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Socio-economic and Environmental Impacts of Clay Brick Manufacturing in Gbado-Lite City (Nord Ubangi Province, DR Congo)

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Abstract

Clay brick is one of the most important materials for the construction in rural areas of Africa. However, the consumption of such earth-based materials in the production process resulted in resource depletion, environmental degradation, and energy consumption. The aim of the present study was to evaluate the socio-economic and environmental impacts of the manufacture of clay bricks in Gbado-Lite city. To this end, a survey was carried out among 30 clay brick manufacturers in Gbado-Lite city, Nord-Ubangi between March and June 2019. The results show that the age of the population varies between 18 and 45 years and of which 60% have a secondary level, 13.33% are academics and 26.67% have a primary education. However, 60% of respondents have 5 to 10 people in their household, while 67% of respondents have experience in this activity,. The most slaughtered plant species are *Acacia sp., Triplochiton scleroxylon* K. Schum., *Western Anacardium sp*. L., *Artocarpus altilis* (Parkinson ex F. A. Zorn), *Artocarpus heterophyllus* Lam., *Mangifera indica* L., *Persea americana* Mill. and *Terminalia catappa* L. The profit from the manufacture of clay bricks is estimated at approximately 880,000 CDF (US$522,353). This money is intended for children's schooling, health care and other daily needs. The level of education of the respondents does not positively influence their behavior towards the environment. It is therefore desirable that this informal sector be taxed and that, in addition, it should also create a company specializing in the creation of artificial forests (reforestation or restoration of wood-vegetation) in order to sustainably support the city's supply of baked bricks. In addition, it is important to raise public awareness about environmental protection and to introduce these concepts into the training program at the primary and secondary school level.

Keywords

Clay Bricks, Wood Fuel, Environment, Nord Ubangi, Ubangian Eco-region

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1. Introduction

The clay brick is a handmade brick made from clay baked in an oven at about 1200°C. According to some authors, this natural material is ecological and also has good insulation [1-3]. The industry«bricks clay»is evolving to promote buildings and products with a low carbon footprint that, through their thermal performance, can achieve increasing savings [4-6]. In industrialized countries, the environmental and societal responsibilities of construction stakeholders go beyond the fight against global warming, since they take into account environmental issues through a multi-criteria approach [7]. The exploitation of sites for the production of clay bricks is one of the major factors of environmental degradation, and this activity is still booming today more precisely in rural areas. It provides substantial revenues due to its economic profitability, but also to an environment favoured by the very high price of cement and very high demand [8-12].

The programming law also provided that as soon as new Provinces are installed, the Government of the Democratic Republic of the Congo (DRC) will initiate, in consultation with the provincial authorities, a program of equipment, rehabilitation and especially the construction of the infrastructure necessary for the operation of new Provinces (Programming Act No. 15/004) [13]. This provision has aroused among residents of Gbado-Lite city, the growing needs of infrastructure construction. Currently, the fact that the city of Gbado-Lite is that every street has at least a new construction of semi-durable or sustainable materials using clay bricks through trees that are cut down and sold by the population to manufacturers to serve of energy source. The activity of making baked bricks is detrimental to the environment by the pollution of the air with the emission of carbon dioxide (greenhouse gas) released from these ovens [1]. The population growth in Gbado-Lite city and its advent to the capital of the Nord Ubangi Province is at the base of the high demand for these building materials. The main aim was to assess the socio-economic and environmental impact of clay brick manufacturing in Gbado-Lite city.

The significance of the current study is obvious because acquiring a better knowledge on the impact of this activity on the environment would allow proposing measures to protect trees outside forests and periurban forests that form the belt around Gbado-Lite city through the implementation of rigorous legislation.

2. Material and Methods

The surveys on the clay brick manufacturing process and plant species used as source of wood energy and the socioeconomic impact of this practice were obtained by interviewing manufacturers during field works conducted in Gbado-Lite city and surroundings in the Nord Ubangi province, Democratic Republic of the Congo. Surveys were conducted from February to April 2019 from clay brick manufacturers, in five manufacturing sites (Camp Mbanza, Pangoma, Fondation, Tabac Congo and Huit villas). Gbado-Lite city is located in the Ubangi ecoregion, a sub-set belonging to the Congolese forests of the northeast (Northeastern *Congolian lowland forests).* This eco-region is one of 200 globally-priority land-based eco-regions known as the "G200"» in the world [14-17].

A total of 30 manufacturers were interviewed. Informants were selected for their authentic knowledge on the clay brick manufacture process. Local language Lingala was used during anthropological interviews, and manufacturers were interviewed on a voluntary basis according to the principles laid out in the Declaration of Helsinki. The questionnaires were divided into three sections: (i) personal information (including name, age, gender, education level, marital status, household size and seniority); (ii) plant material used as an energy source for the clay bricks manufacturing (including plant scientific name, and abundance) and environmental impact of clay bricks manufacturing; (iii) socioeconomic impact of clay bricks manufacturing including cost estimation of purchasing, felling and transporting tree feet as well as cooking bricks cost and the profit margin. Plant species used as wood energy for clay brick preparation were identified using taxonomic keys and by comparison with voucher specimens deposited at the herbarium of the INERA (Institut National d'Etudes et de Recherches Agronomiques), located at the Faculty of Science of the University of Kinshasa. Data analysis was performed using conventional descriptive statistical methods with the help of Origin version 8.5 Pro software.

3. Results and Discussion

Table 1 provides the socio-demographic characteristics of respondents.

Table 1. Socio-demographic characteristics of Respondents.

Variables	Frequency	Percentage (%)
Age (years)		
18-30	6	20
31-45	22	73.30
> 45	2	6.70
Education Level		
Primary	8	26.67
secondary	18	60
University	4	13.33
Marital status		
Single	3	10
married	27	90

Variables	Frequency	Percentage (%)
Household size		
<5 people	2	6.67
5-10 people	18	60
11-15 people	8	26.66
>15 people	2	6.67
Seniority		
<5 years	3	10
5-10 years	17	56.67
11-20 years old	9	30
>20 years old	1	3.33

This table shows that the age group between 31-45 and over 45 years are in the majority, 80% compared to the age groups between 18-30 years old which represent only 20%. Regarding the level of education, 73.33% of respondents are able to read and correctly answer the questions in this survey. This confirms the accuracy of our respondents' responses. As for the marital status, 90% of clay bricks manufacturers are married. With respect to household size, Table 1 shows that manufacturers having 5 to 10 people in their household account for 60%, followed by those with 11 to 15 people (26.66%) and finally manufacturers with fewer than 5 people and more than 15 people make up only 6.67% respectively. In terms of seniority, 56.67% of respondents have a seniority of 5 to 10 years in the trade, followed by 30% of respondents who have an experience of 11 to 20 years, then 10% of respondents have seniority less than 5 years old and 3.33% of respondents have a seniority of more than 20 years.

We should expect that the level of education of our respondents can positively influence their behaviour towards the environment. This can be justified by the lack of employment to support households.

Table 2 lists the different plant species used as a source of energy when cooking clay bricks in Gbado-Lite.

Table 2. Plant species used as a source of wood energy for clay bricks.

Common name	Scientific name (botanical family)	status
Mango tree	*Mangifera indica* L (Anacardiaceae)	3
Avocatier	*Persea americana* Mill. (Lauraceae)	3
Lidame	*Terminalia catappa* L. (Combretaceae)	2
Jackier	*Artocarpus heterophyllus* Lam. (Moraceae)	3
Gbado-gbado	*Triplochiton scleroxylon* K. Schum. (Malvaceae)	3
Anacardier	*Western Anacardium* L. (Anacardiaceae)	4
Acacia	*Acacia sp*	2
Bread fruit	*Artocarpus altilis* (Parkinson ex F. A. Zorn) Fosberg (Moraceae)	4

This table shows that eight plant species serve as a source of wood energy for cooking clay bricks. However, *Terminalia catappa* L., acacia sp are still abundant (status 2). On the other hand, *Mangifera indica* L., *Persea americana* Mill., *Artocarpus heterophyllus* Lam,. and *Triplochiton scleroxylon* Schum K. are much less abundant (status 3). Finally, *Western anacardium* L., *Artocarpus altilis* (Parkinson ex F. A. Zorn) are rare (status 4) in Gbado-Lite city.

Table 3 shows the cost of purchasing, felling and transporting tree feet.

Table 3. Estimated cost of purchasing, felling and transporting tree feet.

Number Feet downed	UP/CDF	Total cost of feet (CDF)	Number fellers	Ration/slaughterer (CDF)	Total cost of ration (CDF)	Transportation/vehicle tower (CDF)	Nbr of laps	Total cost/CDF
5 feet	3 000	15 000	2	1 000	2 000	60 000	3	197 000
8 feet	5 000	40 000	3	2 000	6 000	60 000	3	226 000
10 feet	8 000	80 000	5	2 000	10 000	60 000	3	270 000
16 feet	10 000	160 000	5	2 000	10 000	300 000	5	470 000

(Exchange rate: 1 USD=1,700 CDF).

It emerges from this table that the number of feet to be cut varies between 5 and 16 at a cost ranging from 3000 CDF (or 1 765 USD) to 10,000 CDF ($5882) per foot; the number of slaughterers involved ranges from 2 to 5 people, representing a ration cost ranging from 2000 CDF ($1,176) to 10,000 CDF ($5,882). Meanwhile, the transport per lap of vehicle is 60 000 CDF ($35 294) and the total cost of energy-wood consumption varies from 197 000 CDF ($115,882) to 470,000 CDF ($276,471) depending on the amount of bricks to cook.

The table 4 gives the cost of cooking the bricks.

Table 4. Cooking bricks cost.

Number. Of staff engaged	Ration/people (CDF)	Ration Cost (CDF)	Labour (CDF)	Total cost of cooking (CDF)
5 people	2,000	10,000	140,000	150,000
10 people	2,000	20,000	140,000	160,000
15 people	2,000	30,000	140,000	170,000

It emerges from this table that the individual ration is set at 2 000 CDF (1 176 USD) per day. With a team of 5 to 15 people, the cost ranges from 10 000 CDF ($8 882) to 30 000 CDF ($17 647); the workforce includes handling 500 bricks for an amount of 2 000 CDF ($1,176), the ranking specialist fee is equivalent to 50 000 CDF ($29 412) and fire maintenance per entry to 5 000 CDF ($2 941). This brings the overall cost ranging from 150,000 CDF ($88 235) to 170 000 CDF ($100).

Bricks are made of different sizes. We have:

1. Bricks of 30 × 14 cm;
2. Bricks of 30 × 28 cm;
3. Bricks of 28 × 14 cm;
4. Bricks of 30 × 18 cm.

All these bricks are sold at 200 CDF ($0.118) per piece.

Regarding the profit margin, it can be calculated as follows: for a production of 10 000 bricks, we have: 10 000 bricks X 200 CDF=2 000 000 CDF (1 176 471 USD). The overall cost of making clay bricks ranges between 347 000 CDF ($ 204.118) and 640 000 CDF ($376 471).

In addition, the cost of buying land is 80 000 CDF (US$47.059), bringing the overall cost of manufacturing to 720 000 CDF (US$423.529). It should be noted that with 10 000 bricks being cooked, the loss of undercooked bricks is estimated at 20% (the equivalent of 1 000 bricks), due to the transportation and handling after cooking. Thus, taking 1 600 000 CDF minus 720 000 CDF, we have 880 000 CDF ($522.353) as a profit. It must be noted that the manufacturers of clay bricks do not pay taxes related to this activity, this is what encourages them to over-exploit the trees planted in Gbado-Lite city (uncontrolled slaughter) and peri urban forest are as thus infringing the environment.

In relation to the destination of the money generated, manufacturers believe that the money from the manufacture of clay bricks is intended for the pay of children's school fees, family health care and to cover daily needs.

Figures 1 (a) to 1 (f) give the steps of the process of making clay bricks. In fact, the manufacture of clay bricks includes five steps namely clay extraction, dough preparation, shaping, drying and cooking [6, 18]. Figure 2 shows1 the building work of a house using clay bricks in Gbado-Lite city while figure 3 presents the felling and storage of trees used as energy source for cooking. There is currently a strong anthropogenic pressure on plant biodiversity, particularly both fruit and wild trees (Figure 3) due to population growth, poverty and the development requirements of Gbado-Lite city as capital of Nord Ubangi province (Figure 2).

(a) Hill (career).

(b) Ranking bricks for cooking.

(c) Oven.

(d) After cooking (yellow bricks).

(e) After cooking (red bricks).

(f) Brick storage.

Figure 1. Clay Brick Manufacturing Steps.

(a) Foundation of a house under construction using clay bricks.

(b) Wall building of a house using clay bricks.

Figure 2. Building a house using clay bricks in Gbado-Lite.

Figure 3. Cutting down and storing trees used as a source of cooking energy.

Nowadays, it is well established that climate change has already begun to affect biodiversity, including humans. Indeed, the disruption of the rainfall cycle and the accompanying drought are the main consequences of global warming caused by greenhouse gas emissions as a result of the degradation, destruction and fragmentation of rainforests. Thus, it is time to act responsibly in order to adapt to the climate change trend and thus guarantee the social, economic and ecological stability of our society, by passing anthropogenic action before it is late [14, 16]. The manufacture of clay bricks, although socially acceptable and economically viable in rural and/or urban-rural areas, is not environmentally friendly and this practice does not promote sustainable development in Gbado-Lite city. However, it paved the way for over exploitation of wood in peri-urban forest areas and the wild or uncontrolled felling of trees planted in the city. For this purpose, the trees outside the forest and the forest curtain that should make the belt of Gbado-Lite city in order to provide oxygen for the urban population. Furthermore, it is established that in Gbadolite, as in other cities in the country and in Africa, low household income means that more than 90-95% of the population uses woody fuels (biomass) to meet their energy needs [19, 20]. In addition, the exploitation and production of wood energy is concentrated in peri-urban areas, causing deforestation and degradation of forests around Gbado-Lite city [14, 16]. It should also be noted that the issue of domestic energy is a major concern for developing countries where woody fuels cover about 80-95% of household energy needs [19, 20]. In and around Gbado-Lite city, woody fuels remain the main source of energy for the population meanwhile there is therefore a risk of a major energy crisis because of the cooking of bricks. The anarchic use of wood fuel as an energy source for domestic use and for the cooking of bricks in the current context of population explosion in Gbado-Lite accelerates deforestation and compromises reconstruction of forest massif. Thus, although the clay brick trade currently plays a key role in the economy of several households in Gbado-Lite and involves several players, including manufacturers, intermediaries and sellers, the state must ensure good management of federal resources in order to reduce the impact of this activity on the environment.

4. Conclusion and Suggestions

The purpose of this work was to assess the socio-economic and environmental impact of the manufacture of clay bricks in Gbado-Lite city. The study found that.

This practice, although lucrative, is one of the causes of deforestation. The most slaughtered plant species are *Terminalia catappa* L., *Acacia sp; Mangifera indica L., Persea americana, Artocarpus heterophyllus* Lam, *Triplochiton scleroxylon* Schum K., *Western Anacardium* L. (Anacardiaceae), *Artocarpus altilis* (Parkinson ex F. A. Zorn) Fosberg.

The profit from the manufacture of clay bricks is estimated at approximately 880,000 CDF (US$522,353). This money is

for children's schooling, to the health care others daily needs. The level of education of the respondents does not positively influence their behaviour towards the environment.

It is therefore desirable that this informal sector be taxed and that, in addition, it should also create a company specializing in the creation of artificial forests (reforestation or restoration of woody vegetation) in order to support sustainable supply of cooked bricks to the city. I It is important to raise public awareness about environmental protection and to introduce these concepts into the training program at the primary and secondary school level.

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