour et al., 2021) is a key factor that fuels illegal mining activities in Ghana. A major policy goal of Ghana in recent times is to reclaim all degraded illegal mining sites and put a stop to illegal mining activities (Abaidoo et al., 2019; Forkuor et al., 2020). In connection to this, the Multilateral Mining Integrated Project (MMIP) was formulated (Yankson & Gough, 2019), and under it, the Community Mining Cooperative (CMC) was rolled out in 2019 to help transitioned illegal miners into the legal small-scale mining framework across local communities (Adu-Baffour et al., 2021). Notwithstanding, the Community Mining Cooperative was not in operation in Upper West Region at the time of conducting this survey—between May to September 2021 although some lead miners indicated they had consultative meetings with the Minerals Commission on the subject matter.

Distribution of ASM activities in the study districts

Wa East District

Wa East District has a long history of artisanal and small-scale mining activities (Agyemang & Okoto, 2014; Laari et al., 2015). Artisanal mining activities started in the district around the early 2000s largely by the indigenous smallholder farmers who combine mining with agriculture—their mainstream livelihood activity (Bagah et al., 2016). Peak periods of ASM activities in the district were recorded around 2010 with a host of communities resorting to the prospecting and mining of gold on illegal grounds. The results (Fig. 5) showed that a majority of the artisanal and small-scale mining activities occur around the south-western and north-western halves of the district.

Notable artisanal and small-scale mining communities in Wa East District include Bunaa, Baayiri, Danyuokura, Kande, Goripie, Manwe and Jonfien. All the types and forms of ASM activities (underground pit/ghetto, dig and wash, dig and check, cham fi, mill house and shormp) were sighted in the district (Fig. 5).

Nadowli-Kaleo District

Artisanal and small-scale mining activities in Nadowli-Kaleo District like Wa East District commenced around the early 2000s by the indigenous settlers around sub-communities like Nanga, Saa and Bullo under the Charikpong mining enclave. However, the Charikpong mining enclave was later issued to the Azumah Resource Limited commenced prospecting for gold to be mined on a commercial scale. And around 2018, the people of Niiri, a sub-community of Takpo discovered gold on a parcel of farmland and quickly commenced exploration and extraction of the gold on illegal grounds (galamsey). According to a landlord, the Takpo artisanal mining site was discovered based on foreknowledge they had from the exploration activities of Azumah Resource Limited. He gave an account of the events that led to the discovery of the Takpo site as follows:

> *"Although our local miners have their ways and means of discovering the gold at the site, the Takpo site was not discovered by them. The whole of this land is sold out to Azumah Resource Limited and on one of their exploration within this area, a staff leaked the information to the boys that underground pit mining can be carried out here because it has recognisable deposits of gold underneath. Our boys quickly mobilised and started mining and it was successful for them until early 2021*

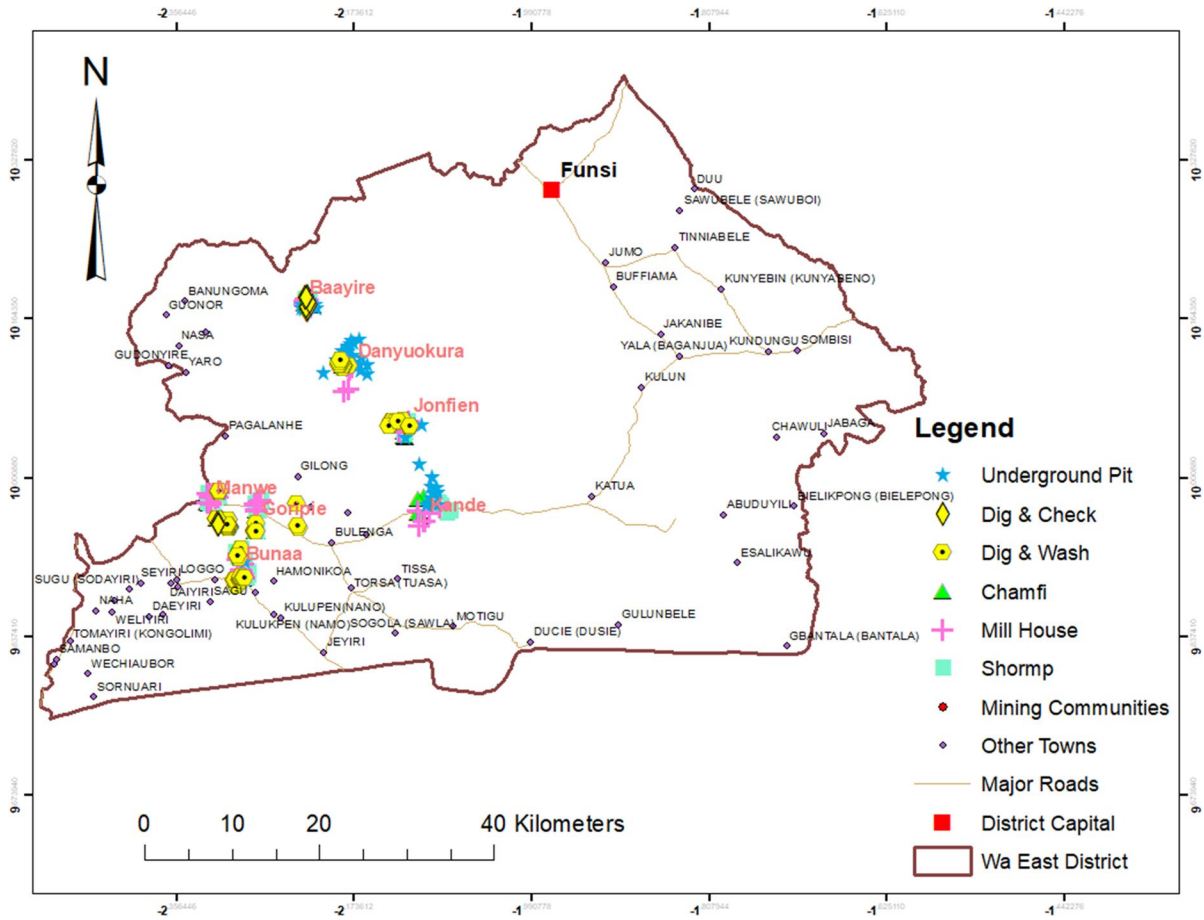

Fig. 5 Distribution of ASM activities in Wa East District. Source: Field Survey (2021)

when they brought the military to fight them" (Source: Interview with a landlord, Takpo, July 2021).

The results (Fig. 6) showed that artisanal mining activities in Nadowli-Kaleo District are taking place in the northwest and south-western halves. However, ASM activities were less distributed spatially in Nadowli-Kaleo District compared to Wa East and Wa West Districts (Refer to Figs. 5 and 7). This notwithstanding, previous studies have reported that the activities of the illegal miners in the district have caused considerable damage to the physical environment with adverse implications on farmlands and food production (Laari et al., 2016). Furthermore, underground pit mining, dig and check, dig and wash, mill house, chamfi and the shormp types of galamsey were found in the district.

Wa West District

Artisanal and small-scale mining activities began in Wa West District around 2016 when local miners gathered knowledge of the existence of gold deposits in Polee (a small farming community), and by 2020 communities such as Nyagli, Eggu, Tandabore, and Boro were attracted to prospecting and mining of gold on illegal grounds in and around agricultural lands. This goes to explain that the commencement and exploration of gold in a local community is likely to push a nearby community to begin prospecting and if possible, engage in galamsey activities as well. Largely, the success stories of mineral wealth in local communities are speedily disseminated among the illegal miners, increasing the number of miners in the said locations, thereby, intensifying the operations and aggravating the environmental tragedies (Nyame

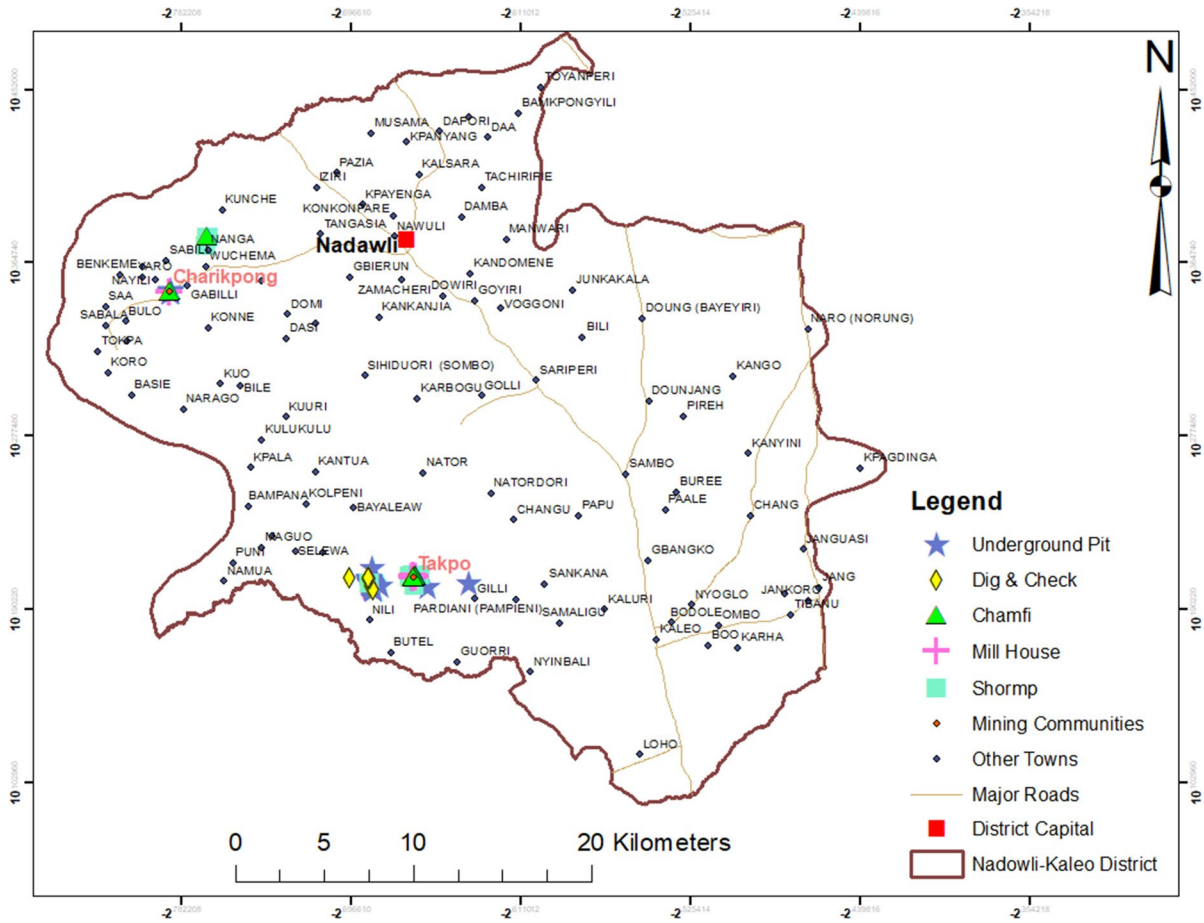

Fig. 6 Distribution of ASM activities in Nadowli-Kaleo District. Source: Field Survey (2021)

& Grant, 2014). In the specific case of Wa West District, the dig and check type of mining was found to dominates and largely confined to the northern halve. Communities such as Boro, Nyagli, Tandabore and Eggu were associated with this type of mining and recorded vast acres of degraded lands. The underground pit mining, dig and wash and associated processing activities such as the mill house, shormp, and chamfi were found in Polee—the south-eastern part of the district (Fig. 7).

The results suggest that in the absence of further monitoring and putting in place punitive measures against galamsey in the district, the nefarious activities of these illegal miners will continue to spread across several communities. Even though the literature has extolled the positive socio-economic effects of artisanal mining activities on the local economy (Guenther, 2018; Yakovleva & Vazquez-Brust, 2018; Yankson & Gough, 2019), the adverse environmental effects of galamsey activities are downsizing these positive effects and require a more nuanced approach to streamline galamsey operations in Wa West District.

Conclusion

The study mapped and outlined the spatial distribution patterns, types and characteristics of ASM activities in Upper West Region. Three districts (Wa East, Nadowli-Kaleo and Wa West) were found to host the ASM activities in the region. Overall, 2505 artisanal gold mining activities under six major classifications—underground pit (ghetto) mining, dig and check, dig and wash, cham fi, mill house and shormp) were sighted. Wa East District was found to hosts the

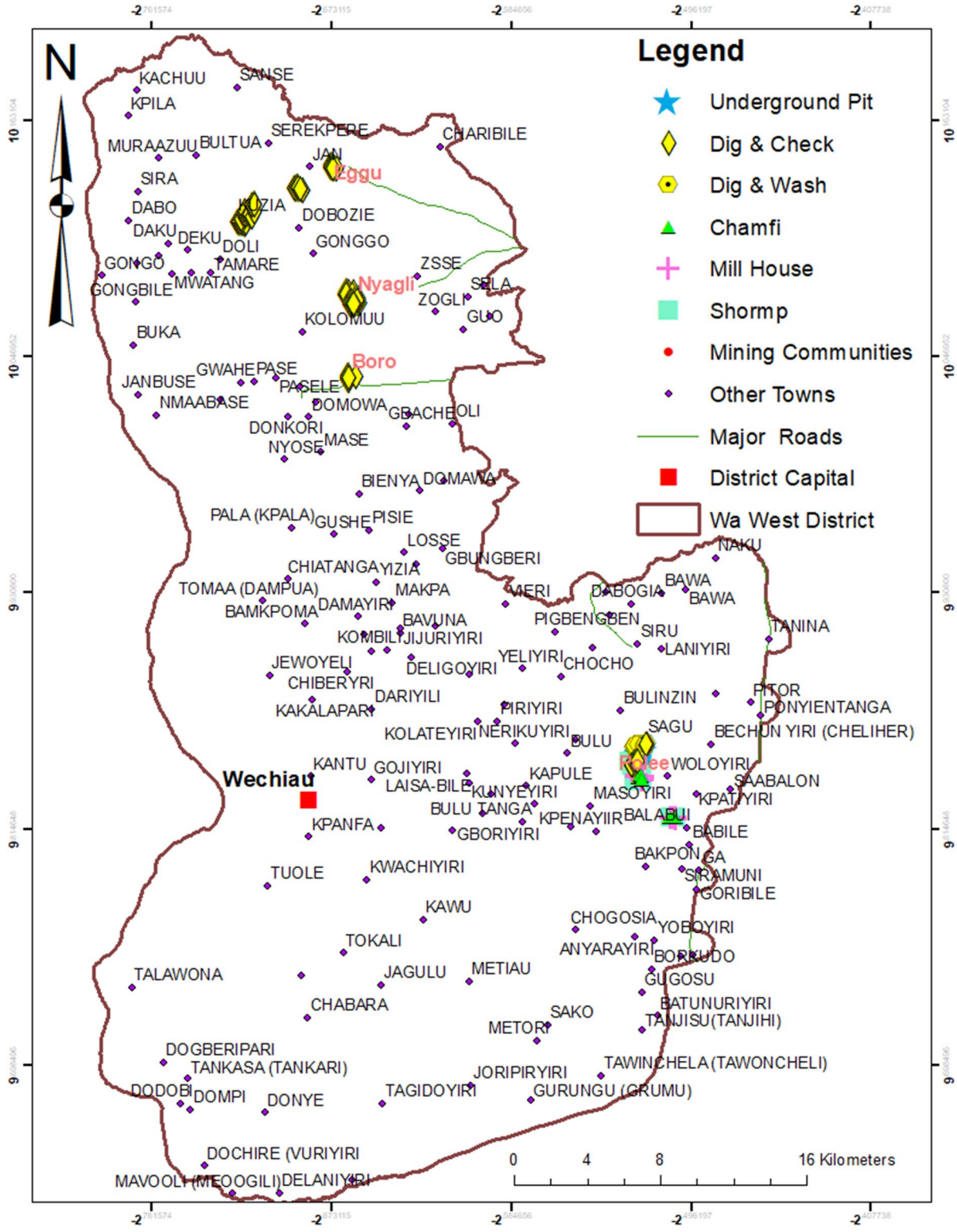

Fig. 7 Distribution of ASM activities in Wa West District. Source: Field Survey (2021)

majority of the individual galamsey activities (1644 sightings), 437 and 424 sightings for Nadowli-Kaleo and Wa West Districts, respectively. However, the findings showed variation in the spatial distribution of the types, forms and characteristics of ASM activities across the study districts. This variation is explained by the nature and occurrence of the gold-bearing rock underneath. Based on the characterization of galamsey activities, this study argued that galamsey operations in Upper West Region are still at the rudimentary stage as compared to other geographies in southern Ghana. Therefore, constant monitoring of the where and how ASM activities are being carried out in the region by the responsible state institutions such as the Minerals Commission, Environmental Protection Agency (EPA) and the host Municipal and District Assemblies (MDAs) is suggested to help flush out the illegal mining operations. Further study focusing on quantifying the degraded areas under galamsey operations is pertinent to guide policy on land reclamation.

Acknowledgements We would like to extend our appreciation to Mr. Godwin K. Naazie, Mr. Abudi Iddrisu, Mr. Inusah Adama Abu, Mr. Peter Dery Bolang, Mr. Abdul-Razak Saaka and Mr. Malik Limman for the diverse support you offered us during the field data collection. Our gratitude also goes to the chiefs, assembly members, lead miners and all the artisanal and small-scale mining groups in the study communities for giving us the audience, space and time to conduct the research.

Declarations

Conflict of interest The authors declared no conflict of interest.

Ethical approval As required in every social research, when conducting a study of this kind, there is the need to consider the ethical codes guiding the study (Creswell, 2014). For the purpose of this study, at the stage of data collection, the study took into consideration all ethical issues that brought about the success of the study.

Informed consent Artisanal miners, traditional authorities and assembly members consent were sought and were assured that whatever so information that was provided will be treated very confidential and that the information was only and only for academic purpose.

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