Available online at www.ejournals.uofk.edu

UofKEJ Vol. 12 Issue 1 pp. 28- 32 (February 2022)

UNIVERSITY OF KHARTOUM ENGINEERING JOURNAL (UofKEJ)

Impact of Grand Ethiopian Renaissance Dam (GERD) on Manufacturing of the Traditional Fired Clay Bricks in Sudan

Abdalla A. Glaladein, Amged O. Abdelatif, Reem F. Digna, Gamal M. Abdo

Department of Civil Engineering, Faculty of Engineering, University of Khartoum
(E-mail: amged.abdelatif@uofk.edu)

Abstract: The Grand Ethiopian Renaissance Dam (GERD), one of the largest dam projects in the world is currently under construction on the Blue Nile River reach in Ethiopia. Such a massive project will have positive and negative impacts on downstream countries like Sudan. These impacts include impounding sedimentation and avoiding flood occurrence. Previous researches indicated that GERD is expected to impound up to 86% of the Blue Nile annual sediment yield. This is expected to adversely affect the manufacturing of traditional fired clay brick (TFCB) at the banks of both the Blue Nile and the Main Nile rivers. The aim of this paper is to study the impact of GERD on TFCB industry which utilizes the sediment as the main raw material in brick manufacturing. Based on the literature and brick market survey, it has been found from this study that the produced TFCB could be reduced by 68.8% following GERD. This reduction in TFCBs is expected to affect more than 170,000 workers around the country. Future studies and market plans are needed to fill the gap of the TFCB shortage.

Keywords: *GERD, Traditional Fired Clay Brick, Sediment, Blue Nile.*

1. INTRODUCTION

The Grand Ethiopian Renaissance Dam (GERD is one of the largest dam project in the world. The GERD is located in the Blue Nile River, about 30 km upstream of the Sudanese - Ethiopian borders. The work on the GERD has started in 2011 and still going-on [1]. Development of such a massive project will have positive and negative impacts for both upstream and downstream countries (i.e. Sudan, Egypt, and Ethiopia itself).

One of advantages of GERD is regulating the flow of the Blue Nile and avoiding flood occurrence at downstream countries [2]. Moreover, the GERD reserves sediment which extends the useful life of downstream dams and cut the sediment-flush cost of irrigation canals [3].

However, reduction of sediment directly results is reduction of fertilizing soil, and negative effect on the sediment-related industries such as potteries and clay bricks. The traditional fired clay bricks (TFCB) are the major building material in Sudan [4].

The TFCBs are made of clay (i.e. sediment), sand, animals dung, water and other agro-materials [5]. In Khartoum State, the manufacturing of TFCBs is mainly located at the banks of both the Blue Nile and the Main Nile rivers because of sediment availability. It is estimated that 72-90% of the Main Nile total sediment yield comes from the Blue Nile [3]. However, the quantity is expected to decrease due to GERD. Therefore, the aim of this paper was set to study the impact of GERD on the TFCB's production.

2. Research methodology

To achieve the research aim the following methodology has been adopted using both primary and secondary data. At first, the literature about the TFCB's in Sudan is given. This followed by surveying the available data on the effect of the GERD on the sedimentation for downstream countries. In order to evaluate the impact of GERD on the TFCB's industry, a series of interviews with manufacturers and visits to the production areas were carried to assess the current situation after the start of GERD's construction and to estimate the production of all types of bricks/blocks in the construction sector and to the market share of each type. Finally, the probability theory was used to predict the influence of the GERD on the TFCB's industry.

3. Background about TFCBs production Industry in Sudan

According to previous studies, production is mainly concentrated in the central states of Sudan where more than 75% of TFCBs is produced [6]. Khartoum State produced 58% of total production of fired clay bricks followed by Gezira State, 23%, Fig .*1*. This is because the production is quietly linked to urbanisation and availability of rivers' sediment (i.e. clay) in these states. It is worth mentioning that 83% of TFCBs manufacturing is concentrated at the banks of the Blue Nile, Fig .*2* [6].

3.1 Manpower in TFCBs production sector

Brick making industry is considered as a small scale labour intensive industry, Countrywide, the number of workers employed in this sector are estimated to about 35000 of which 50 % are in Khartoum and 38 % in the central states [6]. Each worker has a family which consists of more than 7 persons. Additionally, Kilns owners have between 2 to 15 family members. The majority had no other income than Brick Making(BM), and more than a tenth of respondents had more

than one kiln [4]. These numbers giving an approximate idea about the size of community that could be influenced by the impact of the GERD on the TFCBs industry.

3.2 Manpower in TFCBs production sector

Brick making industry is considered as a small scale labour intensive industry, Countrywide, the number of workers employed in this sector about 35000 of which 50 % are in Khartoum and 38 % in the central states [6]. Each family consists of more than 7 people. Additionally, kiln's owner, Kiln owners having from 2 to 15 family members. The majority had no other income than brick making, and more than a tenth of respondents had more than one kiln [4]. These numbers giving an approximate idea about the size of community that could be influenced by the impact of the GERD on the TFCBs industry. (Repeated see section 3.1).

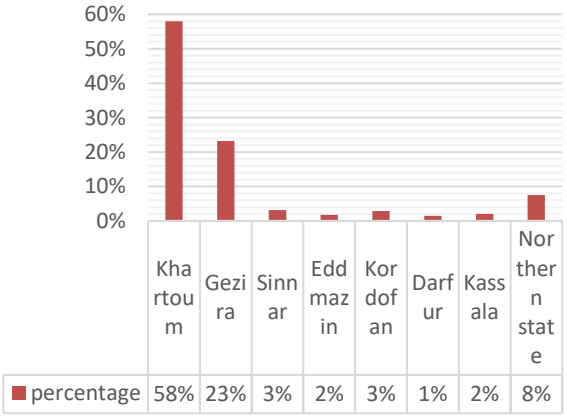


Fig .1. Distribution of Traditional Fired clay Brick Making Industry in Sudan: reproduced from [6]

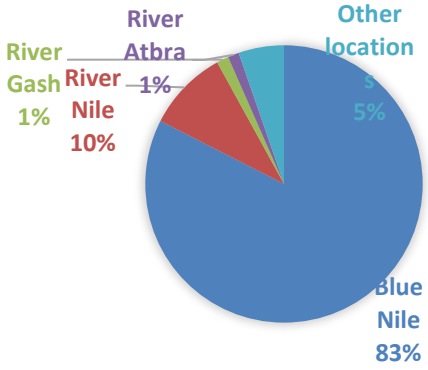


Fig .2. TFCBs production at rivers' banks and other locations.

4 Impact of GERD on Sediment

The Ethiopian highlands experience massive soil erosion resulting in loss of upstream land and increase of sediment load that is carried downstream to Sudan. The high sediment load is the main cause losing both storage capacity of the hydro-system of the Blue Nile and Atbara River and conveyance canals in Aljazeera irrigation scheme. For instance, the reservoirs of Roseires , Khashm Elgirba have lost about 60%, 43% of their storage capacity, respectively [7,8].

The long-term annual average sediment load at Eldeim station upstream of Roseires reservoir is estimated at 140 million tonne/year prior development of GERD [3,9,10]. This amount is anticipated to be reduced following GERD completion and operation [11]. However, different values are reported in the literature. Ali [3] showed that sediment deposition in Rosaries Dam will nearly be reduced by 70% after GERD operation.

The study conducted by Tesfa (2013) indicated that, before GERD, the total sedimentation in Blue Nile was 136.5 million tons per year. After GERD, this is expected to reduce to 19 million tons per year [12], as shown in Fig .*3*. This means the GERD is expected to impound more than 117 million tons per year which is about 86% of the annual Blue Nile sediment load when GERD gets operational [12].

The sediment load before-and –after GERD as estimated by Tesfa (2013) has been used in this study as it would conservatively affect the expected negative impacts of GERD on TFCB .

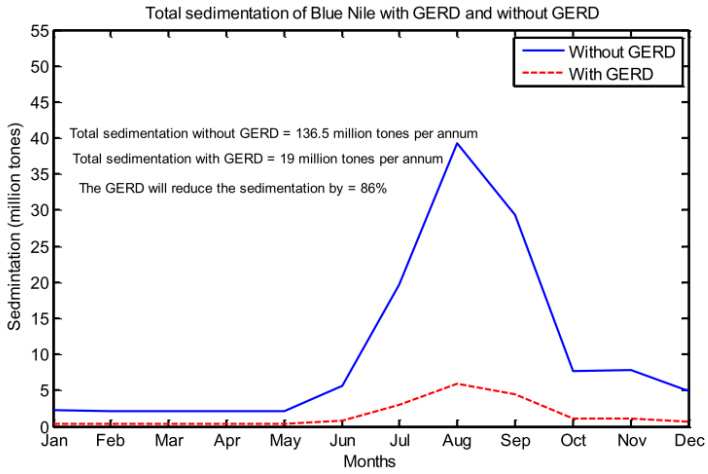


Fig .3. The effect of GERD on sedimentation for downstream Blue Nile countries [12]

5 Sedimentation and manufacturing of fired clay bricks

Clay is the main raw material in manufacturing fired clay bricks as mentioned earlier. The percentage of clay in fired clay bricks vary from 80% up to 94% (87% average) depending on type of clay. TFCBs manufactures used to dig and fetch the clay from sedimentations areas beside the river banks leaving very huge ditches (usually proportioned to their production) to be filled by sediments in the next flood season. The process of filling and refilling of these ditches generally depends on three factors: quantities of sediments; the carrier of sediments (i.e. flood); and the period of settlement. If one of these factors is missed the filling process will be affected and the ditches may be filled partially. Fig .*4* presents an observation showing an example of fully-filled and partially filled ditches.

According to the interviews carried during site visits in 2021 for many kilns in Khartoum state the following key observations are revealed. It was observed that in the last three years (i.e. 2019, 2020, and 2021) there is a noticeable reduction in the sediments as most of the ditches are partially filled. Moreover, the clay contained sand which is not desirable in bricks making. The kilns' owners have been

questioned about what they do in case of largely reduction in sediments, they answered that they will bring clay from South of Khartoum by trucks. This definitely will increase the cost of the produced TFCBs under this condition.

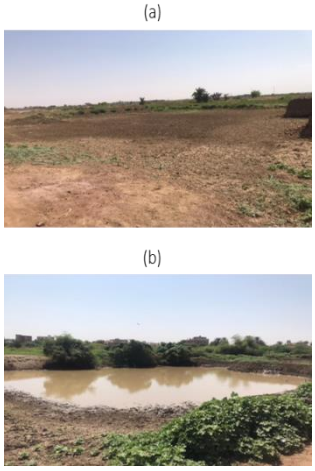


Fig .4. Fully-filled (**a**) and partially-filled (**b**) borrow holes

6 Estimation of bricks production

In this section, the total productions of TFCBs and the other types of bricks are estimated. Moreover, the market share of each type of bricks/blocks is predicted.

6.1 Production of TFCBs

The productivity of brick making kiln unit (locally known as *Kamena*) depends on many factors for example availability of skilled labours, availability of raw materials, market demand, and financial capability of its owners. As a part of this study, a series of interviews were carried with some of the Kilns' owners. Kilns owners' interviewees revealed that the productivity of brick making platform varies from 600,000 to 1,200,000 bricks per year with average of 900,000 bricks per year. The total numbers of TFCBs production units in Khartoum state are estimated to be more than 2000 units. More than 1100 TFCBs production units, which represents 60% of TFCBs production in Khartoum, are distributed along the east bank of the Blue Nile in comparison to 300 units (i.e. 17%) on the west bank. It could be estimated that the average total amount of fired clay bricks that is produced per year in Khartoum state is approximately around 1,800,000,000 TFCBs,

Fig **.5**. This productivity of TFCBs is equivalent to about 10,000,000 m^3 walls (i.e. assuming one square meter consumes 180 TFCBs on the average). This quantity is the largest in comparison to the other states.

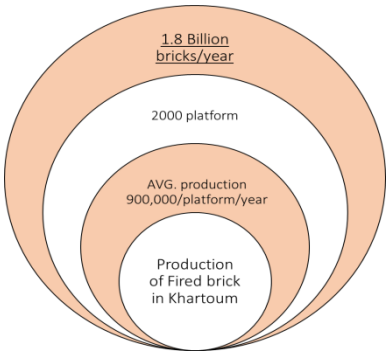


Fig .5. Bricks production in Khartoum State

6.2 Production of other types of bricks/blocks

Beside the TFCBs, there are other two types of wall building bricks that has being used widely in Sudan namely: modern bricks (known locally as thermal bricks) and concrete blocks. The modern bricks is usually manufactured in factories and produced using mixes of clay sediment, additives, sand, kaolin, in addition to the water. In this type, the bricks forming is usually automated. After forming bricks are left to dry and then fired in large kilns. Because all of the four thermal bricks factories are away from river banks, the raw materials (clay) are brought by trucks. According to a sales department of one of these factories, the annual production varies from 17,800,000 to 25,500,000 bricks for the all four factories in Khartoum State (average of 21,650,000 bricks) which is equivalent to 1,275,000 m^3 walls (i.e. one square meter consumes 17 thermal bricks on the average). The total number of labour in this sector is about 1500 labours for all current factories.

On the other hand**, c**oncrete blocks, although they have no direct relationship with sedimentation, there is indirect relationship related with TFCBs market demand. The total annual production of concrete blocks is estimated as 9 million blocks as reported in the literature [13]. So the equivalent area will be 720,000 m^3 walls (i.e. one square meter consumes 12.5 concrete block).

6.3 Market share

As it has been shown above, the equivalent one-brick walls area for TFCBs, thermal brick and concrete block are 10,000,000 m^3, 1,275,000 m^3 and 720,000 m^3 respectively. The TFCBs represents the 83% of the bricks market share,

Fig **..** This means that any influence on TFCBs will affect the whole bricks market. This can easily be observed during the flood season where the productivity of TFCBs decreases and the prices go high. It is worth mentioning that, according to an official, in an interview with main author of this study, the annual approved number of buildings by the authorities is estimated to be equivalent to 14,000,000 m^3 one-brick walls area.

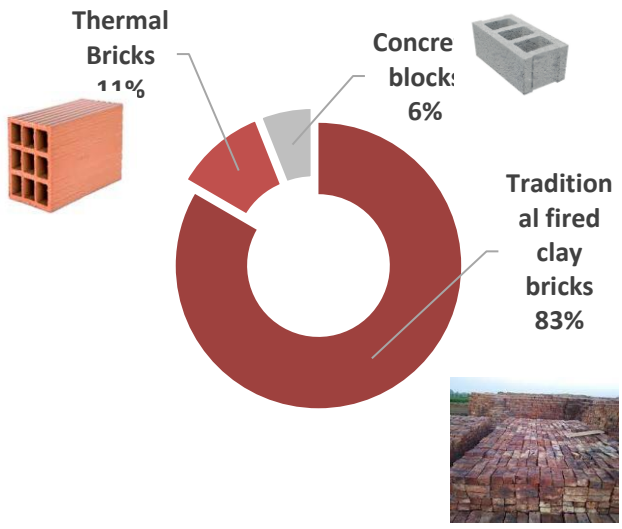


Fig .6. Market share of bricks sectorResults and discussions

7 Prediction of the possible impact of GERD on manufacturing of TFCBs

For simplicity, it is reasonably assumed that on the full operation of GERD the reduction of sediment as the main source of clay used in the brick making is directly proportioned to the reduction of TFCBs production. For the purposes of this study, the reduction in sediments, the percentage of clay in TFCBs, and the current distribution of the production over different rivers banks are considered the only three independent factors that affect reduction of TFCBs due to GERD full operation. Based on those assumptions, the simple probability is used.

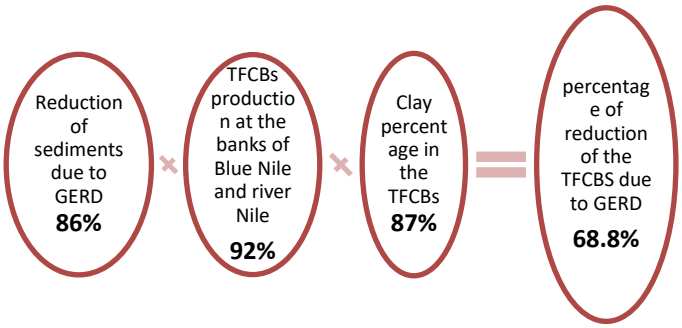
From previous sections, it is shown that:

- Sediments after GERD will be reduced by 86% at maximum (Fig .*3*).
  - $P(A) = 0.86$.
- The clay represents 87% of fired clay brick (Fig .*1*),
  - $P(B) = 0.87$
- 92% of total production of fired clay brick is located onto the banks of both the River Nile and Blue Nile (Fig .*2*)
  - $P(C) = 0.92$

Based on the simple probability theory, impact of GERD on the manufacturing of TFCBs can be predicted by calculating the probability of occurrence of these three factors all together [14]. Therefore, the impact of GERD on production of the TFCBS will be:

$$P(A \cap B \cap C) = P(A) \times P(B) \times P(C)$$

$$P(A \cap B \cap C) = 0.86 \times 0.87 \times 0.92 = 0.688$$



In other words, the reduction of sediments due to GERD will reduce the production of TFCBs by 68.8% before turning to bring clays from new rich clay areas. This represents more than 1.2 billion TFCBs and nearly 7 million square meters of walls.

In social dimension, this could have possible impact on the workers on TFCBs sector and their families. Approximately, 12000 labours (i.e. 84,000 family members) in Khartoum state can be affected. This number could reach 100,000 considering kiln's owners and other businesses related to the TFCBs industry such as transportation and caterings and foods providers. Considering 58% of TFCBs production of Sudan is in Khartoum state, the number of affected people around Sudan could be more than 170,000.

The impact of the GERD on the bricks market could simply be estimated by 57% as a TFCBs producer represents 83% of market. This besides the possible increase of TFCBs manufacturing cost due to bringing clays from far remote areas. The market should be prepared to accommodate such changes and ready to fill the expected TFCBs gap. One of these possible solutions is to ease investments in manufacturing both concrete blocks and modern thermal blocks as future alternatives.

8 Conclusions

This study strived to predict the impact of the Grand Ethiopian Renaissance Dam (GERD) on manufacturing of traditional fired clay bricks (TFCBs). Previous studies showed that the GERD could impound up to 86% of the sediments which is the main raw material in the TFCBs production. Based on current practice and observation, clay represents 87% of brick's components. Nearly 92% of TFCB manufacturing practice concentrates on the banks of both the Blue Nile and the Main Nile rivers where clay is massively annually deposited. Accordingly, and using the simple probability theory, it was found that GERD could reduce the production of TFCBs by 68.8% before the search for new areas for bringing the clay (sediments). This reduction is expected to have a social impact on the communities of TFCBs sector which could reach about 170,000 persons. It is recommended that the bricks market should be prepared for the GERD-caused 1.2 billion bricks gap in the market by easing the investments in the bricks manufacturing industry. Further studies are needed to quantify the actual and projected future TFCB demand in the construction market in Sudan. Also, in-depth socio-economic study is recommended for better understanding and quantification of the impact of sediment reduction following GERD on labour's incomes in TFCB industry.

REFERNCES

[1] Negm M, Abdel-Fattah S. Grand Ethiopian Renaissance Dam Versus Aswan High Dam: A View from Egypt. vol. 79. 2019.

[2] Siddig K, Basheer M. Economy-wide assessment of the impacts of Nile sediment reduction on the Sudanese construction sector. 24th Annu. Conf. Glob. Econ. Anal. (Virtual Conf., 2021.

[3] Ali YSA. The Impact of Soil Erosion in the Upper Blue Nile on Downstream Reservoir Sedimentation. PhD Thesis, IHE Delft Institute for Water Education, 2014.

[4] Abdalla I, Abdalla SB, El-Siddig K, Möller D, Buerkert A. Effects of red brick production on land use, household income, and greenhouse gas emissions in Khartoum, Sudan. J Agric Rural Dev Trop Subtrop 2012;113:51–60.

[5] Mohamed I, Abdalla F. Original Research Article Environmental Impact of Red Brick Manufacturing on the Bank of the Blue Nile at Soba West , Khartoum , Sudan. Int J Curr Microbiol Appl Sci 2015;4:800–4.

[6] Alam SA. Use of biomass fuels in the brick-making industries of Sudan : Implications for deforestation and greenhouse gas emission. Sci Total Environ 2006;407 (2):847–52.

[7] ENTRO (Eastern Nile Technical Regional Office). Multipurpose Development of the Eastern Nile, One-System inventorySynthesis work Report. Addis Ababa: Eastern Nile Technical Regional Office; 2007.

[8] Gismalla Y. Sedimentation Problems in the Blue Nile Reservoirs and Gezira Scheme: A Review. Gezira J Eng Appl Sci 2009;14:1–12.

[9] Borji TT. Sedimentation and Sustainability of Hydropower Reservoirs: Cases of Grand Ethiopian Renaissance Dam on the Blue Nile River in Ethiopia. Master Thesis, Institutt for vann-og miljøteknikk, 2013.

[10] Siyam AM, Mirghani M, Elzein S, Golla S, El-sayed SM. Assessment of the current state of the Nile basin reservoir sedimentation problems. Nile Basin Capacit Build Netw (NBCBN), River Morphol Res Clust Group1 2005.

[11] Mohamed MM, Elmahdy SI. Remote sensing of the Grand Ethiopian Renaissance Dam: a hazard and environmental impacts assessment. Geomatics, Nat Hazards Risk 2017:1–16.

[12] Tesfa BC. Benefit of Grand Ethiopian Renaissance Dam Project (GERDP) for Sudan and Egypt. EIPSA Commun Artic Energy, Water, Environ \& Econ 2013;1:1–12.

[13] Elsharif RA. Quality of bricks produced from non-conventional clays. MSc Thesis, University of Khartoum, 2010.

[14] Devore JL, Farnum NR. Applied statistics for engineers and scientists. 2nd ed. Belmont, CA ; London: Thomson Brooks/Cole; 2005.