ASSESSMENT OF SOCIOLOGICAL AND ECOLOGICAL IMPACTS OF SAND AND GRAVEL MINING – A CASE STUDY OF EAST GONJA DISTRICT (GHANA) AND GUNNARSHOLT (ICELAND)

Jafaru Adam Musah
Environmental Protection Agency
Post Office Box 620 Tamale, Northern Region, Ghana
jafjilima2000@yahoo.com

Supervisor
Mr. Björn H. Barkarson
Environmental and Infrastructural Consultant
VSO Consulting, Reykjavik, Iceland
bjornh@vso.is

ABSTRACT

Sand and gravel mining has been one of the serious environmental problems around the globe in recent years. This often results in land degradation, loss of agricultural lands and biodiversity as well increased poverty among people. In order to address these problems, pragmatic and explicit laws and regulations have to be developed by countries in a participatory manner so as to facilitate enforcement and compliance at all levels within the social settings. This study was therefore carried out to compare sand and gravel mining in the East Gonja District (EGD) of Ghana and the Gunnarsholt area of Iceland. The main objective of the study was to assess the sociological and ecological impacts of sand and gravel mining in the study areas. Specific objectives were: i) to assess agricultural losses through sand and gravel mining in the areas; ii) to gather communities' and stakeholders' perceptions of the socio-ecological impacts of gravel and sand mining; iii) to assess and compare regulations and policies governing such land use; iv) to suggest interventions that can assist in mitigating negative impacts that might be identified during the study. The study revealed fewer mines around Gunnarsholt than in EGD and that mining activities mostly occur in barren lands whilst in EGD the mining activities occur in productive agricultural lands. Also, the impact of gravel mining on agriculture is greater in EGD compared to the Gunnarsholt area. Policies and regulations on mining vis-à-vis monitoring and enforcement activities are quite explicit in the Gunnarsholt area compared to EGD. Other environmental impacts of the two study areas were similar and clear sociological impact appeared in the generation of conflicts and other confrontations.

1. INTRODUCTION

Mining of natural aggregates, including both sand and gravel and crushed rock, represents the main source of construction aggregates used throughout the world, with examples from Australia (Erskine & Green, 2000), France (Petit, Poinsart & Bravard, 1996), Italy (Surian & Rinaldi, 2003), the USA (Kondolf, 1994), Belgium (Gob, Houbrechts, Hiver & Petir, 2005) and Britain (Sear & Archer, 1998). However, operations of mining, whether small- or large-scale, are inherently disruptive to the environment (Makweba & Ndonde, 1996). Also mining of aggregate frequently generates land use conflicts in populated areas due to its negative externalities including noise, dust, truck traffic, pollution and visually unpleasant landscapes (Willis & Garrod, 1999). It also can represent a conflict with competing land uses such as farming, especially in areas where high-value farmland is scarce and where post-mining restoration may not be feasible. As pointed out by social and environmental activists there are potential linkages between mineral resources and conflict and consequential underdevelopment (Ross, 2001).

Gravel extraction can cause changes to channel morphology in rivers through the lowering of the riverbed during extraction (Rinaldi, Wyzga & Surian, 2005). This is enhanced by the disruption to bed armour caused by excavations and the movement of machinery which makes the bed vulnerable to fluvial erosion (Mossa & McLean, 1997).

In the Northern Region of Ghana and the East Gonja District (EGD) in particular, commercial gravel extraction to supply aggregate to the construction industry has been on the increase in recent years. This has to a large extent contributed to land degradation and desertification through the destruction of economically important trees, mostly indigenous in nature. This practice leaves behind bare soil and a large expanse of gullies which can collect water during rainy seasons. This can result not only in health-related problems for neighbourhood communities, but can cause negative impacts on the environment as well (Heath, Merefield & Paithankar, 1993; Veiga & Beinhoff, 1997; Warhurst, 1994, 1999).

In southern Iceland with particular attention to Gunnarsholt, which 50 years ago was almost a desert area, a significant number of mining sites are dotted across its length and breadth (Sigurjonsson, 1958; Gylfi Juliusson, Pers.com.). These mines mainly are used to supply aggregate to the construction industry.

Nonetheless, gravel sites from the study areas are a particularly attractive source of aggregate as they are relatively well sorted, easily accessible and cheap to extract (Sear & Archer, 1998). This has potentially adverse impacts on the natural environment, society and cultural heritage, the health and safety of mine workers, and communities based in close proximity to operations (Moody & Panos, 1997) and dislocation (Akabzaa, 2000). However, although people in general are familiar with the need and importance of sand and gravel mining for construction material, the awareness of the negative impact this has on vegetation, biodiversity and food security may not be as commonly known.

Despite widespread occurrence and potential impact on the environment and agricultural lands, sand and gravel mining has received little attention. Even though some studies have improved our consciousness of the impacts, attention usually seems to be focused on mining along river banks and is seldom considered in the context of farms/cultivated lands.

This study sought to assess the sociological and ecological impacts of sand and gravel mining with particular attention to the East Gonja District of Ghana vis-à-vis the Gunnarsholt area of Iceland.

The main objective of this study was to carry out an assessment of the sociological and ecological impact of sand and gravel mining in the East Gonja District of Ghana and the Gunnarsholt area of Iceland. The more specific objectives of the project were:

- To estimate agricultural losses due to sand and gravel mining in the study areas.
- To gather communities' and stakeholders' perceptions of the socio- and ecological impacts of sand and gravel mining in the areas.
- To assess and compare regulations and policies governing such land use in the areas.
- To suggest interventions that could assist in mitigating negative impacts that might be identified during the study.

2. STUDY AREAS

The study was carried out in two study areas, East Gonja District (Ghana) and the Gunnarsholt area (Iceland).

2.1 East Gonja District

2.1.1 Location and size

East Gonja District is located in the south-eastern section of the Northern Region of Ghana. The district lies between Lat. 8°N & 9.29°N and Long. 0.29°E & 1.26°W (East Gonja District Assembly, 2006). It shares boundaries with the *Yendi* and *Tamale* districts to the north, the *Central Gonja* District to the west, the *Nanumba-North and Nanumba-South* Districts to the east, and the Volta and *Brong Ahafo* Regions to the south (see Fig. 1).

The total land area of the district is 10,787 km^2, occupying about 15% of the landmass of the Northern Region (East Gonja District Assembly, 2006). The district comes first in terms of land area (size) among the districts of the Northern Region.

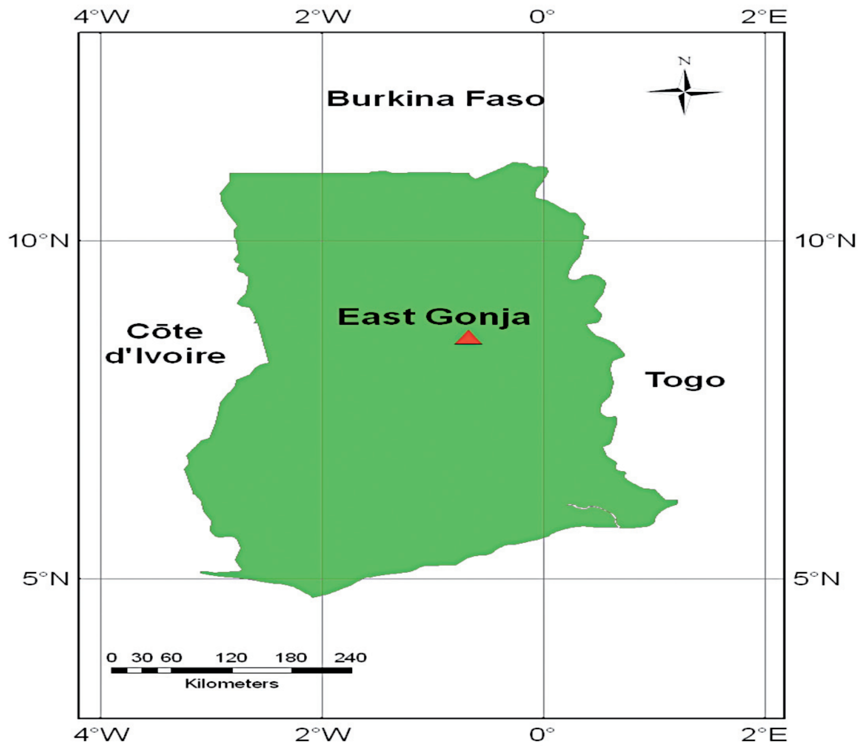

Fig. 1. *Map of Ghana showing the location of East Gonja District. (Source: modified from Google earth).*

The topography of the district is typical of the Northern Region, generally flat with few undulating surfaces. Nowhere does the land rise as high as 200 metres. The district is underlain by the Voltarian sedimentary formation with low potential for mineral formations and poor water retention (East Gonja District Assembly, 2006).

The average annual precipitation in the area is 1,050 mm which is considered enough for a single farming season. Temperatures are usually high, averaging 30°C (East Gonja District Assembly, 2006).

The main drainage system in the district is made up of the Volta and some of its major tributaries, including the White Volta, the Dakar and Oti Rivers. There is a good flow of water collected and stored in Lake Volta, which potentially exists for irrigation and small dam sites. The natural vegetation in the district is Guinea Savannah Woodland, which consists of trees that are drought resistant (East Gonja District Assembly, 2006).

Most of these trees are of economic value. Notable amongst them are the *shea* and *dawadawa* trees (East Gonja District Assembly, 2006). Compared to the rest of the Northern Region, the tree cover is dense although intense harvesting for fuel wood is reducing the natural flora.

At the extreme south-east, the vegetation is dense and semi-deciduous trees such as oil palm trees, raffia palms and others can be found. There are three major groups of soils in the district:

Alluvial Soils, Ground water Laterites and Savannah Ochrosols (East Gonja District Assembly, 2006).

2.1.2 Climate and vegetation

The East Gonja District lies in the Tropical Continental climatic zone with the mid-day sun always overhead. As a result, temperatures are fairly high, ranging between 29°C and 40°C. The maximum temperature is usually recorded in April, towards the end of the dry season. Minimum temperatures are recorded around December-January, during the Harmattan (dry wind) period (East Gonja District Assembly, 2006).

Just like any other part of West Africa, the district comes under the influence of the wet South-West Monsoon and the dry North-East Trade winds which are associated with the rainy season and the dry harmattan conditions, respectively (East Gonja District Assembly, 2006).

The rainfall pattern in East Gonja is characterized by irregularity and variability in terms of timing of onset, duration and total amount of rainfall, which has been the key limiting factor affecting crop production in the district (East Gonja District Assembly, 2006).

2.1.3 Demographic characteristics

According to the *Ghana Population and Housing Census* (2000), the population of the East Gonja District was 174,500 as in 2000. Currently it is estimated at around 198,000, using an annual rate of growth 2.1% per annum (East Gonja District Assembly, 2006). The district's share of the total population of the Northern Region is 9.7%. The total population of the Northern Region stood at 1,820,806 (as of 2000). The district's population growth rate is 2.1% (1984–2000), lower than both the regional and national averages of 2.9% and 2.5%, respectively (East Gonja District Assembly, 2006).

This relatively low population growth rate could be explained by increased migration from the District combined with the modest success in population control and education measures of the Ministry of Health. This lower population growth rate in East Gonja District is an asset to be maintained and reinforced through conscious policy and promotional and educational measures.

2.1.4 Spatial Distribution of Population

The population of the district is predominantly rural. A total of 152,146 of the population, representing 86.4% (in 2000), are located in rural communities (East Gonja District Assembly, 2006). This indicates a decline in the rural population compared to the 1984, 1970 and 1960 figures of 86.8%, 91.2 and 100%, respectively. The proportion of the population located in urban communities is gradually increasing. The urban population in the district in 1970 was merely 8.8% and this had increased to 13.6% by 2000 (East Gonja District Assembly, 2006).

2.2 Gunnarsholt

2.2.1 Location and climatic condition

According to world map co-ordinates, the location of Gunnarsholt in Iceland is at Lat. 63°51'00 N and Long. 20°11'60 W. The area's mean annual temperature and rainfall do not vary much from the national figures. The mean annual temperature varies from 2–6°C, and annual total precipitation varies from 300–3500 mm (Barkarson & Johannsson, 2009).

2.2.2 Soil type and geology

The Gunnarsholt area is in close proximity to one of Iceland's most active volcanoes, Mt Hekla. It has erupted at least twice each century on average (Thorarinsson, 1970) and is the primary local source of the vast tephra (ash) deposits to the north of Gunnarsholt. As these deposits became increasingly unstable during the past several centuries, aeolian erosional activity in the area intensified. The latter part of the 19th and beginning of the 20th centuries were characterised by sand encroachment in the area, devastating many farms and leaving infertile sandy desert in place of arable land (Sigurjonsson, 1958). The land in the vicinity of Gunnarsholt was totally desertified and the aeolian activity caused rapid sedimentation of airborne materials at sites where vegetation remained. As a result, the soil at the Gunnarsholt study area consists of a thick mantle of reworked and *in situ* volcanic materials. Soil that forms in volcanic ejecta develops unique characteristics that are referred to as andic soil properties. These are therefore classified as a special soil type such as Andosols (FAO-UNESCO, 1988) or Andisols (USDA, 1994). The unique properties of Andisols include their low bulk density and high water retention ability, with water infiltration and hydraulic conductivity resembling very silty soils (Maeda *et al.*, 1977; Wada, 1985).

2.2.3 Land use

Agriculture has been the dominant land use in the Gunnarsholt area as in Iceland in general (Barkarson & Johannson, 2009). Livestock production is the largest enterprise in the agriculture sector; hence a significant proportion of the land is utilized as extensively grazed rangelands. The lowlands constitute the privately owned land, while the highlands are divided into commons utilized by local communities for grazing livestock. Land management in the highlands is community-based, and grazing systems in the commons are simply with continuous sheep grazing and in some instances horse grazing during the 3–4 month growing season (Barkarson, 2002). The severity of land degradation in the area, and that of Iceland generally, can be primarily attributed to continuous overgrazing over the years. This is exacerbated by harsh climatic conditions which prevent plant re-growth (Barkarson & Johannson, 2009).

2.2.4 Spatial distribution of population

According to *Statistics of Iceland* (2008), the municipality of Rangárthing Ytra, under which Gunnarsholt falls, had a total population of 1,544 in September 2008. The area is relatively rural as compared to other areas in Iceland such as Reykjavik, Selfoss or Akureyri (Pers.com.).

3. METHODOLOGY

Data for this project were collected via a combination of literature research and field research in the study areas, Gunnarsholt and East Gonja District (EGD), respectively. Data in the EGD were collected in 2008 whilst data for the Gunnarsholt area spanned the period from July to September 2009.

3.1 Interviews

With the objective of identifying sociological aspects of sand and gravel mining, target groups were selected for interviews. These included individual landowners, groups of farmers whose farms were located close to gravel mining sites, and selected individuals from nearby communities. Representatives from relevant departments and agencies in respect of sand and gravel mining and other land use management systems were also included. The aim of the selection was particularly to give broad views on the subject. For individual farmers and community members, qualitative interviews were used since this approach allows a more in-depth investigation into the unique experience of each interviewee (Huntington, 2000). It also allows people to speak for themselves without their answers being biased by predetermined hypothesis-based questions (Huntington, 2000; Rubin J. & Rubin S., 2005). Most of the questions raised during the interview were to elaborate and/or clarify the interviewee's understanding of a point or to direct the interviewee to a new topic relevant to the aim of the study.

The questionnaire was basically focused to gather respondents´ views from the study areas on the impacts of gravel mining and how various regulations are operated to guide the activities. The responsibility for opening and closure of mines and ownership of mining areas were also considered. A sample of the questionnaire is therefore presented in Appendix 1.

3.2 Mines, condition and size

For estimating the size of sand and gravel mining sites, two different approaches were used based on the availability of equipment and technology. In the Icelandic situation, the areas and location of the gravel mines were obtained using the Magellan Meridian GPS co-ordinate system to locate points of new mining sites around the study area. Additionally, locations of old mining areas from aerial photographs were obtained from the Soil Conservation Service (SCS). Based on their locations on the aerial photographs, sizes of mines were estimated using ArcGIS 9.3 (ESRI, 2008). Ground verification visits were also conducted to determine whether mines were abandoned or reclaimed after one or more years of use.

In EGD, gravel mines which are usually opened along major roads were located and their areas measured using a tape measure and step counts. This method was also used for both active and abandoned mines. Mines which were seen to be less than 0.2 ha were not measured.

Active gravel pits considered in the study included mining and extraction operations and other rock crushing. Abandoned pits refer to mining pits that have not been used for over a year. This sometimes was characterised by abandoned vehicles or construction debris and general debris dumping.

4. LAND USE POLICIES AND MANAGEMENT

In recognition of the detrimental consequences that sand and gravel mining have on ecosystems, the environmental and land agencies of Ghana and Iceland have over the years made some effort to institute regulations to protect natural resources as a better alternative and proper management measures to ensure sound and sustainable land management.

4.1 Environmental Policy and Development Objective in Ghana

In Ghana in recent decades, land degradation and the environmental burden from the extraction of natural resources and related activities has been significant (Akabzaa, 2000; Awudi, 2002; International Monetary Fund, 2004). Since the early 1990s the government has taken substantial action to address these challenges. In 1991, Ghana adopted a National Environmental Policy for "ensuring a sound management of resources and the environment, and to avoid any exploitation of these resources in a manner that might cause irreparable damage to the environment" (Ebenezer, 1991).

In 1994, the Environmental Protection Council, in collaboration with the Minerals Commission, adopted guidelines mandating environmental impact assessment for mining activities in the country (Minerals Commission and Environmental Protection Council, 1994). According to the policy, environmental impact assessments must ensure that companies that deal with sand and mining "demonstrate that the project has been planned in an environmentally sensitive manner and that appropriate pre-emptive or mitigative measures and safeguards have been integrated into the projects design" (Minerals Commission and Environmental Protection Council, 1994). On December 30, 2004, government Act 490 formalized the establishment of the Environmental Protection Agency (EPA) as the primary government agency responsible for the formulation and enforcement of policies related to all aspects of the environment (Environmental Protection Agency Act, 1994). The Ghana Poverty Reduction Strategy: 2003–2005 International Monetary Fund, 2003) points out that the country is implementing a number of activities related to natural resource and environmental management. District assemblies have over the years been collaborating with departments such as the EPA, Ghana Education Service, Forestry Commission and other NGOs in the development and implementation of their Medium Term Development Plans.

4.2 Land Management Policy in Iceland

The main developments in regulatory measures regarding land use and land resources since UNCED are the 1993 Law on Environmental Impact Assessment and the 1997 Planning and Construction Law (Agenda 21, 1997). The Environmental Impact Assessment Act was then amended in 2000 (Environmental Impact Assessment Act 106/2000). The power and initiative of local governments with regard to planning was significantly increased with the 1997 law and further in 2000.

A great improvement in the legal environment of planning of land resources occurred with the adoption of the Planning and Construction Law in 1997, which replaced the existing law on planning dating from 1964. Sustainable development is now a stated aim of the Law and all spatial planning: "The aims of this Law is to: encourage the rational and efficient utilization of land and natural resources; ensure the preservation of natural and cultural values; and prevent environmental damage and over-exploitation, based on the principles of sustainable development" (Agenda 21, 1997). The law requires that all land undergo spatial planning, not only inhabited land as was previously required. As a great part of Iceland is uninhabited, this is a major change. All local governments were to finish a municipal plan before the year 2007.

Another recent development, which will have a great impact on planning and management of land resources, is an integrated management plan for the central highlands, which comprise 40% of Iceland. The plan was adopted in 1999 and aims to integrate the development of the highlands with regard to power plants (hydroelectric and geothermal), transport, tourism, etc., as well as nature conservation (Agenda 21, 1997).

Iceland recognizes the right to landownership. Currently, a government committee is attempting to clarify landownership, especially in the highlands, following the adoption of a 1998 law which states that the Icelandic state owns all land that individuals cannot legally uphold their claim for (Agenda 21, 1997).

In Iceland, the level of crop production is extremely small, with agriculture being primarily concentrated on animal husbandry (Agenda 21, 1997).

5. RESULTS

The outcome of mine sizes and conditions as well as interviews from respondents are presented as follows.

5.1 Mines, condition and size

Results presented involve condition and size of mines in East Gonja District and around Gunnarsholt.

5.1.1 Mines in the East Gonja District (EGD)

Table 1 shows results from measurements and assessment of sand and gravel mines in EGD. The total number of mining sites recorded was 46. The total land area of mines observed to be abandoned, active and reclaimed covered 101.5 ha, 32.7 ha and 10.8 ha, respectively, and their percentages are illustrated in Fig. 2.

Table 1. *Results from survey of gravel mines in East Gonja District, Ghana.*

Number	Name of road	Total number of pits	Total size of pits, ha	Average size of pits, ha	Active pits	Abandoned pits	Re-claimed pits
1	Fuu – Salaga	19	68.5	3.6	5	11	3
2	Makango – Salaga	6	33.8	5.6	1	5	0
3	Pkandai – Salaga	7	10.2	1.5	3	4	0
4	Pkandai – Lugni	2	1.5	0.8	0	2	0
5	Kakoosi – Salaga	5	14.6	2.9	0	5	0
6	Bimbilla – Salaga	7	16.4	2.3	2	5	0
Totals		**46**	**145.0**	**16.7**	**11**	**32**	**3**

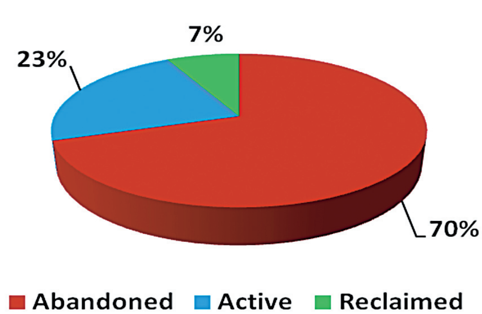

Fig. 2. *Gravel pits condition (abandoned, active and reclaimed) in East Gonja District.*

Results showed that average gravel pit size in the district was 0.8 to 5.6 ha (1.9 to 13.8 acres). Some pits might lie on adjacent land parcels but individual pits, although physically contiguous, were measured separately. Total area in the district covered by gravel pits, active and abandoned, was estimated to be 134.2 ha (326.7 acres). This represented 93% of total mine size. This means that 7% of the area affected by sand and gravel mining has been reclaimed.

5.1.2 Mines in the Gunnarsholt area

The conditions of sand and gravel mines in the Gunnarsholt area are shown in Table 2. The results show that a total of 18 mining sites were recorded, with pit size ranging from 0.2 to 28 ha (0.5 to 69.2 acres). However, the total area covered by the mining sites was estimated to be 67.6 ha (167.0 acres) and most of it remained either active or abandoned (Table 2).

The conditions of the gravel mines in EGD and the Gunnarsholt area are compared in Table 3. The total area of the abandoned, active and reclaimed gravel mines in the Gunnarsholt area was

Table 2. *Results from survey of gravel mines in Gunnarsholt area, Iceland.*

Site location	Type	Size, ha	Condition	Site location	Type	Size, ha	Condition
1	old	1.5	Abandoned	10	old	1.2	Active
2	old	12.5	Abandoned	11	old	0.2	Abandoned
3	old	0.5	Abandoned	12	old	0.6	Active
4	old	5.8	Reclaimed	13	new	1.8	Abandoned
5	old	0.6	Active	14	new	28.5	Abandoned
6	old	0.4	Reclaimed	15	new	0.2	Reclaimed
7	old	0.9	Reclaimed	16	new	1.3	Active
8	old	0.3	Reclaimed	17	new	2.2	Active
9	old	0.6	Reclaimed	18	new	8.5	Active
				Total		**67.6**	

Table 3. *Condition (abandoned, active, reclaimed), total number of mines and size (ha) in East Gonja District (Ghana) and Gunnarsholt area (Iceland).*

Condition	**Number of mines**		**Total area (ha)**	
	East Gonja	Gunnarsholt	EGD	Gunnarsholt
Abandoned	32	6	101.5	44.9
Active	11	6	32.7	14.4
Reclaimed	3	6	10.8	8.3

Table 4. Total number, total size and overall average size of pits (ha) in East Gonja District (Ghana) and Gunnarsholt (Iceland).

Study site	Total number of pits	Total size of pits (ha)	Overall average size of pits (ha)
EGD	46	145.0	3.1
Gunnarsholt	18	67.6	3.7

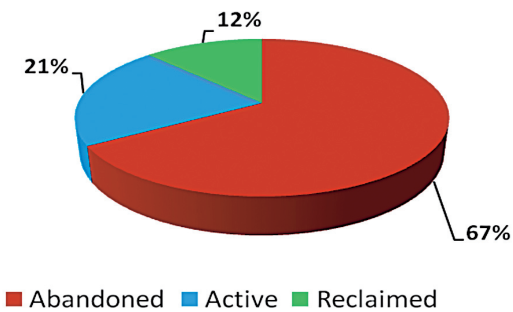

Fig. 3. Gravel pits conditions (abandoned, active and reclaimed) around Gunnarsholt.

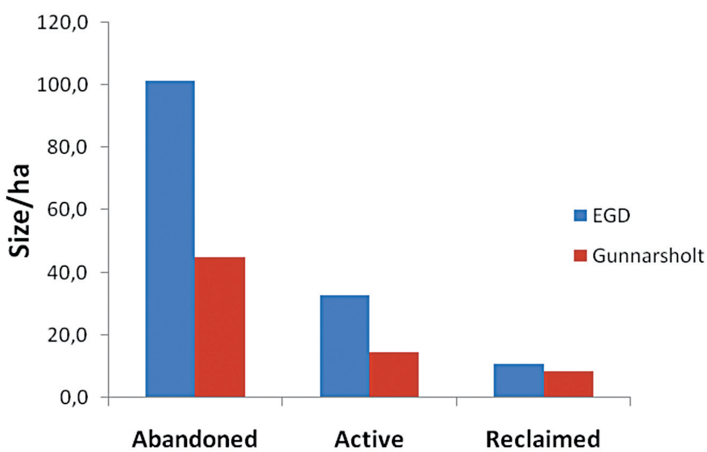

Fig. 4. Size (ha) and condition (abandoned, active and recaimed) of gravel mines in East Gonja District (Ghana) and Gunnarsholt area (Iceland).

44.9 ha, 14.4 ha and 8.3 ha, respectively, with their percentages shown in Fig. 3. The overall average pit size of each of the areas was around 3.0 ha (Table 4).

The total areas of abandoned, active and reclaimed mining sites of the two study areas are shown in Fig. 4. A map showing the location and condition of mining sites in the Gunnarsholt area can also be seen in Fig. 5.

5.2 Interviews

The focus of interviews was on the respondents' perceptions of state regulations on gravel and mining vis-à-vis socio-ecological impacts.

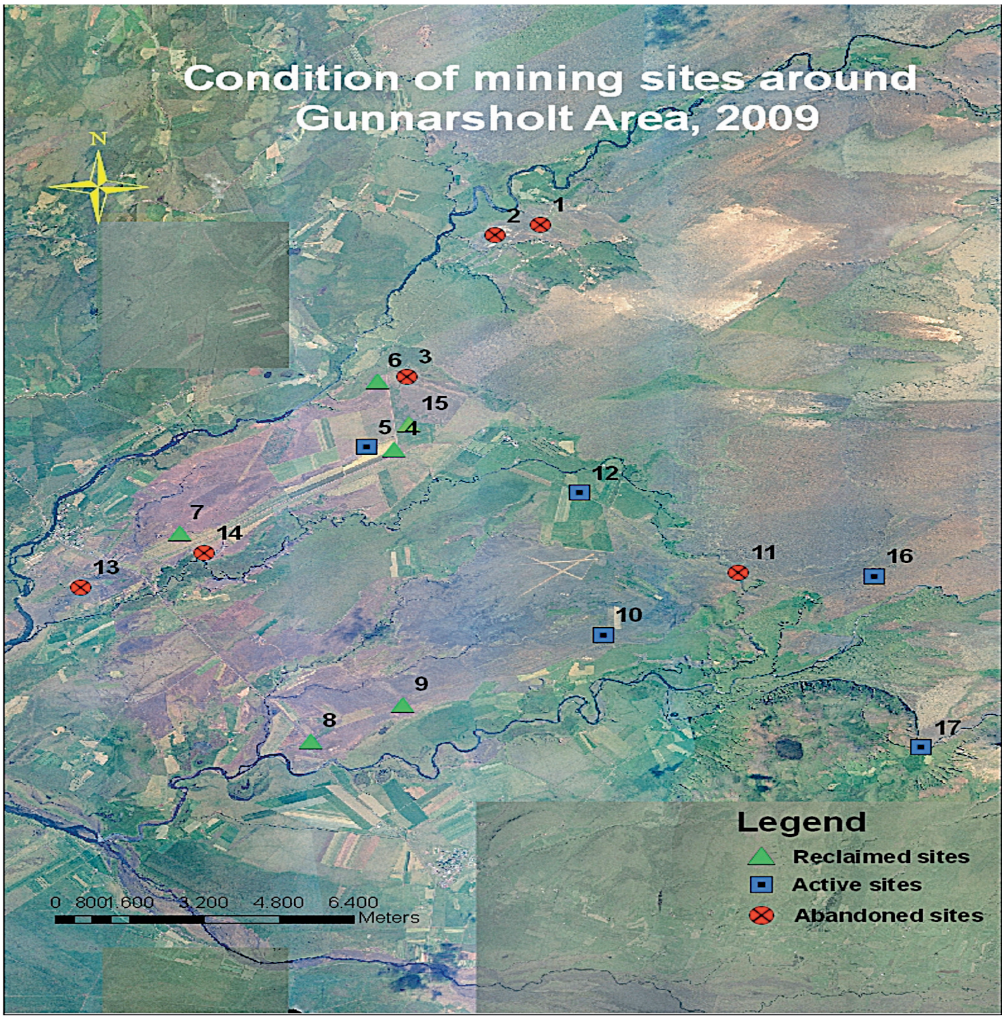

Fig. 5. Location and condition of gravel pits in Gunnarsholt area (Iceland), July 2009. (Source: Modified aerial photograph from SCS, Iceland).

5.2.1 State regulations on gravel mining in EGD

Out of 30 respondents interviewed in EGD, 27 (90%) knew of the existence of state regulation. Also, 22 (73%) indicated the existence of a regulation on the minimum size of a mine to require a permit. However, 25 of the respondents indicated non-compliance with the regulation, and that no closure standards or specification guidelines for reclamation were available. Twenty respondents also indicated a lack of enforcement of regulations on mining activities in the area (Table 5). However, there were some respondents who remained indifferent to each of the variables under consideration.

5.2.2 State regulations on gravel mining in the Gunnarsholt area

In the Gunnarsholt area, most respondents (60%) indicated knowledge of the existence of Icelandic regulations on land use, including mining vis-à-vis closure standards, minimum size requirements, as well as enforcement (Table 6). However, they viewed the availability of

Table 5. *Result from respondents interviewed on state regulations in East Gonja District (Ghana) (percentages are in parentheses and N = 30).*

Number	Variable	Number of respondents N = 30		
		Affirmative response	Negative response	Indifferent response
1	Direct state regulation	27 (90)	1 (3.3)	2 (6.6)
2	Minimum size permitted	22 (73.3)	6 (20)	2 (6.6)
3	Closure standards	1 (3.3)	25 (83.3)	4 (13.3)
4	Other regulations	2 (6.6)	25 (83.3)	3 (9.9)
5	Enforcement	3 (10)	23 (76.7)	4 (13.3)

Table 6. *Result from respondents interviewed on state regulations around Gunnarsholt (Iceland) (percentages are in parentheses and N = 15).*

Number	Variable	Number of respondents N = 15		
		Affirmative response	Negative response	Indifferent response
1	Direct state regulation	15 (100)	-	-
2	Minimum size permitted	10 (66.6)	1 (6.6)	4 (26.7)
3	Closure standards	11 (73.3)	-	4 (26.7)
4	Other regulations	5 (33.3)	10 (66.7)	-
5	Enforcement	12 (80)	1 (6.7)	3 (13)

closure standards and guidelines as particularly explicit regarding agricultural lands because they are the productive lands in the area. Most of the mining activities in the Gunnarsholt area occur on barren land, usually in rocky areas and the highlands. The results also indicated non-existence of other regulations such as byelaws and community rules in respect of mining in the area.

5.2.3 Land use policies, regulations and enforcement in the study areas

The views of respondents on state regulations on gravel mining in the two study areas are compared in Table 7. The results show that, in the EGD, there was in existence the Environmental Protection Agency Act 1994 (EPA Act 490) and the Minerals and Mining Amendment

Table 7. *Comparison of state regulations of East Gonja District (Ghana) and Gunnarsholt (Iceland).*

Num-ber	Study area	Direct state regulation A	Minimum size permitted B	Closure standards C	Other regu-lations D	Enforce-ment E
1	EGD	EPA Act 490 and MMA Act 475	EIA	None	No byelaws	None
2	Gunnars-holt area	NCL 44/1999	50,000 m^2	Re-vegeta-tion levels	None	periodic

A= Sand and gravel winning by comprehensive state permit
B= Minimum size to require permit.
C= State-mandated closure standard or specification
D= Regulation of sand and gravel winning by other jurisdiction
E= Enforcement of regulation to ensure compliance
EIA= Environmental Impact assessment
MMA= Minerals and Mining Amendment
NCL= Nature Conservation Law

Act 1993 (Act 475). These are primary Acts which seek to protect the environment and regulate mining. However, these, including the Environmental Impact Assessment (EIA) undertakings, do not give explicit definitions on closure standards and specifications, especially regarding gravel mining. There is also, no district byelaw and as such, no enforcement of the regulation is being carried out.

On the other hand, views from Gunnarsholt indicated that the Nature Conservation Act 44/1999 regulates mining activities in the area. Mining sites from 50,000 m^2 or 150,000 m^3 in size and above are required to go through the EIA and these gravel pits must not exceed a 10 m depth limit. Closure of the mines is required in such a way that re-vegetation can be carried out effectively. There is regular enforcement to ensure compliance. However, no other regulation at the community level to regulate mining was found. The regulation context is therefore confusing because even though mining operations are required to comply with existing rules, they may not be explicit at the community or municipality level even when there are existing norms they respect.

5.2.4 Socio- and ecological effects of gravel mining in EGD

The views of people obtained during the interviews on the socio- and ecological impacts of gravel mining in EGD are illustrated in Table 8. Ten people interviewed indicated loss or reduction of farmlands as a major impact of gravel mining in the district. This represents 33% of the total respondents. Other significant impacts of gravel mining in the area obtained as views include pits serving as breeding grounds for mosquitoes and spread of other diseases, erosion and loss of vegetation, loss of economically important trees, as well as roots of conflicts (Table 8).

Table 8. *Comparison of negative and positive socio-ecological impacts of gravel mining in East Gonja District (Ghana) and Gunnarsholt area (Iceland). (Percentages are in parentheses and N = number of responses).*

Number	Socio-ecological impacts	EGD	Gunnarsholt area
	Negative impacts	N = 30	N = 15
1	Loss/reduction of farm lands and grazing lands	10 (33.3)	1 (6.6)
2	Source of breeding grounds for mosquitoes and spread of diseases	7 (23.3)	-
3	Erosion/loss of vegetation/fertility	5 (16.7)	7 (46.6)
4	Loss of biodiversity and economically important trees	3 (10)	2 (13.3)
5	Destruction of landscape and beauty	1 (3.3)	3 (20)
6	Confrontations/conflicts	2 (6.6)	1 (6.6)
7	Sand and dust pollution	1 (3.3)	1 (6.6)
8	Pollution of underground water	1 (3.3)	-
	Positive impacts		
1	Enhances communication and other infrastructural developments such as road and housing	26 (86.6)	8 (53.3)
2	Provides employment to mine workers	2 (6.6)	4 (26.6)
3	Provides income for landowners	2 (6.6)	3 (20)

5.2.5 Socio- and ecological effects of gravel mining around Gunnarsholt

In the Gunnarsholt area, 47%, 20% and 13% of respondents indicated erosion, landscape destruction and biodiversity loss, respectively, as the major negative environmental impacts of mining. Other negative impacts indicated are: loss of grazing lands, sand and dust pollution and conflict generation (Table 8). However, all respondents from each of the study areas indicated positive impacts of mining as enhancing infrastructural developments such as road and housing and providing employment to mine workers, as well as providing income for landowners.

6. DISCUSSION

6.1 Condition of gravel mines and effects on agriculture

The frequency and number of gravel mines in EGD was higher compared to the Gunnarsholt area. Gravel mining in EGD had a significant impact on agriculture and the environment in the area. The degree of impact, however, varies in severity depending on whether the mine is active or abandoned, what mining method is being used and the geology of the area (Bell, Bullock, Halbich & Lindsey, 2001).

Inadequate education, enforcement of regulations and monitoring in order to govern development, operation and reclamation of mining activities in the EGD can cause grounds for misconduct in the field of mining activities. Education, which is a key element in informing and guiding people behaviours and decisions, is lacking in most communities. According to the Core Welfare Indicators Questionnaire (CWIQ) Survey (2003), EGD represents a community with a great education deficit with over 60% of both adults and youth being illiterate and therefore they may be unaware of their rights. This may encourage mining companies and contractors to take advantage of such an unfortunate situation in the communities to extract gravel wherever they deem convenient without due consideration of socio-economic needs. Also, chiefs who are the custodians of land in the area are mostly themselves uneducated and therefore may not appreciate the real value of their land. This can urge them to release lands readily for mining activities upon receiving a low premium offered them by contractors or mining companies.

Predominantly, the EGD is agriculture dependent, with maize being the dominant production crop (Ahmed Tijani, pers.com.). However, 33.3% of views obtained during interviews revealed a loss or reduction in farmland as a result of mining activities (Table 8), and this can have significantly negative impacts on agriculture in the area. According to FAO/WFP (2002), the average yield of maize in Ghana and the sub-region is 1.3 tonnes per hectare. Assuming mining sites are based on productive agricultural land, it can be concluded that, since about 93% of 145 ha of the total gravel mining sites remained either abandoned or active, a similar proportion can be lost to agriculture. This means by way of inference that an estimated 134.9 ha of maize production is lost or reduced every year. Other crops grown in the area include groundnuts (peanuts), yam, rice and cassava (East Gonja District Assembly, 2006).

In the Gunnarsholt area on the other hand, sheep production is the most dominant agricultural activity, as it is for all Icelandic farmland (Fridriksson, 1973). This therefore necessitates the production of appropriate crops for the animals. But because there are variations in climatic conditions, the production of native vegetation and cultivated crops also changes. Grass is the most important crop in Iceland. However, there are great fluctuations in the annual yield of hay from cultivated fields. The average yield of hay in Iceland is 1,000kg/ha (Fridriksson, 1973).

Less than 7% of productive grazing or agricultural land is lost to mining activities in the Gunnarsholt area (Table 8). This is because most of the mining activities occur in barren lands such as rocky, pumice and other lava deposit areas. This means that out of 67.6 ha, the total mining size in the area, only 4.7 ha of productive land was engaged in mining activities. By simple estimates, it can be said that on an annual basis, the average yield of hay may be lost or reduced by 4700kg. This indicates far less impact of gravel mining on agriculture and crop production in the Gunnarsholt area than EGD.

It was also observed in each of the areas surveyed that most mines are situated in the vicinity of settlement areas, mainly in locations of either previously uncleared vegetation or where people make use of land for agricultural and other grazing purposes. Some of the respondents had the view that, with good technology and managerial skills, there should be no reason for preventing the opening of any mine. It is however important to recognise that soil or land will always remain the medium that satisfies primary human needs for food and shelter (Verheye, 1997). Therefore, any attempt to sacrifice these primary human needs will affect the very survival of life in the areas.

6.2 State of regulation of gravel mining

Regulation of sand and gravel extraction in EGD of Ghana is not exactly the same as that of the Gunnarsholt area of Iceland. Though the regulations do not adequately address the indiscriminate development and operation of mining activities in the respective study areas, they also are highly variable based on the differences and uniqueness of the two countries. For example, in the Gunnarsholt area, views obtained from the interviews revealed that 80% of land is mostly held by individuals and that opening up and reclaiming mines is determined by the landowners (Tables 9 and 10, respectively).

Views from the interviews revealed that closure of mines is the sole responsibility of the landowners, which is necessary in agricultural lands. Landowners usually take the final decision but in agreement with the mining company, and the agreement is included in the Environmental Impact Assessment (EIA). In this case, development and operation of mines cannot take place without the consent of land owners in question (Pers.com.).

In the Rangárthing Ytra municipality, regulation of small mines is not strict, but in areas where they are deemed large, the EIA tool is used and respective land owners are consulted through negotiation and compensation. This therefore eliminates possible conflicts usually generated in mining areas over royalties and compensation (Pers.com.).

Views solicited from the interviews revealed that there were few mines on productive grazing and agricultural lands and that farmers and landowners seldom allowed mining activities in their lands, despite potential economic benefit.

Table 9. *Results from respondents on landownership in East Gonja District (Ghana) and Gunnarsholt (Iceland). (Percentages are in parentheses).*

Number	Variable	EGD N = 30	Gunnarsholt Area N = 15
1	Government	6 (20)	3 (20)
2	Mining companies/contractors	0	0
3	Chiefs/commons/communities	20 (66.7)	0
4	Individuals	4 (13.3)	12 (80)

Table 10. *Results from respondents on reclamation responsibility of gravel mines in East Gonja District (Ghana) and Gunnarsholt (Iceland). (Percentages are in parentheses).*

Number	Variable	EGD N = 30	Gunnarsholt Area N = 15
1	Government	3 (10)	0
2	Mining companies/contractors	20 (66.7)	4 (26.6)
3	Chiefs/commons/communities	3 (10)	0
4	Individuals	4 (13.3)	11 (73.3)

It was again found that there were explicit regulations on mining activities around Gunnarsholt in respect of the closure standards and guidelines, as well as permissible areas that require a permit as stipulated by the Natural Conservation Act 44/1999. As indicated in the interviews, mines from 50,000 m^2 or 150,000 m^3 and above are required to go through the EIA according to the law, and these mines must not exceed a 10 m depth limit. It was however revealed that the regulation had been revised and the implementation range had been stated to be valid for 2004–2018. This primarily was to test how effective and efficient the law will work within the framework period. It was revealed that enforcement was carried out on a regular basis to ensure that standards and guidelines outlined in the regulation were accordingly complied with by the mining companies, hence the limited number of mines in the area (Pers.com.).

Unlike the Gunnarsholt area, landownership in EGD is predominantly in the hands of chiefs who hold the lands in trust for the people. The people themselves do not have entitlements to the land and as such cannot take decisions regarding land use. However, views gathered from respondents revealed that there was no existence of other regulatory jurisdiction such as district and local bye-laws, which could be one of the responsible factors for the widespread and indiscriminate mining pits in the area.

According to part 5 of the Local Government Act (LGPRSP October, 2006), the Republic of Ghana Act 462 of the Local Government Act 1993 gives the district assemblies the mandate to formulate byelaws and guidelines in order to, among other things, regulate natural resources including sand and gravel mining. By this provision, communities could formulate their own local byelaws to manage and protect their natural resources that are unique to them, under the broader district byelaws. However, the district assembly currently does not have any working document in relation to regulating or guiding gravel mining activities in the district.

The EPA Act 1994 (Act 490), and Minerals and the Mining Amendment Act 1993 (Act 475), are the major state-mandated regulations on mining and general protection of the environment in Ghana and EGD in particular. However, apart from the section under schedule II, undertakings of L.I. 1652 of 1999 of the EPA Act, which requires EIA, none of these Acts give clearly defined guidelines, especially not on gravel mining activities in terms of permissible areas and specifications limits as well as closure standards (Table 7).

This absence of guidelines gives mining companies and contractors the freedom to open and abandon mines indiscriminately without due consideration for reclamation and proximity of mining sites to communities, water bodies and other productive agricultural lands, which has been the cause of many community conflicts in the district. These conflicts may arise because some residents have to live with noise and dust pollution, sleepless nights, cracking of buildings, hurling of rocks on buildings some of the time, increased frequency of snakebites in some communities, and pollution of water bodies near settlements (Pers.com.). This is buttressed by a statement once made by Mr Fui (1997), a renowned Lecturer in law at the University of Ghana: “An Environmental Protection Agency has been established in December 1994 (by Act 490) with powers to promulgate and enforce standards. Neither precise standards nor detailed regulation have as yet been enacted, though impact assessments are now required and guidelines for mineral operations have been formulated.”

6.3 Social and ecological effects of gravel mining

Due to differences in geographical locations and climatic conditions, views of respondents and indeed, actual ecological effects of gravel mining, also differed in the two study areas.

Results from respondents in EGD showed that the single most important effect of gravel mining which was not so common in the Gunnarsholt area was the reduction or loss of farmlands. This was particularly because agriculture is the predominant economic activity in the area. Agricultural activities are often undertaken in Ghana in the rainy season, and during the dry season farmers spend their time in land preparation. This makes farmers engaged throughout the year. Others by way of tradition, practice agriculture as way of life, and so gravel mining, which can take up most of farmers’ productive lands, does not only deny them their livelihood but also infringes upon their cultural heritage. This usually results in the confrontation of farmers and mining contractors (Ross, 2001).

Fig. 6. *Water collected in a gravel pit close to Fuu community in East Gonja District. (Photo: Jafaru Adam Musah).*

Another significant effect of gravel mining in EGD is the abandoned pits serving as a source of breeding grounds for mosquitoes for example, and the resultant spread of malaria and other related diseases. Most mining activities take place very close to communities and are often abandoned after completion. During rainy seasons, the abandoned pits collect water (Fig. 6) and as a result attract malaria parasites resulting in infection of community people. Other diseases such as cholera, dysentery and diarrhoea, among others, are associated with the mining activities, since mining sites are often used as rubbish dumping sites (Moody & Panos, 1997). HIV/AIDs infections mentioned by some respondents are a potential problem in the area, especially in Mankango community where people from other areas of the northern region and parts of Ghana usually go to settle on a temporal basis in order to carry out sand mining along the river.

Views gathered from respondents in the Gunnarsholt area revealed that soil erosion and loss of vegetation have been the most important negative effects of gravel mining. This is also common in EGD. The main agricultural crop in the Gunnarsholt area and in fact in all Iceland is grass which is used for hay production. However, the study area had low vegetative cover and soils are fragile and therefore susceptible to disturbances. Therefore, even though very little mining activities take place on agricultural lands, the gravel mining that occurs in a few productive areas still contributes to worsening the current erosion problem in the area, which is usually facilitated by wind. This consequently results in generation of dust pollution (Fig. 7) (Willis & Garrod, 1999). This can as well result in loss of fertility of the soils, lower hay yields and increase cost of production and land management (Pers.com.).

Another important finding gathered was the occurrence of mining activities along rivers and other water bodies (Fig. 8 and 9). Mining activities along these rivers can retard free flow of

Fig. 7. *Occurrence of dust pollution as a result of gravel mining at Varmadalur around Gunnarsholt. (Photo: Jafaru Adam Musah).*

the water course. As indicated by Sandecki (1989), such direct in-stream mining can alter the channel geometry and bed elevation and may involve extensive clearing, diversion of flow, stockpiling of sediment, and excavation of deep pits. This can also result in significant distortion of the channel morphology (Rinaldi *et al.,* 2005), which often causes silting as a result of erosion of the banks and consequent flooding, which may worsen especially during high precipitation. Machinery which is used to extract gravel sometimes disturbs the vegetation and further exposes the area to erosion and harsh weather conditions (Mossa & McLean, 1997). This can as well cause loss of the protection provided by soil as it filters out pollutants (Kalbitz, Solinger, Park, Michalzik & Matzner, 2000; Rutherford, Chiou & Kile, 1992) and can further affect aquatic life in such riverine areas. A review of the literature reveals that indiscriminate

Fig. 8. *Sand mining in Mankango river in the East Gonja District. (Photo: Jafaru Adam Musah).*

Fig. 9. *Gravel mining in Markafljot River in the Gunnarsholt area. (Photo: Jafaru Adam Musah).*

extraction of non-living resources like sand and gravel from riverbeds threatens the very existence of the river ecosystem (Kondolf, 1994; Poulin, Pakalnis & Sinding, 1994).

Pollution of water sources was identified as one of the negative impacts which potentially can occur in riverine areas. This problem is particularly common in EGD, as viewed by some respondents. Machinery used for mining usually has spillages in respect of oils and other dangerous lubricants. When these spillages find their way into the water, they pollute it, and people downstream, who may use the water for drinking and other domestic purposes, will be affected. Most people in EGD drink river water directly from the source.

Removal of vegetative cover usually take place in order to make way for quarrying quality aggregate (Fig. 10). The Vakalag area near Gunnarsholt is a clear example of such removal

Fig. 10. *Destruction and stockpile of vegetation through mining at Vakalag in Gunnarsholt area. (Photo: Jafaru Adam Musah).*

of vegetation. These activities significantly contribute to erosion and loss of fauna around the mining area. Since most miners do not preserve the topsoil removed before excavation begins, the topsoil is often washed away into surface water, carrying with it ecologically valuable seed banks that are necessary for the regeneration of vegetation (Asa L. Aradottir, Pers. com.). Moreover, removal of the organic layer of soil found on the surface of sand and gravel deposits decreases the soil's capacity to absorb contaminants and thus to help purify water as it passes through its pores (Pers.com.).

Landscape destruction as found during the interviews was one of the significant effects of mining, common to both areas. Mining activities usually scar the landscape with excavated pits and trenches, leaving behind unsightly views which as well render the land unsuitable for any productive purpose. A respondent indicated in the interview that in Iceland where summerhouses are common, landowners whose lands have been destroyed as a result of mining may not be able to rent their lands for summerhouses. This therefore can deny landowners not only some economic benefit, but social gains as well (Pers.com.). Such destruction of land as a result of mining therefore changes the land surface and this can also affect the quantity and quality of water in aquifers (Welhan, 2001).

Another effect of mining is modification of the recharge area for groundwater by changing the land surface, such as forming depressions so that water no longer flows along original pathways. Such changes may increase or decrease rainwater recharge to groundwater. Shorter flow paths may increase susceptibility to contamination while re-directed flow paths may deplete total recharge of the aquifer (Peckenham, Thornton & Whalen, 2009).

Fig. 11. *Potential destruction of shea trees through mining in East Gonja District. (Photo: Jafaru Adam Musah).*

Loss of economically important trees such as *sheanut* and *Dawadawa* has been one tremendous setback of gravel mining in the EGD (Table 8). The *shea* trees which are also called *Mangifolia* trees are not cultivated but grow in the wild. They are sometimes referred to as the *northern cocoa* or *women's gold* because they are found mainly in the northern savannah zones of Ghana and many women are employed in the production of *shea* butter, using the nuts as raw material. This reduction in *shea* trees due to mining can result in reduced income for women and consequent reduction in household income (Fig. 11). Women are usually responsible for the up-keep of homes in the area (Farmer, Pers.com.).

7. CONCLUSION

Sand and gravel mining in terms of numbers, sizes and distribution of mining sites is higher in the East Gonja District of Ghana than in the Gunnarsholt area of Iceland. This may be due to a number of factors. The geology of the Gunnarsholt area for instance consists mostly of volcanic rocks and pumice soils, and as such, very little mining activities occur in productive or agricultural lands. Additionally, the Gunnarsholt area has a very low population compared to EGD, and as such, there is very little pressure on the land for housing and other development projects.

The regulatory mechanism in terms of land use policy is relatively comprehensive and enforced with high compliance in Iceland, which makes implementation quite simple and easy. Land, especially in the lowland areas which usually are productive agricultural lands, is owned by individuals, and as such, mining in these areas is rare since owners take direct decisions in determining the purpose for which their lands should be used. In EGD however, individuals mostly do not have authority over the land. Chiefs, who hold these lands in trust for the people unilaterally, allow unauthorised mining activities to take place upon usually entering into unpublicised agreements with the district assembly and contractors.

Moreover, regulations in EGD such as the EPA Act 1994 (Act 490) and the Minerals and Mining Amendment Act 1993 (Act 475), which are major state-mandated regulations on development and operation of mining, do not give precise and detailed standards and specifications in respect of gravel and sand mining. The EIA is the only effective tool that has been in use over the years, but because of the lack of these standards, monitoring and enforcement become difficult.

Perceived sociological and ecological impacts in the two study areas vary but some appeared common to both. The common impacts shown in the results were loss of farm or grazing lands, enhancement of erosion and loss of vegetation, destruction of landscape, generation of conflicts, loss of biodiversity and dust pollution.

Other impacts of mining peculiar to EGD were abandoned mine pits serving as sources of breeding grounds for the spread of diseases, loss of economically important trees which causes unemployment among women folk, and the pollution of underground water.

RECOMMENDATIONS / SUGGESTIONS

Sand and gravel mining practices have already caused serious social and ecological impacts in the two study areas. These problems include land degradation, damage to water, loss of productive farmlands, destruction of landscape and land beauty, spread of diseases, harm to wildlife and biodiversity, and conflicts or confrontation. Although there is growing awareness of the importance of sound environmental management amongst mining companies and government officials in both EGD and Gunnarsholt, mitigation strategies are possibly offset by inconsistencies and non-availability of comprehensive regulatory standards and guidelines, as well as monitoring and enforcement.

To address the impacts of gravel mining, the following measures are suggested:

- Environmental agencies which have the responsibilities of prescribing standards and guidelines to prevent all forms of environmental damage including sand and gravel in the two areas should develop and strengthen binding and enforceable standards and specifications for the effective regulation of the mining industry. This should be done in consultation and harmonisation with all relevant stakeholders in the mining sector and the various districts and municipalities (participatory approach).
- In the case of Ghana particularly, the EPA should fight enough at the policy level in order to gain signatory status in the award of and the disbursement of contract funds at the district level. This will empower the agency to ensure that gravel miners adhere to guidelines and standards as outlined in the reclamation bonds recommended. In this case, however, failure to adhere to the prescribed guidelines proposed should therefore deny the mining contractors the rights to access the funds.
- Prior to gravel removal, a thorough review should be undertaken of potentially toxic sediment contaminants in or near stream beds where gravel removal operations are proposed or where bed sediments may be disturbed (upstream and downstream) by the operations. Furthermore, extracted aggregates and sediments should not be washed directly in the stream or river or within the riparian zone.
- An integrated Environmental Assessment, Management, and Monitoring programme should be a part of any gravel extraction operation, and encouraged at national, regional, district, and local levels. Assessment is used to predict possible environmental impacts and encourage public participation at the decision level, whilst management is used to implement plans to prevent or minimize negative impacts. A mitigation and restoration

strategy should be included in any management programme. Monitoring must be used to determine if the assessments were correct, to detect environmental changes, and to support management decisions.

- The District assembly and/or Municipality should ensure formulation, monitoring and enforcement of byelaws which may involve development and implementation of reclamation plans and bonds. Sensitisation and awareness creation should be integrated in this component to ensure that people are aware of what is involved in gravel mining and what mitigation measures are required. Involvement of chiefs, landowners and other key persons in communities, especially in the EGD, is very important in the reclamation process since they can pester miners or contractors to follow agreed guidelines when given the powers to do so within the framework. This will further prevent future occurrence of disease spread and other conflicts associated with gravel mining.

ACKNOWLEDGEMENTS

I wish to express my special thanks to the managers of the LRT Programme, Hafdis Hanna Ægisdottir (PhD) and Sigridur Dalmannsdottir (Asst. Prof.), and all the lecturers and staff of the Agricultural University of Iceland and Soil Conservation Service who have variously taught and shared with us some rich and useful knowledge as well as field experience during the introductory courses through to successful completion of the programme. My special thanks also go to Mr Björn Barkarson, who with due diligence, ability and guidance supervised and reviewed the project to a successful completion. Mention must also be made of Johann Thorsson (PhD) and Jon Ragnar Örlygsson for their wide-ranging assistance and directions, especially during the data collection and GIS.

My sincerest thanks and gratefulness go to the management and staff of EPA Ghana, for nominating and supporting me for this important training programme. I acknowledge all my respondents, as well as my colleagues at LRT, 2009, especially Toshpulot Rajabov for the company and various ideas we have shared together throughout the training programme. To my family and friends, I say, thank you for the moral support you have given me during my stay in Iceland.

REFERENCES

Agenda 21. (1997). Natural resources aspect of sustainable development in Iceland. Retrieved July 9, 2009, from http://www.un.org/esa/agenda21/natlinfo/countr/iceland/natur.htm#land.

Akabzaa, T.M. (2000). *Boom and Dislocation: The environmental and social impacts of mining in the Wassa West District of Ghana*. Accra: Third World Network – Africa.

Awudi, G. (2002). The role of foreign direct investment in the mining sector of Ghana and the environment. *CCNM Global Forum on International Investment*, *7–8 February 2002*. Paris: OECD.

Barkarson, B.H. (2002). *Management of livestock grazing on central highland rangelands in Iceland*. MSc Thesis, Reykjavik: University of Iceland. (English abstract).

Barkarson, B.H. & Johannsson, M.H. (2009). Arctic Landcare. In Catacutan, D., Neely, C., Johnson, M., Poussard, H. & Youl, R. (Eds.), *Landcare*, *local action – global progress* (pp. 55–63). Nairobi, Kenya: World Agroforestry Centre.

Bell, F.G., Bullock, S.E.T., Halbich, T.F.J. & Lindsey, P. (2001). Environmental Impacts associated with abandoned mine in Witbank coalfield, South Africa. *International Journal of Coal Geology*, *45*, 195–216.

Core Welfare Indicators Questionnaire (CWIQ) Survey. (2003). Northern Region District summary, Flyer No.18. Retrieved 16 September, 2009, from http://www.statsghana.gov.gh/docfiles/cwiq%20north_-_dist.pdf.

East Gonja District Assembly. (2006). Retrieved 13 June, 2009, from http//:eastgonja.ghanadistricts.gov.gh/.

Environmental Impact Assessment Act. (2000). Icelandic National Planning Agency. Retrieved 18 September, 2009, from http://www.skipulag.is/focal/webguard.nsf/Attachment/MÁU%20lögin%20á%20ensku/$file/MÁU%20lögin%20á%20ensku.pdf.

Ebenezer, L. (Ed.). (1991). *Ghana Environmental Action Plan*. Accra, Ghana: Environmental Protection Council.

Environmental Protection Agency Act, (Act 490). (1994). *The Ghana EPA Act 1994*, *Arrangement of Sections*. Retrieved 11 August, 2009, from http://www.lexadin.nl/wlg/legis/nofr/oeur/arch/gha/490.pdf.

Erskine, W.D. & Green, D. (2000). Geomorphic effects of extractive industries and their implications for river management: the case of the Hawkesbury–Nepean River, New South Wales. In Brizga, S. & Finlayson. B. (Eds.), *River Management: The Australian Experience* (pp 123–149). Chichester, UK: Wiley.

ESRI. (2008). Environmental Systems Research Institute. *ArcGIS*, Version 9.3.

FAO-Unesco. (1988). *Soil Map of the World*. Revised legend. Rome: FAO.

FAO/WFP. (2002). *Crop and Food Supply Assessment Mission to Ghana*. FAO/WFP Special report.

Fridriksson, S. (1973). Crop Production in Iceland. *Int. J. Biometeor*, *17*, 359–362.

Fui, T. (1997). The vicissitudes of minerals Policy in Ghana. *Resources policy*, *23*, 9–14.

Ghana Population and Housing Census. (2000). *East Gonja District population*. Retrieved 30 August, 2009, from http://en.wikipedia.org/wiki/East_Gonja_District.

Gob, F., Houbrechts, G., Hiver, J.M. & Petit, F. (2005). River dredging, channel dynamics and bedload transport in an incised meandering channel (The River Semois Belgium), *River Research and Applications*, *21*, 791–804.

Heath, M.J., Merefield, J.R. & Paithankar, A.G. (1993). Environmental impact of mining on tropical forest. *Mining Environmental Management*, *37*, 14–16.

Huntington, H.P. (2000). Using traditional ecological knowledge in science: Methods and applications. *Ecological Applications*, *10*, 1270–1274.

International Monetary Fund. (2003). *Ghana poverty reduction strategy paper: An agenda for growth and prosperity*. IMF Country Report No. 03/56, March 2003, Washington, D.C.

International Monetary Fund. (2004). *Ghana poverty reduction strategy paper annual progress report*. IMF Country Report No. 04/207, July 2004, Washington, D.C.

Kalbitz, K., Solinger, S., Park, J., Michalzik, B. & Matzner, E. (2000). Controls on the dynamics of dissolved organic matter in soils: A review. *Soil Science*, *165*, 277–304.

Kondolf, G.M. (1994). Geomorphic and environmental effects of instream gravel mining, *Landscape and Urban Planning*, *28*. 225–243.

Local Government Act (LGPRSP October, 2006), *Local Government Act 1993*, *a Comparative Analysis in the context of the Act*, *1–3*. (n.d.) Retrieved 17 June, 2009 from http://www.ghanadistricts.com/home/?_=48&sa=4716.

Maeda, T., Takenaka, H. & Warkentin, B.P. (1977). Physical properties of allophane soils. *Advances in Agronomy*, *29*, 229–264.

Makweba, M.M. & Ndonde, P.B. (1996). The mineral sector and the national environmental policy. In: M.J. Mwandosya *et al* (Eds.), *Proceedings of the workshop on the national environmental policy for Tanzania (Dar es Salaam*, *Tanzania)*, *1994; 1996*. *(*pp 164–173).

Minerals and Mining Amendment Act (Act 475). (1993). *Mining legislation in Ghana*, *legislative overview*. Retrieved 12 September, 2009, from http://www.ghana-mining.org/ghweb/en/geologymining/policy/legislation.html.

Minerals Commission and Environmental Protection Council. (1994). *Ghana's Mining and Environmental Guidelines*. Accra, Ghana.

Moody, R. & Panos, S.P. (1997). *Environmental assessment of mining projects*. Retrieved 2 June, 2009, from http://www.worldbank.org/mining.xls.

Mossa, J. & McLean, M. (1997). Channel planform and land cover changes on a mined river floodplain - Amite River, Louisiana, USA. *Applied Geography*, *17*(1), 43–54.

Nature Conservation Law 44/1999. Icelandic Road Administration. Retrieved 15 August 2009, from http://www.ust.is/media/adsturutanvega/Akstur_utan_vega.pdf.

Peckenham J.M., Thornton, T. & Whalen B. (2009). *Sand and gravel mining: effects on ground water resources in Hancock County*, *Maine*, *USA*. *Environmental Geology 56*, 1103–1114.

Petit, F., Poinsart, D. & Bravard, J.P. (1996). Channel incision, gravel mining and bedload transport in the Rhône river upstream of Lyon, France ("canal de Miribel"). *Catena*, *26*, 209–226.

Poulin, R., Pakalnis, R.C. & Sinding, K. (1994). Aggregate resources: Production and environmental constraints. *Environ Geol*, 23, 221–227.

Rinaldi, M., Wyzga, B. & Surian, N. (2005). Sediment mining in alluvial channels: Physical effects and management perspectives. *River Research and Applications*, *21*(7), 805–828.

Ross, M. (2001). *Extractive resources and the poor*. Boston: Oxfam *America Report*.

Rubin, H.J. & Rubin, I.S. (2005). *Qualitative Interviewing: The Art of Hearing Data*. California: Sage Publication, Thousand Oaks.

Rutherford, D., Chiou, C. & Kile, D. (1992). Influence of soil organic matter composition on the partition of organic compounds. *Environ Sci Technol*, *26*, 336–340.

Sandecki, M. (1989). Aggregate mining in river systems. *California Geology*, *42*, 88–94.

Sear, D.A. & Archer, D.R. (1998). The effects of gravel extraction on the stability of gravel-bed rivers: A case study from the Wooler Water, Northumberland, U.K. In Klingeman, P.C., Beschta, R.L., Komar, P.D. & Bradley J.B. (Eds.), *Gravel-bed Rivers in the Environment*. *Proceedings of the 4th International Gravel-Bed Rivers Conference*, *Water Resources Publications* (pp. 415–432). Colorado: LCC.

Sigurjonsson, A. (1958). Agrip af grodursögu landsins til 1880 (Outline of history of Icelandic vegetation to 1880. In Arnor Sigurjonsson (Ed.), *Sandgrædslan (Sand Reclamation Service)*, (pp. 5–40). Iceland: Agricultural Society of Iceland & Soil Conservation Service. (In Icelandic).

Statistics of Iceland. (2008). Iceland: Municipalities and Localities. Statistics Iceland. Retrieved 30 July, 2009, from http://www.citypopulation.de/php/iceland.php.

Surian, N. & Rinaldi, M. (2003). Morphological response to river engineering and management in alluvial channels in Italy. *Geomorphology*, *50*, 307–326.

Thorarinsson, S. (1970). *Hekla: A Notorious Volcano*. Reykjavik: Almenna Bokafelagid.

USDA. (1994). *Keys to Soil Taxonomy* (6th ed.) USDA-SCS. Washington D.C.: U.S Government Printing Office.

Veiga, M.M. & Beinhoff, C. (1997). UNECA centers: A solution to reduce mercury pollution from artisanal gold mining activities. *UNEP Industry and Environment*, *20*, 49–52.

Verheye, W.H. (1997). Land use planning and national soils policies. *Agricultural Systems*, *53*, 161–174.

Wada, K. (1985). The distinctive properties of Andosols. *Advances in Soil Science*, *2*, 173–229.

Warhurst, A. (1994). *Environmental Degradation from Mining and Mineral Processing in Developing Countries: Corporate Responses and National Policies*. Paris: Development Centre, OECD.

Warhurst, A. (1999). Environmental Regulation, Innovation, and Sustainable Development. In Warhurst, A. (Ed.), *Mining and the Environment: Case-Studies from the Americas*. Ottawa: International Development Research Centre.

Welhan, J. (2001). *Ground-water interactions near the highway pond gravel pit*, *Pocatello*, *Idaho*. Staff Report 01-3. Moscow: Idaho Geological Survey.

Willis, K.G. & Garrod, D. (1999). Externalities from extraction of aggregates regulation by tax or land-use controls. *Resources Policy*, *25*, 77–153.

APPENDICES

Appendix I.

Questionnaire

Assessment of sociological and ecological impacts of sand gravel mining – a case study of East Gonja district (Ghana) and Gunnarsholt (Iceland).

Background information

i	Information about the interviewee	Name: ……………………………………… Questionnaire No: ………………………… Date: ………………………………………
ii	Location and Name of Community	District: …………………………………… Name of Community: ………………………..
iii	Interviewee work profile	Farmer: ……………………………………. Fisherman: ………………………………… Government: ……………………………… Others (specify): …………………………...

1. Do you think gravel and sand mining has positive or negative impact on local or neighbouring communities?
2. What is the main positive impact?
3. What is the main negative impact?
4. Do you think mitigation measures should be applied to limit negative impact (in 3 above)? If yes, which measures?
5. Do you think gravel and sand mining is causing depletion of vegetation around the mines?
6. In your opinion, is gravel and sand mining negative or positive for agriculture? Why?
7. In your opinion, do you have a comprehensive state permits on sand and gravel mining?
8. Is it clear in your opinion, who is responsible for applying rules regarding gravel mining?
9. What is the minimum size to require permit and what are the state mandated closure standards or specifications?
10. Is monitoring often done to ensure compliance?
11. Are rules regarding gravel mining enforced properly?
12. If no, do you have any opinion why it is not properly enforced?
13. In your opinion, are mines being restored soon enough after use or are they left open?
14. Is it clear who is responsible for restoring and closing the mines?
15. Who are the usual owners of gravel or sand mined areas (landowners) in the area/country? (a) Government (b) Individuals (c) others (specify).

Appendix II.

Acronyms / Abbreviations

AUI – Agricultural University of Iceland

EIA – Environmental Impact Assessment

EPA – Environmental Protection Agency

EGD – East Gonja District

FAO – Food Agriculture Organisation

L. I. – Legislative Instrument

NR – Northern region

WFP – World Food Programme

SCS – Soil Conservation Service