



An analysis of illegal mining on the Offin shelterbelt forest reserve, Ghana: Implications on community livelihood



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ABSTRACT

Mining in tropical countries contributes significantly to the global minerals supplies but unregulated mining activities in reserved forests is associated with destruction, loss of habitats and loss of biodiversity. This study determined the area of the Offin shelterbelt forest reserve, Ghana, degraded through illegal mining (galamsey) and the impacts on the livelihoods of fringe communities. Thirty-two (32) coordinates were recorded around the peripheries of disturbed site in the reserve using hand-held Global Positioning System and were then imported into a geodatabase in ArcGIS which was used to estimate the area degraded. Data was obtained from 60 purposively sampled respondents from two communities fringing the reserve and 10 key informant interviews. Increased income (13%), employment opportunities (6.7%) and increased market activities (2%) were some benefits of the illegal mining activities identified by the respondents. Eight respondents associated their employment with of the advent of illegal mining activities out which 6 (70%) were engaged directly in mining activities, while 2 (30%) were into trading. The miners earned cash income range of US \$ 2.9–22.9 daily. Within 5 years, illegal mining had degraded 2.5 km² (4.4%) of the total area of the reserve and the destruction of cocoa farms and water sources (31). Farming among respondents reduced from 90% to 76% after illegal mining. The relatively high cost (US\$ 6424.1) involved in flushing out and the subsequent return of such miners poses a threat to sustainable forest management and requires a more holistic approach in tackling such a problem.

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1. Introduction

Mining is one of the key areas of natural resources exploitation in tropical countries like Ghana (Yaro, 2010) and contributed approximately US \$ 4 billion in foreign direct investment to Ghana (Yelpaala & Ali, 2005; Garvin, McGee, Smoyer-Tomic, & Aubynn, 2009). Destruction of forest, loss of habitats and biodiversity, due to mining activities, have been widely reported (WWI, 1992; Majer, 2013). Though mining is important it is said to be illegal when it is practiced without permit or in unapproved areas like the forest reserves, game reserves or near water resources even with a

secured permit (World Bank Group Department, 2002). Illegal mining locally known as “galamsey” in Ghana, has been given a lot of media publicity, and has created public concern on the perceived extensive damage it has caused to forest cover. It is estimated that about 300,000–500,000 Ghanaian artisanal miners work without an official license or illegally and the have contributed about \$ 461.1 million to Ghana's economy since 1989 (Tschakert, 2009). Thus, a significant contribution to mining revenue is made by the artisanal and small-scale mining sector whose operations are mostly classified as illegal (Hilson, 2001).

Deforestation and forest degradation, primarily in developing countries, accounts for some 18% of global carbon dioxide emissions (IPCC, 2007). In Ghana most of the accessible rainforests are shrinking due to the combined effect of forest fires, logging, agricultural colonization, mining activities, wildland fires and other development projects (Hansen, Lund, & Treue, 2009). From the country's original forest cover of 8.2 million hectares at the beginning of the 20th century only an estimated 1.6 million

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hectares remain. The deforestation rate is 2.0% leading to an annual loss of around 135,000 ha (Ministry of Lands and Natural Resources, 2012). With the dependence on forest as a source of livelihood to local people, protection of the remaining natural forests may be a difficult goal to achieve given socio-economic constraints associated with mining (Appiah et al., 2009).

The government of Ghana has long legalised artisanal and small-scale mining and require prospective applicants to follow a series of regulations to obtain a concession. However, ineffective policies and bureaucratic processes have impeded formalisation, making illegal activity more appealing (Banchirigah, 2008). Specifically, most artisanal miners have elected to remain unregistered because governments have created procedurally complex regulatory environments, and have failed to provide adequate on-site support and extension services (Hilson & Potter, 2003). Illegal mining is a poverty driven activity that is practiced in most developing countries where there is a poorly educated population and few employment opportunities (Yaro, 2010; Bagyina, 2012). Globally, an estimated 20 million people engage in illegal mining with nearly one quarter of the world's gold output originating from it (Hilson, 2001). Although illegal mining could help reduce poverty, on the contrary, it could bring negative impacts on forest resources (Sachs & Warner, 2001).

The activity of illegal miners in reserved forests is seen as a major threat to sustainable forest management and impact on livelihoods of communities. The Offin shelterbelt forest reserve in Ghana has been plagued by illegal mining since the year 2010. Currently information on the extent of mining driven deforestation and degradation of forest reserves, as well as its impacts on livelihoods is limited. Also, the estimated cost incurred in flushing out illegal miners and the sustainability of such operations has not been well documented.

For planning and execution of remedial measures, it is essential to document the presence of illegal mining activities in forest reserves taking into consideration the area or extent of degradation as well as its impact on livelihoods. This study aimed to determine the area of the Offin shelterbelt forest reserve degraded through illegal mining activities and its impacts on the livelihood of fringe communities as well as the implication on sustainable forestry.

2. Materials and methods

2.1. Study area description

Offin shelterbelt forest reserve lies between latitude 6° 37' and 6° 45' and longitude 2° 00' and 2° 06' West. The reserve, is made up 44 compartments, covering a total area of 56.67 km². Reconnaissance surveys conducted, led to the selection of two fringe communities at the North East of the reserve (Ataso and Nnwerem), due to their proximity to the reserve (i.e., 250 m and 150 m respectively). Also, the farmlands along the reserve are owned mostly by members within the two communities.

These communities are dominated by environments with steep terrain and dense vegetation interspersed with cocoa and small plots of palm oil, cassava and vegetables. There are two seasonal variations - wet season (from April to October) and dry season (from November to March). The reserve lies in the two-peak rainfall belt, with the maximum during May–June and the minimum during September–October. The mean annual temperature of the area for the period 2009–2014 was 27.9 °C and the mean annual relative humidity recorded is about 84%. The land is undulating over the greater part of the reserve with an average height of 152–198 m above sea level. There are hill ranges trending north-east in the Eastern tip of the reserve; these ranges average 259 m to over 305 m (Ghanadistricts, 2016).

2.2. Data collection methods and analysis

Purposive sampling method was used to select respondents at the community level. A total of sixty (60) respondents were sampled from Ataso and Nnwerem communities. Ten percent of the communities were sampled based on the populations as recommended by Diaw, Blay, and Adu-Anning (2002). Respondents consisted of 54 individuals whose livelihoods have been affected by the illegal mining activities as well as 6 illegal miners. Thirty-five (35) respondents were selected from Ataso and twenty-five (25) from Nnwerem communities. Primary data was gathered through interviews by means of semi-structured questionnaires. Data gathered focused on the negative and positive effects of illegal mining and the incomes obtained by the miners. The obtained data were coded and analysed using Statistical Package for Social Sciences software (SPSS) Version 16. The outputs from the analyses of responses were presented in tables and charts.

Additionally, 10 key informants were interviewed and included: officials from the District Forest Services Division, the Military, the Police and opinion leaders from the two communities. These interviews focused on the strategies, personnel, cost incurred and other resources used by the Forest Services Division in flushing out illegal miners from the Offin shelterbelt forest reserve. The number of personnel, tools and expenditure incurred by the Forest Services Division (FSD) in flushing out illegal miners were also estimated and presented in a table.

To estimate the area of the reserve degraded by mining activities, thirty-two (32) coordinates were recorded around the peripheries of the disturbed site using hand-held GARMIN 60 CSX Global Positioning System (GPS). The GPS data were then imported into a geodatabase in ArcGIS. A polygon representing the degraded portion of the reserve was created and then used to estimate the area degraded by illegal mining activity. The degraded portion of the reserve was illustrated in the form of a map.

3. Results and discussion

3.1. Effects of illegal mining on the livelihoods of the people

Twenty-three percent (14) of respondents indicated that the advent of illegal mining in the communities has yielded positive effects on their livelihoods. Increased income (13%), employment opportunities (6.7%) and increase in market activities (2%) were reported (Table 1). Banchirigah (2008) reported on illegal mining operations as a complex operation involving people from several fields and offers employment ranging from menial work to book-keeping positions (Table 2). Individuals can work as haulers, machine operators, packers, ore washers, diggers and vendors, all of whom earn regular wages (Banchirigah, 2008). Our study indicated that 13.3% (8) of respondents associated their employment with of the advent of illegal mining activities. Out of those employed, about 70% (6) were engaged directly in illegal mining activities, while the remaining 30% (2) were engaged in the trading of mining related items. Depending on the workload, our study revealed that miners earn cash income range of US \$ 2.9–22.9 daily. In line with our results, Bush (2009) reported that *galamsey* activities provide markets for village products or entrepreneurial activity for hawkers and traders and markets for technical supplies to repair machinery used in gold extraction and processing. Thus, *galamsey* provides an enormous boost to economies in the areas where they operate and this boost is far greater than anything that accompanies legal mining (Bush, 2009). As such, if well regulated, illegal gold mining could be is a very important activity that provides employment for people in rural communities (Heemskerck & Oliveira, 2003; Yaro, 2010).

Table 1
Effects of illegal mining on the people.

	Number of respondents
Positive effects	
Income generation	8 (13.3)
Increase in employment opportunities	4 (6.7)
Increase in market activities	2 (3.3)
Negative effects	
Destruction of farmland (cocoa) and pollution of water bodies	31 (51.7)
High cost of living	10 (16.7)
Increase in social vices and school dropouts	5 (8.3)
Total	60 (100)

Parenthesized numbers are percentages of respondents.

Table 2
Descriptions of selected income-earning positions from illegal mining.

Job/activity	Description
Transport	Fees paid for transporting sacks of ore.
Machine owners	Fees charged to a 'pit owner' for grinding ore.
Entrepreneurs/ gold buyers	Sponsor miners, and provide them with supplies of mercury in exchange for gold.

Adopted from (Banchirigah, 2008).

However, forty-six (76.7%) of our study respondents indicated that the inception of mining activities within the reserve, has brought negative effects on their livelihoods (Table 1). Of these, the majority (31) indicated destruction of cocoa farms and water pollution as a challenge faced by community members. The finding of this study confirm reports that associated a plethora of environmental complications such as mercury pollution, reduction in vegetation cover and land degradation with such illegal activities despite providing people with employment, and making important contributions to foreign exchange earnings (Hilson, 2002; Tom-Dery, Dagben, & Cobbina, 2012). Hilson (2002) suggested that these problems could be attributed to low safety awareness and levels of training, poor exploitation of available resources due to selective extraction of rich ores, absence of environmental standards and utilization of highly inefficient equipment. Ten respondents also indicated a rise in the cost of living, while 5 hinted of an increased school dropout rate and social vices in these communities associated with illegal mining (Table 1).

Our study further revealed that these negative impacts apparently influenced the livelihoods of the respondents, consequently leading to a drop in student population from a previous number of 3 to 1 and about 15% decline (i.e. from 54 to 46) in farming activities within five years since the inception of illegal mining (Fig. 1). A decline in student population and farming could have accounted for a rise in the number of trading activities from 1 to 5 among respondents and higher number people (6) venturing into illegal mining over the five years (Fig. 1). Consistent with these findings, Hilson, Natalia, and Banchirigah (2007) indicated that, farmers who lose their land to such mining activities have very limited means for survival, and therefore resort to illegal mining, which provides the quickest means of securing income in Ghana's informal economy. This complements the assertion that the impairment of traditional sources of livelihood such as farming by illegal mining activities without alternative employment could lead to social problems. Furthermore, the fall in food production in the communities, accounts for high food prices thereby increasing the cost of living in such communities (Akabzaa & Darimani, 2001). This study reveals that negative effects of the illegal mining activities are strongly opined by community members than the positive effects and that

the possible economic benefits may not be able to account for the losses incurred. This study therefore highlights the need to put in place measures to ensure the protection of vulnerable groups or rural poor farmers whose options to pursue livelihoods may be curtailed by such mining activities.

3.2. Area of the reserve degraded, the financial cost of flushing out illegal miners and implication on sustainable forestry

Our study revealed that, illegal mining activities by people in the two communities (Ataso and Nnwerem) has resulted in the degradation of an estimated area of 2.5 km² representing 4.4% of the total area (56.67 km²) of the reserve (Fig. 2) within five (5) years. Consistent with our findings, illegal mining in forest reserves has been reported to be aggravating the already alarming rate of forest degradation in Ghana (Aubynn, 2003). Thus it could be projected that the Offin shelterbelt forest reserve is being degraded at a rate of 0.88% annually only by illegal mining activities. This projection contrasts an estimated national rate of between 2.1 and 3.0% resulting from the combined effect of forest fires, logging, agricultural colonization, mining activities, wild land fires and other development projects (Appiah et al., 2009; Thomas & Insaiddo, 2012).

Sustainable forest management principles espouses activities that are economically viable, environmentally benign and socially beneficial, and which balances present and future needs. For most initiatives the elements of sustainable forest management usually assesses the legal and policy framework e.g. compliance with legislation and regulation; sustained and optimal production of forest products e.g. protection of the forest from illegal activities; protecting the environment e.g. ecological sustainability; and wellbeing of people e.g. contribution to development (Dubinski, 2013). In relation to our findings, assessment of the mining activities based on these criteria is a major disincentive to sustainable forest management.

For any operation geared toward elimination of illegal miners in the Nkawie Forest District, 25 individuals are involved. They include the Forest District Manager, Range supervisor, Military personnel (5), Police Officers (5), Rapid Response Unit of the Forestry Commission (5), Forest Guards (4), Mechanic (1), Electrician (1) and Representatives from the fringe communities (2) (Table 3). Such an operation has however been reported to require considerable financial backing and risk which includes accidental falls into uncovered pits, death and injuries as a result of gun shots and physical confrontation between the team members involved in the flushing out operation and illegal miners (Banchirigah, 2008; Forestry commission, 2010).

The Forestry Commission of Ghana bears the cost paying twelve (12) individuals (military, police, mechanic and the electrician) involved after every operation. The remaining thirteen (13) individuals (District manager, Range supervisor, Rapid response unit, Forest guards and representatives from the fringe communities) receive allowances borne by the Nkawie Forest District and ranges between US \$ 4.3–14.3. It was found that there is a recurrent cost of US \$ 415.5 during every operation, which is the estimated total cost, minus the cost of equipment when not needed (Table 3). The equipment cost is incurred when newly selected members from the rapid response unit and the fringe communities need to be armed. Our study confirm the use of Military-led 'sweeps' of mining areas as one of the principal approaches used to discourage illegal mining in Ghana (Hilson et al., 2007). Usually, such attempts to stop illegal mining in Ghana results in the confiscation all equipment at mining and processing sites, burned land around existing shafts, and dug trenches to prevent *galamseyers* from returning to continue working (Tschakert, 2009). Similar to our observations made in the Offin

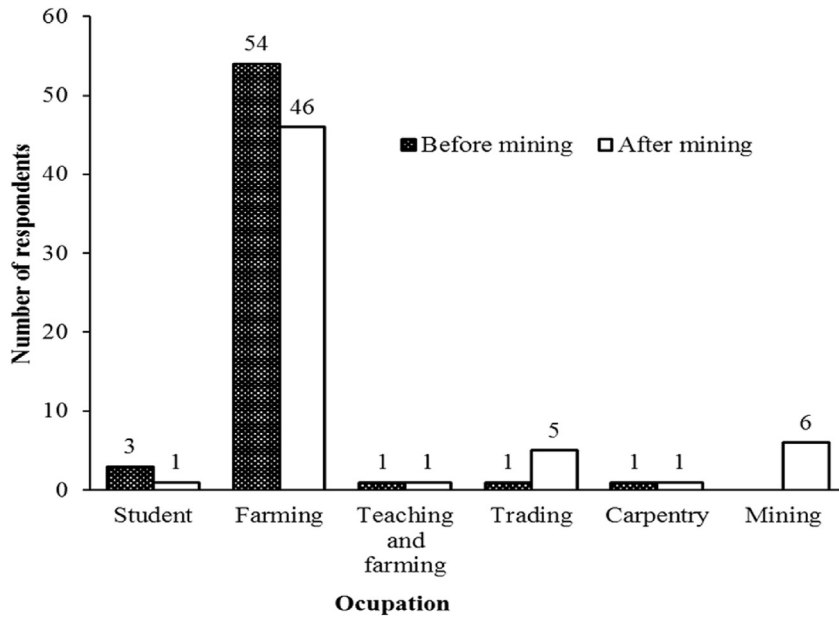


Fig. 1. Changes in livelihood activities resulting from the commencement of illegal mining in two communities fringing Offin shelterbelt forest reserve.

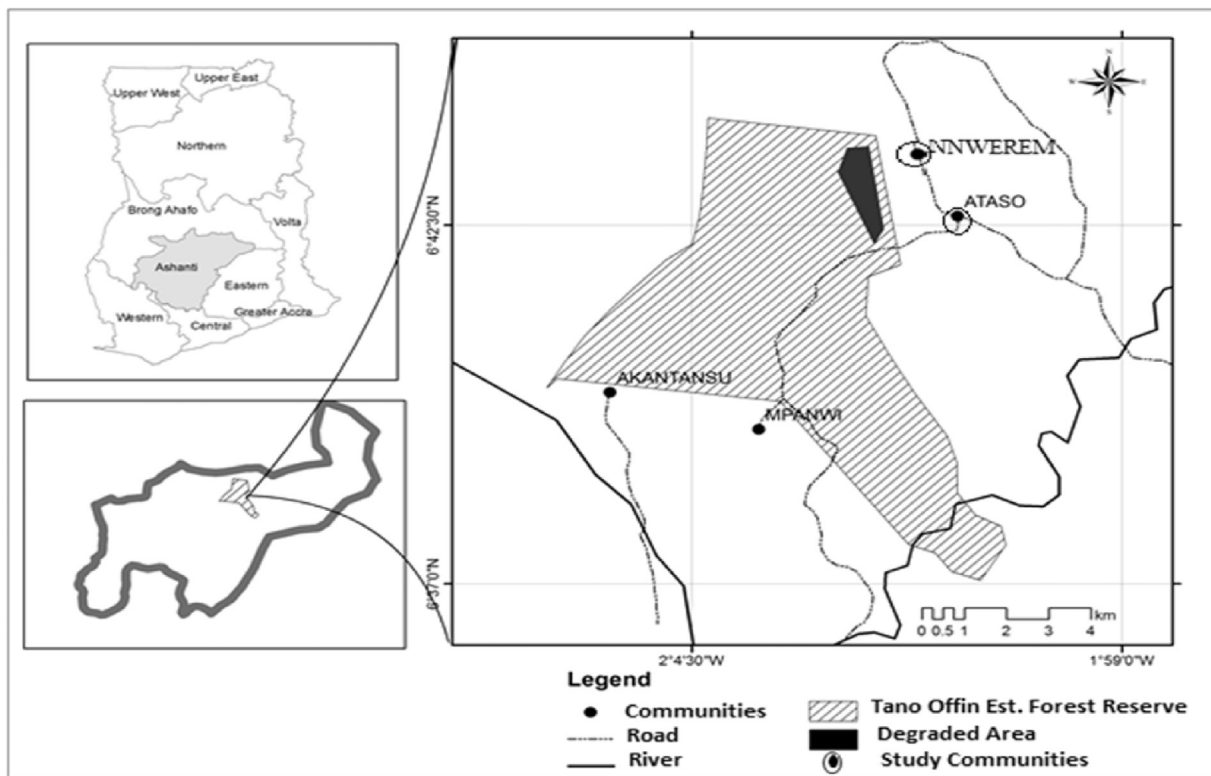


Fig. 2. Map of Ghana showing the location of the Offin shelterbelt forest reserve and the estimated degraded area through illegal mining.

shelterbelt forest reserve and ineffectiveness of such an approach, the miners generally return to the operations that they have been forced, typically at gunpoint, to abandon (Banchirigah, 2008; Bush, 2009). A report also indicated that some miners under such circumstances continued operating secretly and, at night, transported loads of crushed ore to processing sites (Tschakert, 2009).

Illegal mining in Ghana is increasingly larger in scale, they are using bulldozers and have big floodlights to work at night—all of

which means there is capital up front (Tschakert, 2009). Consequently, increasing illegal mining in forest reserves across Ghana, could raise the cost (financial and personnel) involved in curbing such activities and cast doubts on the sustainability of such operations and/or the protection of forests from illegal mining. The perpetuity of such activities despite such measures demands a holistic approach to tackling such a problem.

Table 3

Expenditure incurred per an operation in flushing out illegal miners from the Offin Shelterbelt Forest Reserve, Ghana.

Required resources	^a Amount (US \$)	^a Total (US \$)
Personnel		
Military Commander	7.10	105.6
Police Commander	7.10	
Military Officers (4 × 15)	17.10	
Police Officers (4 × 15)	17.10	
Electrician	28.60	
Mechanic	28.60	
Allowances		
Military Commander	5.7	138.6
Police Commander	5.7	
Military Officers (4 × 20)	22.9	
Police Officers (4 × 20)	22.9	
District Manager	14.3	
Range Supervisor	7.1	
Rapid Response Unit (5 × 20)	28.6	
Forest Guards (x 4)	22.8	
Representatives from fringe communities (x 2)	8.6	
Fuel per day (x 3 vehicles)	171.3	171.3
Equipment		
Guns (x 5)	6000	6008.6
Cutlass (x 2)	8.6	
Total		6424.1

^a Amounts calculated at an exchange rate of US \$ 1 approximately equivalent to 3.5 Ghana cedis.

4. Conclusion

The study showed that although illegal mining offered some opportunities in terms of employment, income and increase in market activities, 76.7% of respondents indicated that the negative effects – destruction of farmlands and water pollution, high cost of living and increase in social vices and school dropout – far outweighs its benefits. It was also established that, the two communities (Ataso and Nnwerem) in 5 years have degraded 4.4% of the total area of the Offin shelterbelt forest reserve in addition with some admitted farms and some farm lands fringing the reserve through illegal mining activities. Although farming remains the dominant occupation after the inception of illegal mining, the percentage of people into farming reduced from 90% to 76% in contrast to a 6.7% increase in trading activities. This may have negative impact on food production. Despite efforts made to flush out illegal miners from the reserve, the relatively high cost (US \$ 6424.1) involved and recurrence of the miners is a major drawback to the sustainability of such efforts. The quest to protect and manage forest sustainably in relation to the challenge of illegal mining therefore requires a multifaceted approach to find lasting solution to the problem.

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References

Akabzaa, T., & Darimani, A. (2001). *Impact of mining sector investment in Ghana: A study of the tarkwa mining region, draft report prepared for SAPRI*. Retrieved June

- 10, 2016 from http://www.saprin.org/ghana/research/gha_mining.pdf.
- Appiah, M., Blay, D., Damnyag, L., Dwomoh, F. K., Pappinen, A., & Luukkainen, O. (2009). Dependence on forest resources and tropical deforestation in Ghana. *Environment, Development and Sustainability*, 11(3), 471–487. <http://dx.doi.org/10.1007/s10668-007-9125-0>.
- Aubynn, E. A. (2003). *Community perceptions of Mining: An experience from western Ghana*. Master of Science Thesis in Earth and Atmospheric Sciences (Published). Edmonton: Alberta University, Department of Earth and Atmospheric Sciences.
- Bagyina, O. A. (2012). *Assessment of the impact of mining on land use systems and livelihoods in the Obuasi municipality*. Master of Science Thesis. Kumasi, Ghana: Kwame Nkrumah University of Science and Technology.
- Banchirigah, S. M. (2008). Challenges with eradicating illegal mining in Ghana: A perspective from the grassroots. *Resources Policy*, 33(1), 29–38.
- Bush, R. (2009). 'Soon there will be no-one left to take the corpses to the morgue': Accumulation and abjection in Ghana's mining communities. *Resources Policy*, 34(1), 57–63.
- Diaw, K., Blay, D., & Adu-Anning, C. (2002). *Socio-economic survey of forest fringed communities: Krokosua hills reserve. A report submitted to the forestry commission of Ghana* (pp. 1–86). Accra, Ghana.
- Dubiński, J. (2013). Sustainable development of mining mineral resources. *Journal of Sustainable Mining*, 12(1), 1–6.
- Forestry commission (FC). (2010). *Illegal mining destroying forest cover. Main Report*. Accra, Ghana: FC Publications.
- Garvin, T., McGee, T. K., Smoyer-Tomic, K. E., & Aubynn, E. A. (2009). Community – company relations in gold mining in Ghana. *Journal of Environmental Management*, 90(1), 571–586.
- Ghanadistricts. (2016). Retrieved June 10, 2016 from <http://ghanadistricts.net/DistrictSublinks.aspx?s=665&d=13>.
- Hansen, C. P., Lund, J. F., & Treue, T. (2009). Neither Fast, Nor Easy: The Prospect of Reduced Emissions from Deforestation and Degradation (REDD) in Ghana. *International Forestry Review*, 11(4), 439–455. <http://dx.doi.org/10.1505/1for.11.4.439>.
- Heemskerck, M., & Oliveira, M. (2003). *Perceptions of small-scale gold mining impacts: Results from focus group discussions in mining camps and affected communities*. Guianas, Paramaribo: World Wildlife Fund (WWF).
- Hilson, G. (2001). *A contextual review of the Ghanaian small-scale mining industry. Mining, minerals and sustainable development (MMSD) working paper No. 76*. Retrieved May 2, 2016 from <http://pubs.iied.org/pdfs/G00722.pdf>.
- Hilson, G. (2002). The environmental impact of small-scale gold mining in Ghana: Identify problems and possible solutions. *Geographical Journal*, 168(1), 57–72.
- Hilson, G., Natalia, Y., & Banchirigah, S. M. (2007). 'To move or not to move': Reflections on the resettlement of artisanal miners in the Western Region of Ghana. *African Affairs*, 106(424), 413–436. <http://dx.doi.org/10.1093/afraf/adm038>. <http://afraf.oxfordjournals.org/>.
- Hilson, G., & Potter, C. (2003). Why Is Illegal Gold Mining Activity so Ubiquitous in Rural Ghana? *African Development Review*, 15(2–3), 237–270.
- IPCC. (2007). *Climate change: Synthesis report. Intergovernmental panel on climate change*. Cambridge, United Kingdom: Cambridge University Press.
- Majer, M. (2013). The practice of mining companies in building relationships with local communities in the context of CSR formula. *Journal of Sustainable Mining*, 12(3), 38–47.
- Ministry of Lands and Natural Resources. (2012). *Ghana investment plan for the forest investment program (FIP)*. Retrieved September 16, 2015 from www.fcghana.org/assets/file/...Plan.../Ghana.
- Sachs, D. F., & Warner, A. M. (2001). Natural resources and economic development. The curse of natural resources. *European Economic Review*, 45, 827–838.
- Thomas, F. G., & Insaioo, E. A. (2012). Forest governance arrangement and innovations related to forest and tree based livelihoods in Ghana. In *Paper presented at the IUFRO-FORNESSA conference, 25–30th June, Kenya*.
- Tom-Dery, D., Dagben, Z. J., & Cobbina, S. J. (2012). Effect of illegal small-scale mining operations on vegetation cover of arid northern Ghana. *Research Journal of Environmental and Earth Sciences*, 4(6), 674–679.
- Tschakert, P. (2009). Digging deep for justice: A radical Re-Imagination of the artisanal gold mining sector in Ghana. *Antipode*, 41(4), 706–740.
- World Bank Group Department. (2002). *Treasure or Trouble? Mining in developing countries*. Washington, DC (p. 32). Retrieved June 10, 2016 from <http://siteresources.worldbank.org/INTOGMC/Resources/treasureortrouble.pdf>.
- WWI. (1992). *World Watch Institute report. WWI paper No. 109*. Washington: WWI.
- Yaro, J. I. (2010). *Impact of mining on livelihoods of local communities: A case study of newmont Ahafo south mining project of brong Ahafo region of Ghana*. International Institute of social studies, Netherlands. Retrieved June 10, 2016 from https://thesis.eur.nl/pub/8643/RP_final.docx.
- Yelpaala, K., & Ali, S. H. (2005). Multiple scales of diamond mining in Akwatia, Ghana addressing environmental and human development impact. *Resource Policy*, 30, 145–155.