Impact Analysis Of Informal Brick Production On The Environment: Gaborone Dam Area, Botswana

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Abstract: Fired clay bricks are one of the materials used for the construction of buildings in Africa. The bricks are usually produced locally in industries and in small enterprises in villages and at a rural scale. Most raw materials that are used to produce bricks are found naturally in the environment. The extraction of these raw materials needs therefore to be environmentally sustainable so as to preserve these resources. If sustainable extraction is not observed then, the environment will be under threat. This study follows the different stages followed during informal clay brick production. The purpose is to identify the hot spots which are important to the total environmental impact. The analysis is performed using an EIA and EMP-REHAB methodology. These methods are used to identify and quantify the environmental impact of the process of brick production. The system investigated raw material extraction, industrial production and rehabilitation. The environmental burden that arise from the operation of brick production is mainly through raw material extraction without due care to rehabilitate the environment.

Key words: Brick making, environmental impacts, rehabilitation, sustainable development

1.0 Introduction

In many developing countries, there is a close relationship between poverty, the informal sector, and environmental problems or degradation [1]. While poverty results in certain kinds of environmental stress, the major cause of the continued deterioration of the environment is the unsustainable pattern of consumption and production, particularly in developing countries, which is a matter of concern, emanating from shadow economies within these developing countries [2]. Informal brick making is not a new phenomenon in Botswana. Informal brick making supported construction industries in Botswana's earlier years of development. Since then Botswana has been a rapidly urbanizing country. The level of urbanization has increased from less than 10% in 1971 to close to 60% in 2011[3],[4],[5. The urbanisation process in Botswana can be described as typical peripheral capitalist urbanisation [6]. This is characterised by rapid urban growth that exceeds the rate at which the urban economy can absorb and adequately accommodate the population in terms of gainful employment and access to basic infrastructural service. This inability of the economy to adequately absorb the population in gainful employment has consequently led to the population seeking alternative routes to earning an income. This rapid urbanisation has created a high demand for construction materials and has created a conducive environment for the proliferation of un-gazetted brick making that has a serious impact on the environment such as the one found around the Gaborone Dam. Gaborone Dam was first built in 1963 to supply water to the urban centre of Gaborone when demand for water exceeded the supply from the older Notwane Dam. The area around the dam is underlain with the Gaborone granite and the dominant soil types are sandy loam and clays soils which are conducive for vegetation. The area is also favourable to any business that requires space but at a proximate distance from the urban area [7]. Although statutory requirements that govern the environment are available in Botswana such as the Environmental Impact Assessment Act of 2005, Environmental Assessment Act of 2011 and the Mines and Minerals Act of 1999, informal sector businesses seldom follow the outlined procedures. EIA studies ensure that extraction or excavation of material from the environment is conducted in an environmentally friendly manner. The Mines and Minerals Act ensures that extraction or excavation of materials for commercial purposes is licensed. These are just examples of statutory instruments that are used to protect the environment but are often flouted by informal sector brick making activities. The fact that the environment, stands as a refuge to social insecurities such as poverty, hunger and unemployment makes its protection all the more important. If use of resources is left unchecked then future generations will be disadvantaged. Many countries are taking action to protect environmental degradation in order to restore and protect the quality of their natural environment. They have developed management strategies to prevent or control environmental degradation. Most environmental management strategies involve legal requirements that must be met by individuals and facilities that cause environmental degradation. In Botswana the following Legal Instruments are available for the protection for the environment specifically regarding the mining of industrial minerals

a) Environmental Impact Assessment Act of 2005 and 2011
b) Mines and Minerals Act of 1999
c) Reclamation/ Rehabilitation Guidelines for Sand and Gravel Concession 2005

These instruments although binding, are flouted by the informal sector mainly because a lack of enforcement by those who have the mandate to oversee that these legal instruments are adhered to. The objective of this study is to

1.1 Objectives of the study

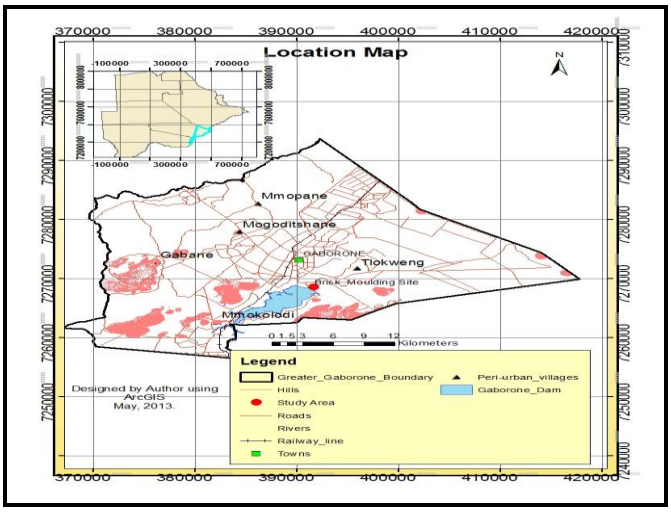
1. Determine the quantity of raw materials extracted from the environment at each stage of clay brick making
2. Investigate the environmental impacts of the process of brick making
3. To investigate strategies adopted by the brick makers to address environmental degradation.

1.3 Description of study area

The Gaborone Dam is located south of Gaborone along the Gaborone-Lobatse road and the geographical co-ordinates are 24° 43′ 5.87″ S, 25° 54′ 26.92″ E. Gaborone Dam provides water for both Gaborone and Lobatse. The dam is

the biggest in Botswana, able to hold 141,400,000 cubic meters (3.735×10^{10}US gal)[8]. Gaborone has a hot semi-arid climate with very hot sunny summer days and cool nights. Precipitation in Gaborone is sparse and variable. Most of the rainfall in Gaborone falls during the summer months, between October and April [9]. Soils around the dam areas generally consist of sandy loams, clays and sandy clay loam types. Good fertile soils are found in depressions and floodplains[9].

1.4 Locational Map



2.0 Methodology

In this study, primary data was collected from all the 15 brick making sites identified. This was done to provide the current description of the study area and outline the impacts of brick making on the environment.The footprint area displayed differing characteristics and therefore impacts could not be generalized. The area had to be stratified into 3 different divisions based on the characteristics they displayed, and were labelled A, B, C. The area was measured using the simple formulae (L× W× H), to obtain the total footprint area. To measure data on site the core raw materials required for the process of brick making(clay, sand, water, coal ash) were identified and quantified as per production of a batch of bricks (e.g. 1000 bricks) over a day and projected to a week and month. To investigate the environmental impacts of the brick making enterprise an EIA Matrix adapted from the ISO 14004, 1996 was drawn that had environmental parameters investigated. Indicators such as existence of pits, extent of burrowing and rehabilitation were investigated, analysed and scored. The following characteristics were used in the prediction and analysis of impacts.

***Magnitude/extent*:** the measure in general degree, extensiveness or scale of impact.

***Nature of Impacts*:** whether positive, negative, direct or indirect, cumulative, etc.

***Duration*:** the period of time over which an impact may occur and remain on site, from once-off to total life.

***Likelihood*:** probability or certainty of an impact occurring before mitigation is applied.

***Significance*:** a measure of the importance of a particular action on the environmental factor in relation to its characteristics and based on specific standards, criterion or accepted policy. This helps the decision maker to focus on specific impacts likely to bring about adverse change to the environment and people and provide practical solutions.

***Irreversibility*:** an indication of whether an impact can be reduced reversed or stopped.

2.1 Impact Evaluation and Interpretation Criteria

After identifying the positive and negative environmental impacts the project will have on the environment, further analysis was conducted to determine the extent/magnitude and significance of impacts. The formula: Significance of Impact = consequence x probability is used. The consequence of impacts is derived from the consideration of the magnitude or extent of the following parameters:

- Severity of impacts (scored out of 10)
- Spatial extent (scored out of 4)
- Duration of the impact. (scored out of 5)

Severity refers to the magnitude of the impact; duration refers to the time component of the impact and spatial extent refers to the area covered by the impact.

Consequence = severity + duration + spatial scale.

Probability refers to the likelihood of the identified impact occurring. The highest significance (SG) score which can be obtained is 100. The significance of environmental impacts is then classified as **high**, **moderate** or **low** as follows:

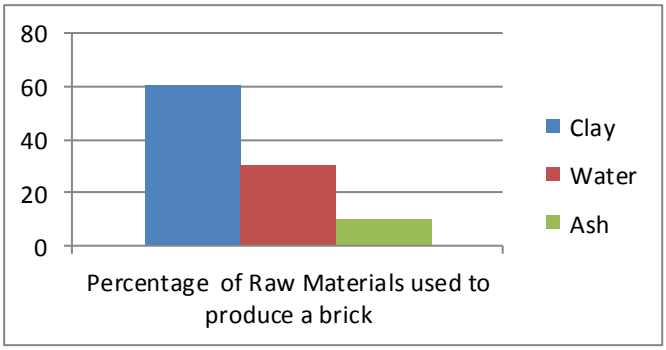
SG>60: **High** environmental significance

SG>30<60: **Moderate** environmental significance

SG<30: **Low** environmental significance

3.0 Analysis

To produce a clay brick there are 3 key materials that are used and these are clay, coal ash and water. The proportions of materials in a brick are shown in the figure 3.0 below



From the above figure it is clear that clay is the major material used in the production of clay bricks, and this process is followed in all 15 sites identified. To understand the process of brick making the process had to be followed over a day.Materials used depended on the number of bricks to be produced. The following is an example of the quantities of raw materials used to produce1000 bricks.

Table 3.0 Raw Materials quantities needed to produce 1000 bricks

Raw Materials	Quantities	Obtained from
Clay	50 (25/) Buckets	On site
Coal Ash	8(25/)Buckets	Princess Marina Hospital/ Abattoirs
Water	25(25/) Buckets	Notwane River / Streams / Ponds On site

Based on the above table 3.0 and Figure 3.0 it is clear that clay is a major component in the clay brick, river sand is used sometimes as a releasing agent during the moulding of the brick. It is also sometimes used as a stabiliser and mixed with very clayey soils to prevent the bricks from cracking when drying [10]. Coal Ash is used for firing the bricks and may be used also as coagulative agent when very poor clay is used to ensure that the brick mixture stays intact to avoid cracking when drying. Materials used in the brick making process are obtained onsite or offsite. Clay which is the major component is obtained onsite, mostly adjacent to the working area. It is important to have the major component onsite as it is bulky and also required in bulk for the brick making process. Water is also a core material and is also found onsite. Water in all the sub areas is obtained either from the adjacent ponds within the site and or along the Notwane River. To produce a 1000 bricks one may need about 500litres of water to at least reach a smooth consistency required for production of bricks. Water is also used in the tempering of clay. This is a process of adding water to the clay and allowing it to stand undisturbed a few days before mixing occurs [10]. This is done so as to break the lumps of clay making the mixing process easier. The Coal Ash is purchased from Princess Marina Hospital. The Coal ash is a residue from the Hospital Boiler and is sold to the brick makers in 50kg sacks. The two common ways used by the brick makers on site to measure any of the required components is by using a wheelbarrow and or a 25 litre bucket. It is important to be consistent when choosing a particular measuring tool. Based on the information that has been put forward from the primary and secondary sources it is clear that the choice of a brick making site is largely dependent on the proximate availability of the major materials required for brick making (clay and water).

3.1 Average Production of Bricks

To find the average number of bricks produced for the whole area, the production of bricks per site per day was added and divided by the number of sites to get the average production per site and the results are:

Total number of sites = 15

Average number of bricks produced in a day = 1 600 per day per site

Total collective production for a month = 1 600×15×21= 504 000 bricks in a month

The production of bricks largely depends on demand and is seasonal. According to information obtained from the brick makers, business is brisk towards the end of the year while slow at the beginning of the year. The brick makers attributed the slow business to the financial constraints people experience in the beginning of the year due to expenses incurred during the festive season.

3.2 Extraction quantities

The clay requirement has to be calculated so as to know how much of it is extracted. Table 3.2 shows quantities of clay extracted

Table 3.2 Clay quantities

Number of Bricks	Required Clay	Conversion	Total
1000	50*25litres	Litres to cubic metres	1250litres = 1.25m^3
1600	80*25 litres	Litres to cubic metre	2000litres =2m^3

To produce 1600 bricks 2m^3 of clay is needed per site; therefore if this number is multiplied by 15 the brick makers need a total of 30m^3 a day of clay. To project clay extraction for a month and a year respectively, the number of extraction per day is multiplied by 21 working days. As shown below-

Extraction of Clay a day from all the sites × 21 working days

= 30m^3×21 days

630m^3

Extraction for a month × 12 months

630m^3× 12months

= 7560m^3

Based on the results tabulated above the brick making activity consumes a substantial amount of clay and therefore the extraction of this resource needs to be monitored. Sub division B is the area were clay is harvested; the harvesting is combined for some of the brick makers who contribute towards the hiring of a caterpillar vehicle that comes in to dig out the clay for a fee. From just the observation of the brick making process, it was noted that the production of handmade bricks is exhausting, tedious and dirty work.

3.3 Scale of production

On all the15 sites identified, the major difference was the scale of production and the nature of the brick maker's participation. The brick maker's participation in the activity is classified as Part time, Full time and Casual. Part time refers to an individual who works less than five days a week and has other jobs that he or she engages in on the other days of the week, full time refers to an individual who is engaged in the business 5 days of the week and has no other business that they are involved in and causal refers to an individual who is only engaged in the business as and when needed.

Table 3.2 Scale of Production

Participation	Number of sites	Scale of production a Day	Number of working days
Fulltime	4	2500+	5
Part Time	6	> 1000<1500	3-4
Casual	5	< 1000	When needed

From the field findings 4 out of the 15 sites produced en masse (2500 bricks or more a day) for 5 days in a week. Mostly these were partnerships amongst friends and they were the owners of the business and were in the business on a fulltime basis. The other 6 sites produce 1500 bricks or more for specific orders, their production largely depended on these orders and therefore most of those found in this category work less than 5 days a week. The last category is made up of those who produce less than a 1000 bricks in a day and these consist of those who have other jobs elsewhere, who consider this as a part time job or a pastime.

3.4 Environmental Impact Assessment

To adequately identify impacts two major Botswana regulations were used. These are the Reclamation/ Rehabilitation guidelines for Sand and Gravel Concessions (Version 1, 2005) and Regulation 215 of the Mines, Quarries, Works and Machinery Act (No# 17 of 1999). These two acts in summary outline specific specifications on the requirements of environmental management plans and rehabilitation guidelines. For instance in the former regulation are borrow pits specifications on slope degrees and these were used as a bench mark in identifying the impacts on the site. Instead of generalising the EIA for the whole area the sub-divisions according to characteristics were adhered to. In sub-division A it was found that because it is at the fore front it is used as market, were the bricks of those within the area are displayed. The burrowing although present was of low significance as well as the topsoil removal and the burning. The vegetation was cleared off so that the area is clear when the product (bricks) are being displayed. It was noted that, were there were traces of burrowing the surface had been reshaped to blend in with the surrounding environment and the site was generally safe for humans and animals. Most of the materials for the business is obtained off site (away from sub area A, but within the study area) therefore in terms of the environmental impact on resource extraction the significance is low for all parameters. Sub-division B was notably the area that had the greatest environmental impact as most raw materials are obtained within this area. That is the river sand, the clay and the water ponds are situated within this area. The brick makers obtain their raw materials from common sources. No one person can claim ownership of the clay or water; anyone can use the resources to their satisfaction. Therefore, although the results depict that there is high resource extraction of the main raw materials; these are not attributed to the brick makers found in the sub-division, but from all of the brick makers present within the study area. As with sub-area A, the majority of raw materials used in this area are obtained off site in exception of the water as the ponds were water is obtained are in this sub sect. The EIA results depict that sub area C is mostly affected moderately by the brick making business. Unlike sub division B, the numbers of burrow pits are fewer and the size varies from 4m wide to 6m. Sub-division B in comparison has the average depth of a burrow pit at 3m to 4m and the average width 5m upward with the largest being 10m. The overall intention of collecting the above data was to: Identify areas within the study area that are most, moderately and least affected by brick making. Based on the results obtained from the EIA, the footprint area can be clearly demarcated into the 3 zones mentioned above. The sub-area B painted orange is the most affected; while the sub-area C painted yellow is moderately affected and last sub-area A painted green, is the least affected. See Sketch Figure 3.2 below:

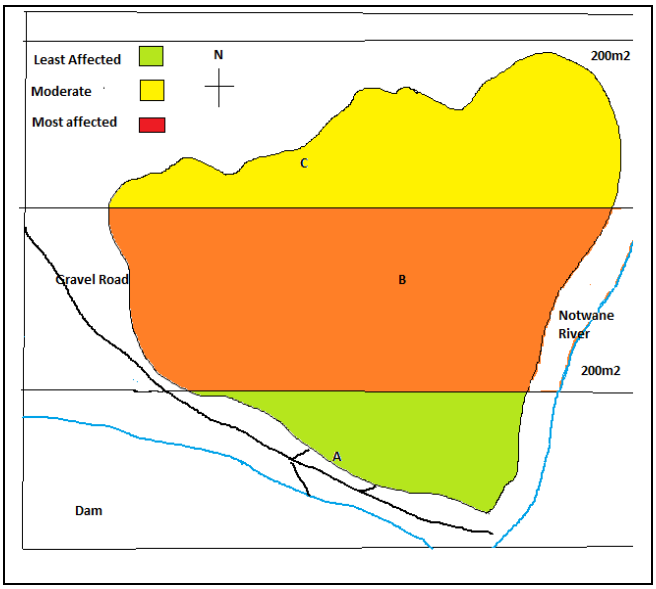


Figure 3.2: Sketch Diagram showing Least, Most and Moderately affected areas

3.5 Rehabilitation

The footprint area did not show any signs of rehabilitation work done. What was evident was traces of dumped material consisting of construction rubble and this was what was found in some of the borrow pits found in the area and this is what some brick makers claimed were their efforts to rehabilitate.

4.0 Findings

a) Quantity of Raw Materials extracted at each stage

The brick makers although they have been in the business for quite some time they do not keep any records of how much they extract and how much they make at any time. Therefore determining the amount of raw materials extracted at each stage proved difficult and therefore the researcher had to work estimates from a batch of bricks. It was found that clay is the major material used to produce a brick, making up approximately 60 % of the mixture. The required Coal ash is 10% while water required is at 30% of the total mixture. Water is obtained on site from the stream and ponds while clay is also extracted on site. Clay and water are the two major materials that determine the site of the brick making activity. Ash is obtained off site and is purchased while clay and water are not.

b) Environmental Impacts of Brick making on the environment

Based on the environmental Impact assessment done, the study found out that the major physical environmental impact is land degradation due to extraction of the clay.

c) Strategies adopted by brick makers to address environmental degradation

In response to the environmental impacts some brick makers claimed to have adopted land rehabilitation although there was no evidence of this on the ground.

4.1 Environmental Sustainability

According to Herman Daly, one of the early pioneers of ecological sustainability environmental sustainability is the "maintenance of the factors and practices that contribute to the quality of environment on a long-term basis" [11]. Daly [11] looked at the problem from a maintenance of natural capital viewpoint. In 1990 he proposed that for the environment to be sustainable the following points need to be considered:

1. For renewable resources, the rate of harvest should not exceed the rate of regeneration (sustainable yield);
2. [For pollution] the rates of waste generation from projects should not exceed the assimilative capacity of the environment (sustainable waste disposal); and
3. For non-renewable resources the depletion of the non-renewable resources should require comparable development of renewable substitutes for that resource.

Based on the above conception the current resource use pattern used in the making of bricks is unsustainable, if the results were to be extrapolated over a year and then 5 years, it would be evident that the area around the Gaborone Dam is under threat if no environmental monitoring is put in place. The current resource intensive pattern is ecologically and ultimately unsustainable.

5.0 Conclusions

While the exploitation of natural resources according to Neil [12] is vital for human survival, human disturbance has introduced a source of change that is foreign to the ecosystems geomorphic conditions and this has led land degradation. The immediate and underlying causes are inappropriate practices and technologies used in exploiting natural resources The Gaborone Dam area has been identified as a sensitive area in that the area adjacent to it houses a water body that supplies the city with water. Nevertheless very few studies have been done around this area and in particular on the brick making activity. The findings of this study show that the brick making activity and its associated activities have degraded the land and if left unchecked will have detrimental effects on the surrounding area. Based on the above the recommendations are as follows:

1. There is a need for encouragement of multi-disciplinary environmental coordination and improved awareness of the magnitude of the effects of brick making.
2. There is a need for government parastatals and nongovernmental organisations to engage as individual organisations and collectively to address this activity before there is irreversible damage to the land

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