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Socioeconomic impacts of sand harvesting along the Sanaga River in Nkol'Ossananga locality (Yaoundé-Cameroon): a vision toward a mechanized operation for sustainable exploitation

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Abstract

This paper presents the impacts of Nkol'Ossananga sand harvesting on social live and local economy based on field investigations and data analysis. Laboratory analysis of sand samples from the site has shown that the cleanliness of the Nkol'Ossananga sand nears 100%. This means that Nkol'Ossananga sand is pure and clean, most appropriate for house constructions and building engineering. The activity produces incomes to all actors of the chain value and government. Incomes generated are used by artisans to build their houses, buy some electronic devices, and take care of their families or to capitalize in their business investigation. In spite of the positive impacts presumed, Nkol'Ossananga sand harvesting also stands as the origin of many negative impacts including cultural brewing, delinquency, precocious abandon of studies and abandon of agriculture. The exploitation is done with rudimentary tools and poor technics thereby exposing artisans to several risks and illnesses. For sustainable exploitation, a mechanized operation has to be implemented. This kind of exploitation is the one that will improve the working conditions, increase production and incomes of workers as similar as that of government, and also reduces negative environmental impacts.

Key words: Nkol'Ossananga sand, rudimentary tools and poor technics, incomes, negative impacts, sustainable exploitation, mechanized operation.

Résumé:

Cet article présente les impacts sociaux et économiques de l'exploitation artisanale du sable de Nkol'Ossananga sur la base d'enquêtes de terrain et d'analyses de données. L'analyse en laboratoire des échantillons de sable collectés sur le site a montré que la propreté du sable de Nkol'Ossananga 100%. Ce qui signifie que le sable de Nkol'Ossananga est pur et propre, approprié pour les bâtiments des travaux publics et le génie civil. L'activité génère des revenus importantes à tous les acteurs de la chaîne de production et le gouvernement. Les revenus générés sont utilisés par les artisans pour se faire construire leur maison d'habitation, acheter des appareils électroniques, prendre soin de leur famille ou alors sont capitalisés dans le commerce. Malgré les impacts positifs susmentionnés, l'exploitation artisanale du sable de Nkol'Ossananga est également source de nombreux dangers, notamment le brassage culturel, la délinquance juvénile, l'abandon précoce des études et l'abandon de l'agriculture. L'exploitation se fait avec des outils rudimentaires et des techniques archaïques, exposant ainsi les artisans à plusieurs risques et maladies. Pour une exploitation durable, l'exploitation semi-mécanisée est envisageable. Ce type d'exploitation est celui qui pourra améliorer les conditions de travail des artisans, augmenter leur production et leurs revenus au même titre que ceux du gouvernement, et réduira par ricochet les impacts environnementaux.

Mots-clés: Sable de Nkol'Ossananga, outils rudimentaires et des techniques archaïques, revenus, impacts négatifs, exploitation durable, exploitation semi-mécanisée.

1. Introduction

The exploitation of construction materials has been developed since 5,000 years before [Hooke, 2000]. In many African countries, this exploitation is often based on archaic methods and rudimentary tools, and concerns sand, gravels and massive rocks. After the industrialization, sand is henceforth used in manufacturing industry such as abrasive and in several other industries like textile, glass, mirror and lasers industry. This material also found its applications in building, public works and pulverization industry.

Because of its wide use, the demand grows while one attends the natural resource weariness in alluvial deposits of sands. In order to meet up with the demand, one turns toward the exploitation of substitution resources, notably the marine sand. The discovery of reinforced concrete, the crescent used material in houses building because of its technical performances and its relatively low cost, compared to that of stones, stands as the major

reason that explain double [Langer and Glanzman, 1993], or even triple growth of sand demand in developing countries such as Cameroon.

Sand mining is of immense importance to the African economy [Manga et al., 2013]. More generally, the practice of natural resource extraction is a global phenomenon which involves income streams along all strata of the value chain, from the extraction to haulage and end users. The activity enhances local economy [Muiruri and Meshack, 2017], no matter the remarkable negative issues which disturb the functionality of the ecosystem [Langer, 2003].

The Sanaga River is a stream of 918 km long and 20 m deep and reaching about 130 000 km²[Debreuil et al., 1975] Despites some adversative environmental consequences presented in detail by [Ekengoue et al., 2018], Nkol'Ossananga Sand harvesting activity is a source of certain social and economic impacts on the local community and the government.

The goal of this paper is to present social impacts and economic profitabilities of the Sanaga River sand harvesting, at Nkol'Ossananga locality. Presence of such information will help draw the attention of investors toward a mechanized operation for sustainable exploitation as proposed in annex 1 for example. Prior to address this aspect in this study, the proposed site construction model has taken into account the proposed site organization established by [Ekengoue et al., 2018] in the same study area, no matter some modifications due to environmental impacts which can be generated. For more information concerning the study area, readers should refer to [Ekengoue et al., 2018].

2. Material and method

2.1. Sampling technique

On the field, a detail field survey was carried out using Global Positioning System (GPS) in order to design a practical model for a mechanized exploitation of Sanaga sand at Nkol'Ossananga. For the localization of the exploitation site, it is mentioned elsewhere in this paper that readers should refer to [Ekengoue et al., 2018]. To get great insight on social and economic impacts of sand mining activity at Nkol'Ossananga, structured questionnaire were used to conduct interviews on the miners, community members and government employee and observations were recorded. These include various types of materials (sand) extracted, techniques and technologies employed and changes in the physical environment of the locality (buildings, life mode, and so on).

2.2. Sample collection and analysis

Samples of sand were collected for analysis to determine some physical properties of Nkol'Ossananga sand, including particle size analysis, sand equivalent and absolute and apparent volumetric mass. 5kg of fresh sand was collected on the site and were equitably divided into 5 parts of 1kg each for various analysis. Among those parts, two focused on cleanliness and equivalent sand were not dried before used in analysis; while others were previously dried before being involved into analysis. The analysis where conducted in the *Sol Solution Afrique Centrale* Laboratory.

Particle size analysis: the aim of this analysis is to find out the distribution of grains according to their size percentage. Theoretically, the cumulative percentages (%Cu) of rejection from each sieve are obtained by eqn (1) below. In eqn (1), the quantities M and M_t represent the cumulative mass of rejection at the corresponding sieve and the total mass of refusals respectively.

$$\%Cu = \frac{M}{M_t} \times 100 \quad (1).$$

Sand equivalent: this fine aggregate characterization is investigated to determine the cleanliness of sand samples. The test was carried out according to the ASTM D2419 principle. The sample is shaken in a clear graduated cylinder containing a solution of flocculants and preservative. After shaking, the particles are allowed to settle for some twenty minutes. The SE value is taken as the ratio of the height of the sand column to the height of the sand and flocculated clay multiplied by one hundred. Thus, higher percentage indicates lower amount of clay.

Sand apparent volumetric mass: this test is governed by NFP 18-554 norm and is defined as the mass of the unit of apparent volume of the body [eqn (2)]. That is, the volume formed by the matter of the body and the voids it contains.

$$\rho'_s = \frac{M}{V} \quad (2).$$

Sand absolute volumetric mass: this test is governed by the NFP 94-053 norm and is defined as the mass by unit of volume of the material constituting the aggregate without taking into account the voids that may result between grains. The formula used is given by

eqn (3) below. There, M is the material mass and V_2 (V_1) the volume of the material (volume of voids).

$$\rho_s = \frac{M}{V_2 - V_1} \quad (3).$$

3. Results and discussions

Result due to laboratory analysis of our samples at the *Sol Solution Afrique Central* laboratory is indicated in Table I below. The table well indicates that $SE \phi 90\%$. Results of particle size analysis (as shown in Figure 1) demonstrates that, the major part of Nkol'Ossananga sand consists of grains larger than 2mm, while only a few part consist of particles up to or greater than 0.063mm. Furthermore, Nkol'Ossananga sand is thin and dense and possesses some coarse particles, with nearly low porosity. Accordingly, the requirement of the latest European standard, [EN ISO 14688-2, 2004] has established that pure sand includes sand, where larger than 2mm particles compose up to 20% and smaller than 0.063mm particles compose up to 15% of total mass [Dundulis et al., 2010]. Summarizing presented particularities of Nkol'Ossananga sand and recommendations of [BAD, 2014], it may be stated that in particular, Nkol'Ossananga sand is pure and clean sand, most appropriate for house constructions and building engineering.

The yearly production of sand in Nkol'Ossananga evolves in an increasing way in time (Figure 2). This is the consequence for the growth of demand proceeding from the fact that Nkol'Ossananga sand is clean sand, well adapted for house and other engineering constructions. This result has been firstly demonstrated by [Manga et al., 2013] who have clearly shown that in Cameroon, building constructions, particularly those in the urban centers, exert the greatest demand on sand and particularly river channel deposits. In the same way, [Ayenagbo et al., 2011] stated that the phenomenon of urban sprawl has increased the demand of sand further. In central region of Cameroon, people prefer Sanaga sand, no matter the distance and the cost, because of its quality and affordable rates creating competition with other exploited type of sand. This explains the up-growing of Sanaga sand demand.

In contrast to the result obtained by [Tieguhong et al., 2009] for other types of mineral resources exploitation, Nkol'Ossananga sand harvesting activity is hierarchically well organized and this organization is well presented by [Ekengoue et al., 2018]. The

Nkol'Ossananga sand harvesting is made in three major steps: extraction, storage or heaping and merchandizing [Ekengoue et al., 2018]. Each of these steps of activity generates incomes to artisans involved. Here, in other to present additional incomes generated by the activity to local community and government, attention is focused on merchandizing. No matter this step of activity has been also revealed by [Ekengoue et al., 2018], some aspects due to merchandizing out of the site have not been revealed. Merchandizing of Nkol'Ossananga sand consists of the sale on the site (Figure. 3a) and that out of the site (Figure 3b), the whole being bound by the distribution channel. The sale on the site joints two groups of individuals: the truck drivers and the loaders.

Loading is an activity made by eight loaders who generally stay about very closely, among four of every side of the truck. Loading of a truck is paid XAF 5,000 FCFA by the driver (buyer) [Ekengoue et al., 2018]. Merchandising out of the site involves two groups of artisans: truck-drivers and users. Lastly is the group that corresponds to different peoples to whom sand is delivered by truck-drivers. They are construction companies, civil engineering technicians and, private or public person. The transportation of sand in the Nkol'Ossananga locality from the extraction site to outlets secondary retail, like elsewhere in the central region of Cameroon, uses trucks. This activity is under the supervision of a controller assigned to collect from the chiefs of station a sum of XAF 3,000 FCFA considered as capital gains tax or sales tax. These expenses at the end of day are returned to the accountant assigned to value his boss's daily incomes: the owner of the exploitation site.

The potentialities offered by the artisanal sand harvesting constitute the favorable assets that must cause a large involvement of the government and local collectivities for more lasting activities. Data investigation analysis showed that Nkol'Ossananga sand harvesting has a considerable positive contribution to both national and local level, as well as domestic, no matter the high risks due to the exploitation to which artisans are exposed. In general, sand as a resource is of great socioeconomic value.

Exploitation of Sanaga sand generates some incomes to the national level in different phases that constitute the activity, which are exploration, exploitation and commercialization. In the first two cases, the competent administration collects revenue due to the concession of prospector's card and business license respectively. Otherwise, Nkol'Ossananga sand commercialization activity generates an amount of XAF 3,000 FCFA by truck of elated sand from the site to the secondary selling places in the township of Nkol'Ossananga as local taxes.

This represents a sum of XAF 40,290,000 FCFA, for the only year 2014, considering data collected from the Obala weighbridge. Besides, other incomes that benefit more or less the government through the artisanal harvesting of Nkol'Ossananga sand are road toll gate and police taxes.

Anyway, the amount of XAF 500 FCFA is paid twice at the toll gate. Investigations opened to the dealers and essentially the truck drivers reveal that the prices for a truck of Sanaga sand in general vary on the market depending on the season. Therefore, they vary between XAF 165,000 FCFA and 230,000 FCFA for corresponding values of XAF 45,000 FCFA and XAF 80,000 FCFA, between dry and rainy season respectively. This represents an increase in of margin of XAF 15,000 FCFA for the dealers per day, for a total of XAF 450,000 FCFA per month. In addition to the aforesaid incomes that the artisanal sand harvesting generates to artisans, this activity has several other impacts, especially with regard to the occupation and the remuneration for jobless. For this purpose, [Sen and Fukuda-parr, 1989] estimated that unemployment for people can generate both deterioration in their living standards and dependence on other people and loss of their autonomy as well as security. Indeed, Nkol'Ossananga sand exploitation activity improves the standard of life for artisans considerably. With the incomes that it provides, one attends new houses constructions, often equipped with electronic devices and other needs such as televisions, computers, smart phones, and motorcycles to cite a few. Others use their incomes in their business ventures or in their children schooling fees.

An estimation of artisan's incomes for a period of five years is presented in figure 4. From the figure, it becomes evident that Nkol'Ossananga sand harvesting is more profitable to government than artisans who carry out the activity, and who are exposed to various risks which could lead to death. These revenues generated by the townships like local taxes at the end of five years of exploitation, correspond to three times the necessary budget needed for the Nkol'Ossananga sand exploitation to jump from ground state (artisanal harvesting) to the first level state (semi-mechanized exploitation). Apart from the impacts previously listed, one attends on the site to the development of the economic activity by the neighboring populations, essentially the merchandising of current consumption products also mentioned by [Razack, 2012] for gold exploitation sites (bread, palm wine, alcoholic drink, meat, etc.). Even clothes are commercialized in the site. Finally, sand harvesting at Nkol'Ossananga do not only constitute an efficient means of struggle against poverty, but also a source of income.

Globally, this activity can have enough geographical impacts coupled with the fact that the storekeepers sometimes get a stock in the distant villages and cities.

Among this wide range of contribution to the improvement of peoples live and as well as growth of government finances, Nkol'Ossananga sand harvesting also stands as the origin of many negative impacts including demographic growth of the population which stands as the factor of the social imbalance. Nkol'Ossananga locality didn't escape the transfer of the populations from their area to Nkol'Ossananga locality where sand exploitation is made. One attends then to a cultural brewing capable to succeed to a new system of cultural values. Yet, a village or a community is endowed with a particular tradition characterized by beliefs, ideologies and considerations clean to the inhabitants. Transformation of Nkol'Ossananga locality in a regrouping point of several cultures, ideologies and behaviors has as direct consequence, the new life style installation. This is how one attends to the development of prostitution, delinquency and the consumption of narcotic drugs (alcohol, cigarette and tramadol). For certain artisans, the artisanal sand harvesting activity in general, is considered like a "trap to poverty ", in spite of its potential effect for creation of employment.

In contrast to some artisans, others are not capitalizing on their incomes. They spend it in prostitution and alcohol, sometimes ending up getting into debt, mostly in the rainy season when the Nkol'Ossananga sand harvesting activity idled. Data analysis shows that Nkol'Ossananga sand harvesting involves both genders. Although the total activity of Sanaga sand exploitation is handled by men, women are involved most for food merchandizing. Nkol'Ossananga artisans form a young population. 25% of the population is less provided with schooling. This value is because students abandon their studies very earlier to the profit of sand harvesting in the Sanaga River. The abandon of studies is also the consequence of lack of school infrastructures in the locality. Sanaga sand harvesting possesses negative impacts on education of pupils in primary school in Nkol'Ossananga locality, since major part of those student are involved in sand harvesting activities during school hours. Another reason for involvement of pupils in sand harvesting activities is that, pupils dropout at standard six and reach a peak at standard seven, just before they get into their final year of the primary school cycle. Another important impact induced by Nkol'Ossananga sand harvesting activities concerns abandon of agriculture. As a consequence, women are taking part in farming work just to maintain and take care of their families.

4. Conclusion and recommendation

The artisanal harvesting of Nkol'Ossananga sand in the Sanaga stream is the most practiced exploitation activity of natural resources in the Central Region of Cameroon. This activity is for many habitants of the locality their main source of income. It is an activity that has some considerable impacts on the national economy, from the incomes that it generates, but also contributes to the survival of increasingly numerous populations. Incomes earned by artisans are sometimes invested in other business, or for education as school fees for their children. With those incomes, artisans build their houses and buy electronic devices. No matter its importance either for incomes generated or for employment offered, artisanal sand harvesting remains a poor activity, which uses classical techniques and rudimentary tools. This constitutes the origin of low production. In spite of positive impacts generated by the activity of sand harvesting, it also has negative impacts.

Considering above discussions, it becomes necessary to propose another way to carry on the Nkol'Ossananga artisanal sand harvesting (annex 1). This is the type of exploitation that uses suction hopper dredger equipped with drag head as material. It is an exploitation method more effective and more efficient. It will improve the working conditions, increase production and incomes of workers as similar as that of government, and also reduces negative environmental impacts.

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Tables

Table I. Physical properties of the Sanaga sand exploited from Nkol'Ossananga site

<u>Physical properties</u>	<u>Minimal value</u>	<u>Mean value</u>	<u>Maximum value</u>
Absolute volumetric mass $\rho_s (kg / m^3)$	2560	2620	2880
Apparent volumetric mass $\rho'_s (kg / m^3)$	1425	1509	1594
Sand equivalent SE (%)	95.3	95.8	96.3
Water content W (%)	3.1	3.2	3.3

Figures

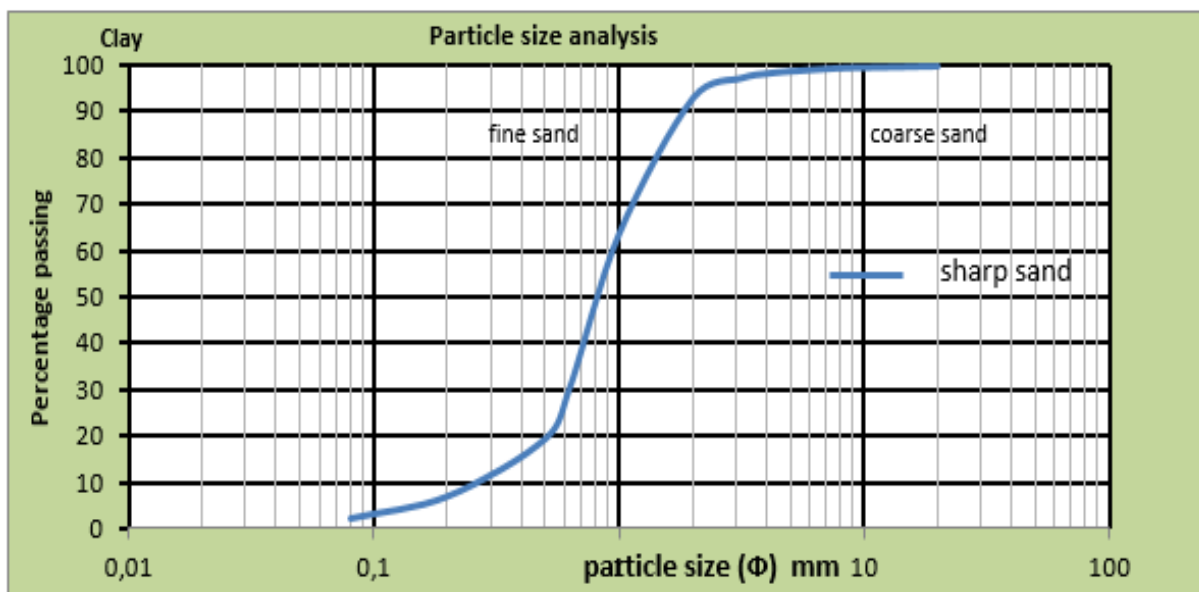


Figure 1. Sanaga River sand granulometric analysis curve.

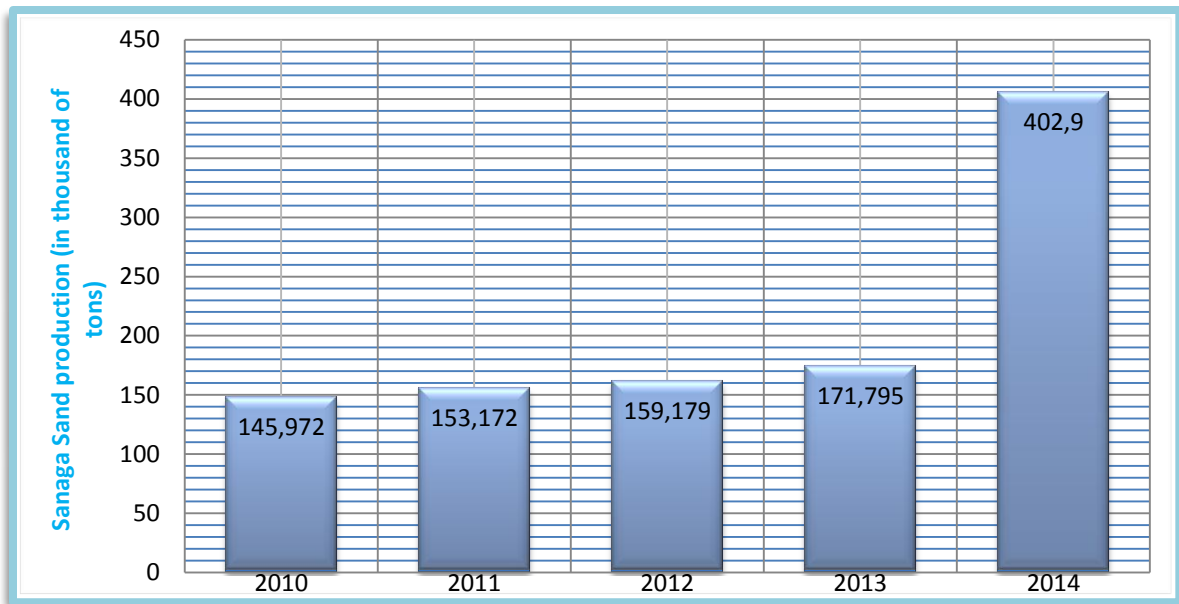


Figure 2. Evolution of the production in the artisanal sand quarry of Nkol'Ossananga. Source: Obala weighbridge, Yaoundé Cameroon.



a)



b)

Figure 3. Merchandizing of Nkol'Ossananga sand. a) Merchandizing of Nkol'Ossananga sand in the site of extraction; b) Transportation of Nkol'Ossananga sand from the site toward the secondary retail outlets.

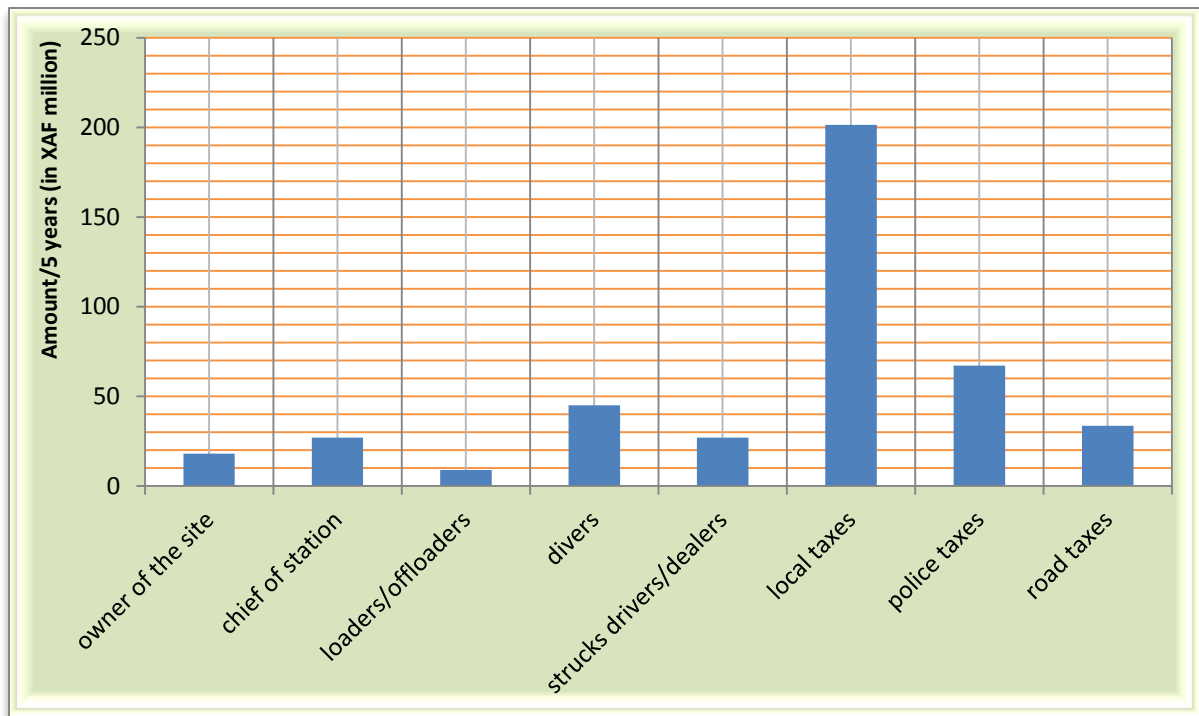


Figure 4. Evaluation of the incomes of elements of the value chain of exploitation of the sand in Nkol'Ossananga

Research Highlights

- Nkol'Ossananga sand is pure and clean, most appropriate for house constructions and building engineering;
- The artisanal harvesting of Nkol'Ossananga sand in the Sanaga stream is the most practiced exploitation activity of natural resources in the Central Region of Cameroon;
- Approximately 13,430 trucks of sand, representing 402,900 tons were exploited in the Sanaga stream at Nkol'Ossananga for the year 2014 only and demand still grow up since then;
- The Nkol'Ossananga sand harvesting is main source of income for many habitants of the locality;
- The incomes generated by the Nkol'Ossananga sand Harvesting to artisans are sometimes invested in other business or for education as school fees for their children. With those incomes, artisans build their houses and buy electronic devices;

- The Nkol'Ossananga sand Harvesting remains a poor activity, which uses classical techniques and rudimentary tools.

Annexes

Annex 1: proposed mechanized model (3D) of Nkol'Ossananga sand harvesting for sustainable exploitation.

