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PRODUCTION OF COOKED BRICK AND ENVIRONMENTAL IMPACTS IN DOLISIA SOUTH OF CONGO BRAZZAVILLE

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ABSTRACT

Dolisie, 3rd city of the Republic of Congo, since the colonization, the constructions are realized much more with the bricks cooked to the detriment, the block work and compressed earthen brick (BTC) or brick stabilized. Although less expensive (25 to 50 CFA francs) compared to the other two whose prices vary between 350 and 475 CFA francs, the production of the baked brick has effects on the urban environment of Dolisie city. Thus, evaluating these effects is the objective of this study, whose methodological approach is summarized in three phases: documentary research, fieldwork and laboratory phase. The results obtained show that the production of baked brick has ecological advantages (thermal insulation, durability, internal humidity, water proofness and aesthetics). Despite this, we can see that there are many negative impacts related to the production of the baked brick, thus compromising the sustainable development of the city (destruction of the urban space by the crevasses whose earth losses are evaluated between 1,473.7 and 3,445.9 tons thus slowing down spatial growth, urban mobility and creating growing insecurity in the neighborhoods concerned).

Keywords: cooked brick, negative impacts, environment and development

1. INTRODUCTION

The clay brick consists of raw clay soil that is shaped into wooden molds that give it its parallelepiped or rectangular shape. It is dried in the sun for days and cooked in a wood or electric oven. It then becomes the cooked brick.

Cooked brick is a building material that is used and prized around the world, especially in developing countries even though production techniques differ. It is competing with Compressed Earth Bricks (BTC) in both Western and Third World countries. Cooked brick is an ecological material (Jegousse 2017, p.2) and cheaper (CTCN 2017, p.7), compared to the cinder which costs more expensive unlike developed countries (Monomur 2010, p.1). Clay, a raw material for the manufacture of fired brick, is available in many developed and developing countries and brick makers use it with great ease even with precarious materials such as the various plank molds (Kahozi 2014, p.15). In Dolisie, the brickmakers use the same materials and work materials described previously. In this city, almost all the houses, since its creation in 1933, are

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built in baked bricks, material most appreciated, especially because they are accessible on all the stock exchanges.

The baked brick, a material with enormous ecological potential, very much appreciated by the population and architects, unfortunately has many drawbacks which are detrimental to urban growth, mobility and urban safety in Dolisie. It should be noted that the manufacture of baked brick also causes in the city other problems such as the pollution of the air, the soil, the degradation of the grounds and the vegetation. There are then negative impacts on the environment, thus compromising sustainable development while "the development of the city passes through the urban extension which itself is a consequence of demography" (Chenal 2013, p.333) . These negative impacts on the environment are also observed elsewhere in the world.

1.1 Location of the study area

Dolisie is the third city in the urban framework of the Republic of Congo. It is between 44 ° 00'3 " and 44 ° 13'26 " South Latitude and 12 ° 07'36 " and 12 ° 42'02 " East Longitude (see Map No. 1). It is the chief town of the Department of Niari. Its population is estimated at 83,798 inhabitants according to the General Population and Housing Census (RGPH) of 2007 and in 2011, it amounted to 118,182 inhabitants according to the administrative census

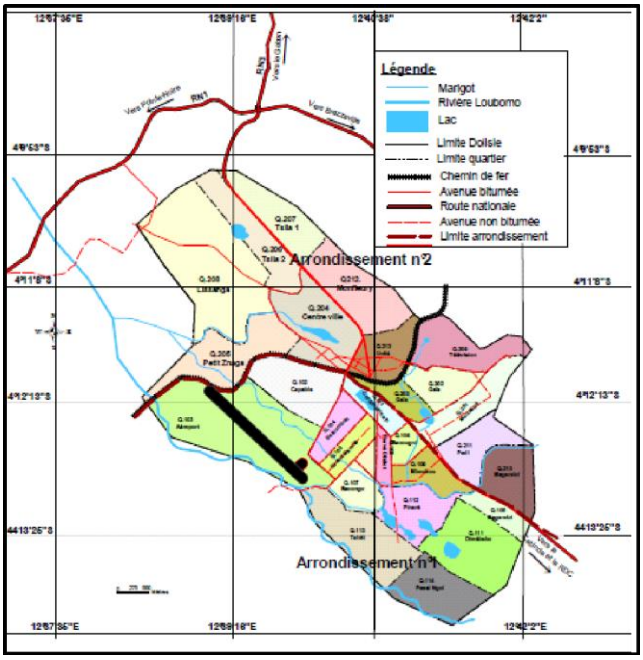

Fig. 1: Dolisie and its districts Source: Dolisie Town Hall

2 MATERIAL AND METHODOLOGICAL APPROACH

2.1Hardware

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We used the modest but operational equipment to carry out this study. This is a digital camera to take photos and a GPS to georeference the different sites of manufacturing and cooking bricks and a double decameter to cuber the shapes encountered.

2.2 Methodological approach

2.2.1 Data collection

Two main methods were used to collect the data, namely: desk research and field surveys.

- The documentary research is in some libraries but especially on the Internet where there is a plethora of writings (articles and memoirs) on the manufacture of raw or cooked bricks all over the world.

- Field surveys focused on administrations through interviews or interviews and with the population through a questionnaire and focus groups. The administrations visited are the Dolisie Central City Council [Directorate of Urban Land Management (DIGEFUR)] and the Departmental Directorate of Forest Economy. Our sample is random by the number of respondents, but reasoned by the choice of people to investigate. This has made it possible to target 10 brickmakers and 90 inhabitants, heads of households who have already built brick fired. In addition, the depth and length of the excavations were measured to determine the volumes that led to the evaluation of the earth losses. The measurements concerned sections taking into account regular geometric shapes. For this purpose, the circle was the main regular geometrical form encountered. The formula used is as follows:

$$\textbf{Volume du cercle (m3)} = \pi(r^2)xH$$
$$\textbf{Volume du cercle (m3)} = \pi(r^2)xH \quad \textbf{(1)}$$

Avec $H_{moy} = (h_1+h_2+h_3+h_4)/4$ ***(2)***

H= profondeur moyenne

Perte en terre

$$\textbf{perte en terre (t)} = \textbf{DA x V} \qquad \textbf{perte en terre (t)} = \textbf{DA x V} \quad \textbf{(3)}$$

Samples for the measurement of bulk density were taken from each site with a 25 cm3 cylinder and transported to the BCBTP Dolisie antenna laboratory. After weighing the wet sample, these samples are put in an oven at 105 ° C. After 24 hours, they are weighed again using a precision scale to evaluate the total dry mass. The bulk density was determined according to the following formula:

With Ms (mass or weight of the dried sample) and V (volume of the wet sample).

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Da: apparent density in g / cm3

2.2.2 Data processing

The analysis of the data was based on some software Sphinx and Word and Excel for data entry and the realization of calculations and figures. The QGIS software was used to prepare the maps.

3 RESULTS AND DISCUSSION

3.1Results

3.1.1 The positive effects of the baked brick

The baked brick, ecological material used since colonization

In Dolisie, a colonial city, since the colonization, the baked brick was the only building material used. The raw material, clay, was abundant on site because it was easy to use to produce the ecological brick that refreshes the houses (Monomur 2010, p.1).

All buildings, both public and private, were built with baked brick. This is the most popular material to date, because, according to the DIGEFUR and according to our field observations, nearly 90% of the houses are built in fired bricks. This is despite the availability of cement and even the construction of a cement plant since 2016.

The baked brick, cheaper construction material

In Dolisie, the cooked brick is cheaper (Ditengo 2012, p.237) even if over the years this price has evolved and fluctuated lately. It went from 5 to 10 francs in the 60s, from 15 to 20 francs in the 70s, 25 frs from the 90s to the year 2000. This price has increased because of the Accelerated Municipalization in 2006. Cooked brick was now costing 50 francs. The economic difficulties having decreased the purchasing power of the populations, it is resold since 2017 to 25 francs at the expense of the brick makers but to the profits of the populations. However, according to the brickmakers, this brick is sold at 100 francs to Mouyondzi, a town in the Niari countries to which Dolisie belongs.

Compared to stabilized brick or compressed earth brick (BTC) and cinderblock, fired brick is sold cheaper in Dolisie. To buy 500 or 1.000 cooked bricks, it is the minimum accepted by the brickmakers to better sell their stocks, it is only necessary to pay 50.000 francs if the brick costs 50 francs or 25.000 francs if the brick is sold at 25 francs like now. While the compressed earthen brick amounts to 475 francs and 1,000 bricks cost 475,000 francs (Geo-consulting company in Dolisie) and the prefabricated block is sold at 350 or 400 francs then 1,000 bricks then come back to 400,000 francs. This goes without saying on the choice of brick baked in construction in Dolisie, because it is the cheapest material of the three. Table I below corroborates these statements in relation to what the 90 heads of households or populations state

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as mentioned in the table. It can be seen that 74 heads of households have already built in fired bricks and 10 are also building bricks against only 6 in cinder block.

Table I: The choice of building materials

Matériaux et % Populations	Briques cuites		Briques de terre comprimée (BTC)		Parpaings	
	Nombre d'enquêtés	%	Nombre d'enquêtés	%	Nombre d'enquêtés	%
Ayant construit	74	82	00	00	06	07
En train de construire	10	11	00	00	00	00
Total	84	93	00	00	06	07

Source: Personal Investigations, September 2018.

The analysis of Table I shows that those who used the brick in their buildings are more numerous in the order of 93% against only 07% for those who built in cinder block. All the respondents recognize that the low price of the baked brick facilitates the construction for those who engage in it. The BTC is almost not bought by the people of the city. According to our investigations in the company, it is sold in Brazzaville and Pointe-Noire (1st and 2nd cities) and especially in two cities Sibiti and Madingou where took place the accelerated municipalizations and independence celebrations in 2015 and 2017. On the other hand, construction with the cinderblock is taking place, even timidly, because certain populations say that the house is more solid, resistant and more comfortable in spite of a higher expenditure. These are also, according to our investigations, prestigious expenses compared to the brick-built construction. The selling prices of both the cinder block and the compressed earth brick do not satisfy the majority of respondents. As shown in Table II, this reflects the reality of practices in the city.

Table II: Opinions related to the price of different types of bricks

Les types de briques Les avis	Briques cuites	Briques de terre comprimée	Parpaings
Satisfaits	100	00	06
Moins satisfaits	00	00	94
Pas satisfaits	00	100	00

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Total	**100**	**100**	**100**

Source: Personal Investigations, September 2018.

All respondents are satisfied and unanimous that the baked brick is the cheapest and that the price of the BTC is too high hence their dissatisfaction. On the other hand, 06 respondents prefer the construction in cinderblock for reasons mentioned well before they recognize the advantages of the cooked brick. For 94 respondents, the block is as expensive as the BTC and they are not satisfied so far.

Despite these advantages mentioned for those who opt for the use of baked brick, there are unfortunately many drawbacks, even negative impacts in the sites of their production intra-urban and peripheral.

3.1.2 Negative impacts of cooked brick production on the environment

In Dolisie, the production of baked brick causes a lot of problems.

Compromise of spatial growth and problems of intra-urban and peripheral mobility and insecurity

Brick production sites are located in central, peri-central, peripheral and out-of-town areas.

In Gaia, a central district, there are two brick production sites where crevasses have disrupted people's lives and mobility. The streets become impassable especially during the rainy season, because the crevasses are flooded and also cause flooding plots, surroundings of which some are now abandoned. More than 5 children have already drowned, according to our field surveys. These sites become wild garbage dumps and mosquito breeding sites, vectors of malaria, an endemic disease in the Republic of Congo (Photos 1 and 2).

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Photo 1: Gaïa 2 cooked brick manufacturing site transformed a lake reducing mobility in the neighbourhood (Photo MAYIMA, September 2017).

Photo 2: Fabrication site of Gaia 1 cooked bricks and wild garbage dumps

(Cliché Ditengo, September 2018).

▪ In Mboukou, a peri-central district, there are two brick production sites where crevasses cause the same misdeeds described previously. One of the sites, Mboukou 1, being a marshy area, is permanently flooded as shown in photo n ° 3.

Photo 3: Manufacturing site of cooked bricks Mboukou 1

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(Cliché Ditengo, September 2018).

▪ In Manganzi, a peripheral neighborhood, spatial growth is compromised as dwellings are within 100m of the brick production sites. The crevasses are the most spectacular by their extent; the depth and height exceeding 2m at the Manganzi 1 site, because large quantities of soil were removed (see photo 3). Photo 4 is of the site Manganzi 2 with sun-dried raw bricks before cooking and a kiln of 10.000 bricks.

Photos 3 and 4: Manganzi 1 and 2 brick making sites (Photo MAYIMA, September 2018).

These different sites pose not only problems of intra-urban mobility, but also growing insecurity at night especially. Sanitation issues are important. The frantic growth of the city will certainly "span" these sites on the periphery especially that the authorities do not have the control of the urban land managed by the landowners. The Urban Master Plan (PDU) became obsolete, because elaborated in 1980, had to be updated since the year 2000, but nothing is done until today. It is a visual urbanism that does not take into account or rely on any operational urban planning document while urban planning is used to think the city (Baud et al, 2012, p.568). The urgency imposes the intervention of the public authorities in order to solve these various problems which arise with acuity.

Extinction of trees and pollution of air and soil

During our surveys, we learned from the brickmakers that there are species of fruit trees and savannah type, or even forest they seek because of their potential or energy capabilities to properly cook the brick.

▪ Exaggerated cut of fruit trees, even extinction

For the fruit trees, there are the mango, the avocado and the safoutier which, nowadays, are prized by the brickmakers, because they maintain the flame, especially the embers for days when the bricks are fired. Natural orchards of mango trees north-west of the town at Tsatou Meya, along the railway and southeast of Manganzi at Buku dia NGOUABOU (photo 5), have been decimated. At this point, there remains a flap of about 10 mango trees while this orchard was spread over more than 3ha. Today, the brick makers attack the fruit trees planted in the plots they buy between 5,000 francs and 15,000 francs depending on the diameter of the trunk and the size of the tree (photo 6). This is a recent phenomenon of the 2000s, because before that, the brickmakers bought pieces of logs or recovered wood waste from SOCOBOIS, a logging company that owned a large sawmill. These devastating practices do not appeal to the urban authorities of both the Town Hall and the departmental directorates of agriculture and forestry. However, according to the regulation in force, no fruit tree or not, in an urban space, can not be cut without authorization of the competent structures.

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Photo 5: Flail of the natural orchard Buku dia NGOUABOU (Cliché Ditengo, September 2018).

Photo 6: Mango tree sold at 10,000 FCFA at Mboukou district

(Cliché Ditengo, September 2018).

▪ Extinction of the species imenocardia acida

These are shrubs that are often found in the savannahs of the Republic of Congo. According to the brick makers, these trees with robust trunk, resembling ironwood and thick bark, have the same energy characteristics as mango, avocado and safoutiers. These trees are now becoming scarce around the city (see photo 7); to find a large quantity, it is necessary to take the national

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road No. 4, commonly known as the Kimongo Road, which reaches the city to the Southeast. To cook the bricks correctly, according to our surveys, and this also depends on the size or the capacity of the furnaces, it takes 4 vehicles of brand Dumps, when it comes to furnaces of 15.000 bricks, most built. It will take more for furnaces of 20,000, 30,000 and 45,000 bricks that we also find. If the bricks do not cook because it happens sometimes, we must resume by increasing the amount of wood. It is estimated that about 100 active brick makers, who in September before the arrival of the rains, are looking for imenocardia acida to cook their bricks whose manufacture begins in May-June, at the end of the rainy season. From these practices we can see the negative impacts on vegetation, because we know the beneficial effects of vegetation on photosynthesis. We can also talk about deforestation especially that some brickmakers use some forest trees around the city.

Photo 7: Extinction of imenocardia acida in savannah near brick making sites

(Cliché Ditengo, September 2018).

Air and soil pollution

The cooking of bricks gives off smoke, therefore emissions of carbon dioxide or CO2, greenhouse gases. This smoke constitutes an incontestable pollution of the air which impedes the breathing and the sight of the neighboring populations, because the furnaces are lit and cooled during days. This feeling is perceptible in all intra and suburban sites such as Gaia, Mboukou and

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Manganzi where we investigated. It is certain that the heat stored in the soil impoverishes it by destroying biodiversity.

Geomorphological effects

These spaces that become dangerous because of these large holes are huge losses in the earth. Table III shows the extent of the different sites and the amount of soil removed.

Table III: Empty volume and loss of soil caused by activity in the town of Dolisie

Sites de fabrication des briques	Rayon (r) en m	Superficie	Hauteur (m)	Volume (m^3)	DA (en g/cm^3)	Perte en terre (t)
GAYA1	26		1	2122,6	1,6	3396,2
GAYA2	24		1	1808,6	1,5	2712,9
MBOUKOU 1	17		1,9	1724,2	1,4	2413,9
MBOUKOU 2	19		1,9	2153,7	1,6	3445,9
MANGANZI 1	20		2	2512	1,5	3768
MANGANZI 2	19		1,2	1360,2	1,7	2312,3
LOUBOMO	19		1	1133,5	1,3	1473,6

Source: Field measurements

The walls of these crevasses lead to collapse during the rainy season, favoring major ravines that evolve through regressive erosion. The losses in soil are large and vary between 1473.6 and 3445.9 tons.According to the areas of Table III in m², the site Gaia 1 represents 15 parcels, because in Dolisie a residential area is 400 m² since colonization; Gaia 2 is equivalent to 6 plots. As for Manganzi 1 and 2, these sites constitute respectively 5 and 3 parcels.

Fig. 2 makes it possible to locate the geolocation of the brick-making sites we visited in Dolisie, knowing that there are other sites outside the city, such as Loubomo. The names of these sites are those listed in Table III.

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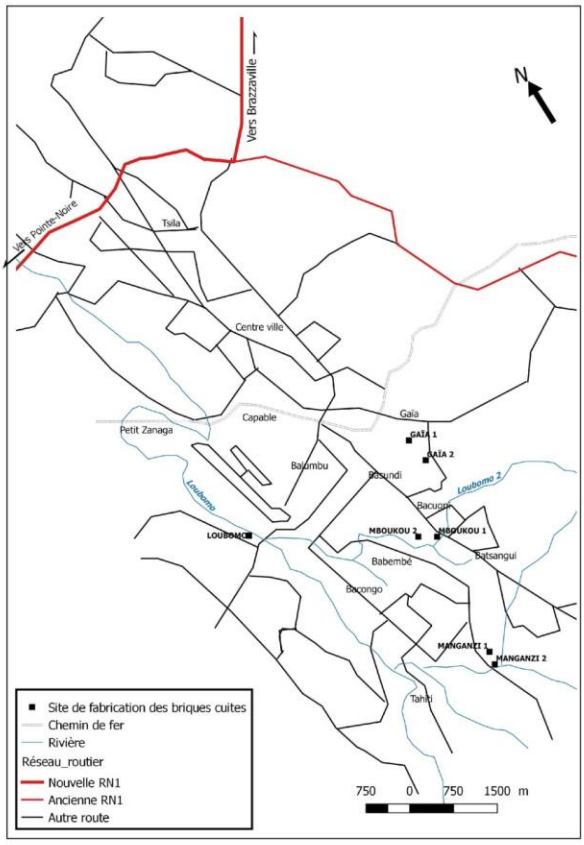

Fig.2: Spatialization of various sites for the production of cooked bricks

We have just amply detailed the harmful effects of the production of bricks cooked on the environment compromising sustainable development in Dolisie. It is then necessary to take appropriate solutions in order to curb these negative impacts resulting from this activity. This is not only happening in Dolisie, but also elsewhere in the world and several writers have talked about it through abundant literature.

3.2 Discussion

There are many articles and memoirs that evoke not only the production of fired brick, but also that of raw brick and compressed clay brick (BTC) whose raw material is clay or kaolinite. pinning the positive and negative effects of this activity.

Some authors skip the ecological effects of clay brick, fired, raw and compressed, because homes built with this material have advantages in insulation and sealing capabilities, indoor humidity and aesthetics (Jegousse 2017, p.2 and Monomur 2010, p.4). For the Belgian

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Federation of Bricks (2010, p.1) even after firing, the brick retains a certain porosity that distinguishes it from other building materials. As for the partner investors (2015, p.1), it is recognized that the fired brick, apart from the thermal and sound insulation, has a very long life, because it is flammable and almost indestructible like the other materials built in Earth.

Despite these positive impacts, the production of baked brick has many disadvantages.

About geomorphological effects

According to CTCN (2017, p.6), the cracks caused by the removal of land constitute a destruction of the space and the damage is important, because the banks and the beds of the rivers in Guinea are destroyed because of the production of the cooked brick. We have identified these large crevasses at all brick-making sites in Dolisie. The values of soil lost as a result of this activity are considerable and comparable to those found by A.B. Mayima (2016, p.115) on the coastal plateaus.

In Quebec, IRSST (2000, p.1) notes that the production of bricks creates significant excavations, the collapse of the walls even causing accidents or even deaths of workers. These are the same collapses we see in Dolisie. Apsam (2002, p.1) points in the same direction by indicating that there is a risk of landslide, because the slopes of the walls of the trench or excavation are greater than the angle of repose of the ground. In Dolisie too, these brick production sites suffer from erosion effects.

Babumukama (2010, p.1) also notes the disadvantage related to the excavations found at Dolisie. He points out that, when you go to places where you make baked bricks, you have big ditches that you do not know how they will be clogged up. These sometimes cause collapses if the excavated plot is sloping and this also constitutes soil infertility. All these facts are also seen on the brick production sites in Dolisie.

Destruction of the plant cover

Mahamba (2017, pp.1-2) acknowledges that 10 hectares of forest disappear each year, solely because of the brick-firing activities at BUKAVU. He said that to produce 10,000 bricks, manufacturers use 5 wood steres; which equates to 20 young trees. As the monthly production is 100,000 bricks, 50 wood blocks are used, ie 200 trees covering 10 hectares of forest. We find that the damage is very significant. This deforestation accentuates the emission of greenhouse gases in the provinces of BUKAVU.

CTCN (2017, p.7) also discusses the destruction of vegetation due to the production of fired bricks, noting that "the degradation of vegetative cover on banks is usually due to profitability, because farmers are forced to exploit wood resources available near quarries.It estimates the amount of wood for brick firing at 21m3 per 10,000 bricks, or 1,627,500 m3 per year in the overall area of intervention of the program ".

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Pinchemel (2002, p.333) show that, when intensification of harvesting exceeds a certain threshold, overexploitation temporarily or permanently impairs the recovery of resources. Some environments are especially fragile. In this context, Derruau (2012, p.36) adds that deforestation disrupts the water cycle by destabilizing the equilibrium between evaporation, infiltration and runoff, because it disturbs the moisture reserve.

Kahozi (2014, p. 15) points out that, for the firing of bricks, whole logs of wood are slipped into the mouths of fire where a large amount of embers are carefully stored.

Waiengnier (1989, p.1), meanwhile, points out that in the country in the process of deforestation, the manufacturers of fired bricks use a large amount of wood. To control the cutting of trees, it is now subject to official authorization. Talinabupato Lumila (2006, p.5) points out that brickmakers in Kisangani in the Democratic Republic of Congo are making choices on types of high-energy trees such as: Musanga ceriopioides, Macaranga spinosa, Uapaca guinensis, Rycnanthus angolensis, etc.

This problem of tree extinction also has negative effects on vegetation such as Dolisie.

Pollution of the air, soil and soil dest

Several authors have pointed out that oven fires burn for days, thus producing smoke and white vapors that also escape during all this time proving the firing of bricks (Kahozi 2014, p.15 and Waiengnier 1989, p.3). . According to the Global Environment Facility (GEF 2012, p.18), annual carbon emissions from the production of fired bricks would be in the order of 3 million tonnes. Mahamba (2017, p.2) also notes that kiln fires consume living microorganisms on land and under the earth. As for Geoscop (2014, p.11), it is emphasized that the exploitation of the land to produce the fired brick will lead to the gradual disappearance of about 2.2 hectares of agricultural land.

An energy-consuming activity

The production of fired brick and compressed earth brick requires a large amount of energy. That's why we use so much wood producing a large amount of energy in developing countries and in Western countries, electric furnaces are heated to more than 1,000 ° C. According to the GEF (2012, p.18), Bangladesh produces 12 billion bricks annually. Hence the massive and inefficient consumption of coal and biomass in brick kilns. This manufacturing is the first stationary source of local air pollution and GHG emissions. According to the Belgian Federation of Bricks (2010, p.6), the actual baking of bricks is done at a temperature ranging from 1,000 ° C to 1,200 ° C.

Negative impacts on the environment in many parts of the world, as we have mentioned, are well established. They are proven and corrective action must be taken. For that, we have some suggestions to make.

4 SUGGESTIONS

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To stem the devastating effects of the production of bricks fired at Dolisie, some actions are needed. Despite the absence of an adequate urban policy, since the master plan of urban planning (PDU) of 1980 has become obsolete. It is then necessary to adopt appropriate and salutary measures. We suggest some important actions that must be made by the municipal and departmental authorities:

It is imperative to prohibit the production of raw bricks and baked both in central districts (Gaia), peri-central (MBoukou) and peripheral (Manganzi) and outside the urban perimeter (Loubomo River). These sites must then be closed and the authorities must have talks with the landowners to make available a large space away from the city, thanks to the brickmakers;

- The municipal authorities will work to put in place a plan of development of the excavated areas to make them fit for human occupation, saying to all activities. In Belgium and Guinea, it is proposed to develop these brickyard sites into natural, agricultural and recreational areas (Belgian Brick Federation 2010, p.2 and CTCN 2017, p.4). This reconversion will be an added value if it relies on the concertation of all the actors (administrations and populations);

Tree cutting should be regulated and the application of existing regulations should be a rigorous practice to prevent the extinction of certain species and the degradation of vegetation;

The municipal authorities, in collaboration with the departmental directorate of forest economics, would endeavor to encourage silviculture to protect the vegetation and to have wood available. According to the departmental director of the forest economy, there are many forest trees with high energy capacity that could be offered to brickmakers;

Municipal authorities should think about the framing and conversion of brickmakers to produce the compressed clay brick (BTC) or stabilized whose production does not require wood. We take as an example the reconversion program of brick manufacturers in the Republic of Guinea with the CTCN (Climate Technology Center and Network) since 2017. Similar projects are also carried out in China, Vietnam and Bangladesh. by the Global Environment Facility (GEF) since 2012;

The problem of the price and the material of the compressed earth brick could be solved from the projects which will be put in place. The people stick to the cooked brick because it costs less, 25 to 50 francs. The competent structures (public and private, NGO for example) can group the brickmakers into cooperatives in order to obtain financial aid for equipment and training to produce the compressed clay brick using less water and no wood.

These suggestions make it possible to show our interest in this very worrying issue.

5.CONCLUSION

Cooked brick, it is recognized, is a durable and adequate building material, but its production has many negative consequences. In Dolisie, as elsewhere in the world, in one way or another, the production of fired brick negatively impacts the environment and compromises the sustainable

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development of space. Improvements are imperative to not weaken the spatial growth of this city that is already facing several challenges as the city is called to grow more, by the standards. The authorities must tackle this problem head on to help the successful conversion of brickmakers if people want to perpetuate the use of brick or red brick in construction. Private structures, in this case NGOs, should not remain on the sidelines of safeguarding this activity and the city. In this context, BABUMUKAMA (2010, p.1) adds that "the competent authorities are the first to manage this activity which builds on one side and destroys another. The manufacture of the baked brick is considered as a knife double-edged ".

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