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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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1 **Socioeconomic impacts of sand harvesting along the Sanaga River in Nkol'Ossananga locality**  
2 **(Yaounde-Cameroon): a vision toward a mechanized operation for sustainable exploitation**  
3 **[Impacts socioéconomiques de l'exploitation artisanale du sable Sanaga dans la localité de**  
4 **Nkol'Ossananga (Yaoundé-Cameroun): une vision vers une exploitation semi-mécanisée]**

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18 **Abstract**

19 This paper presents the impacts of Nkol'Ossananga sand harvesting on social **livelife** and local  
20 economy based on field investigations and data analysis. Laboratory analysis of sand samples from the  
21 site has shown that the cleanliness of the Nkol'Ossananga sand nears 100%. This means that  
22 Nkol'Ossananga sand is pure and clean, most appropriate for house construction and building  
23 engineering. The activity produces incomes to all actors of the value chain and government. Income  
24 generated are used by **artisanscraftsmen** to build their houses, buy some electronic devices, and take

1 care of their families or to finance their business ventures. In spite of the positive impacts presumed,  
2 Nkol'Ossananga sand harvesting also stands as the origin of cultural brewing, delinquency and  
3 precocious abandon of studies. The paper there suggests that, for sustainable exploitation to be  
4 achieved, a mechanized operation has to be implemented. This kind of exploitation is the one that will  
5 improve the working conditions, increase production and income of workers as well as that of  
6 government, and also reduce negative impacts.

7 **Key words/Keywords:** Nkol'Ossananga, sand harvesting, social **live**life, incomes, mechanized  
8 operation, government.

### 9 **Résumé:**

10 Cet article présente les impacts sociaux et économiques de l'exploitation artisanale du sable de  
11 Nkol'Ossananga sur la base d'enquêtes de terrain et d'analyses de données. L'analyse en laboratoire  
12 des échantillons de sable collectés sur le site a montré que la propreté du sable de Nkol'Ossananga  
13 avoisine 100%. Ce qui signifie que le sable de Nkol'Ossananga est pur et propre, approprié pour **les**  
14 **bâtiments des travaux publics** **le BTP** et le génie civil. L'activité génère des revenus importants à tous  
15 les acteurs de la chaîne de production et le gouvernement. Les revenus générés sont utilisés par les  
16 artisans pour se faire construire leur maison d'habitation, acheter des appareils électroniques, prendre  
17 soin de leur famille ou alors sont capitalisés dans le commerce. Malgré les impacts positifs  
18 susmentionnés, l'exploitation artisanale du sable de Nkol'Ossananga est également source du brassage  
19 culturel, de la délinquance juvénile et de l'abandon précoce des études. Pour une exploitation durable,  
20 l'exploitation semi-mécanisée est envisageable. Ce type d'exploitation est celui qui pourra améliorer  
21 les conditions de travail des artisans, augmenter leur production et leurs revenus au même titre que  
22 ceux du gouvernement, et réduire **ae** par ricochet les impacts négatifs.

23 **Mots-clés:** Nkol'Ossananga, exploitation du sable, impacts sociaux, revenus, exploitation semi-  
24 mécanisée, gouvernement.

25

1 **1. Introduction**

2 The exploitation of construction materials has been developed since 5,000 years [Hooke, 2000]. In  
3 many African countries, this exploitation is often done using archaic methods and rudimentary tools,  
4 as far as sand, gravels and massive rocks are concerned. With the advent of industrialization, sand is  
5 now used in the manufacturing industry such as abrasive and several other industries like textile, glass,  
6 mirror and lasers industries. Because of its wide use, due to its relatively low cost compared to that of  
7 stones, its demand grows up exponentially and particularly in developing countries such as Cameroon  
8 (Langer and Glanzman, 1993). In order to meet up with the demand, one turns toward the exploitation  
9 of substitution resources, notably marine sand.

10 Sand mining is of immense importance to the African economy (Manga et al., 2013). More  
11 generally, the practice of natural resource extraction is a global phenomenon which involves income  
12 streams along all strata of the value chain, from the extraction to haulage and end users. The activity  
13 enhances local economy (Muiruri and Meshack, 2017), irrespective of the remarkable negative issues  
14 which disturb the functionality of the ecosystem (Langer, 2003).

15 The Sanaga River is a stream of 918 km long and 20 m deep and reaching about 130 000 km<sup>2</sup>  
16 (Debreuil et al., 1975). Nkol'Ossananga sand harvesting activity is a source of certain social and  
17 economic impacts on the local community and the government.

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

25

26 **2. Material and method**

27 **2.1. Justification of the choice of the study area and sampling technique**

1 The data used in the present study comes from a questionnaire survey conducted in  
2 Nkol'Ossananga sand harvesting site within a period of three months (from March to June). The  
3 choice of the site selected for our research resulted from the fact that almost all sand used in the  
4 Capital city (Yaounde) and neighboring towns come from the Sanaga River. On the field, a detailed  
5 field survey was carried out using Global Positioning System (GPS) for the localization of the  
6 exploitation site (Ekengoue et al., 2018). To get great insight on social and economic impacts of the  
7 sand mining activity at Nkol'Ossananga, a structured questionnaire was used to conduct interviews  
8 both on the site and out of the site. On the site, the questionnaires were given to permanent and non  
9 permanent Craftsmen of the Nkol'Ossananga sand harvesting site including dwellers, loaders and  
10 truck drivers. For instance, out of the site, staffs of the local community members and government  
11 employee such as Policemen were considered. On the field, we began with a brief identification of the  
12 prospect. The other questions asked (Annex 12) were oriented towards a double objective: to know the  
13 income generated by the artisanal sand harvesting activity to all the actors of the production chain as  
14 well as the government and to assess firstly economic and secondly social impacts of the  
15 Nkol'Ossananga sand harvesting. About 150 145 questionnaires were printed and allocated to the  
16 different actors in the production chain as shown in Table I.

17

## 18 2.2. Sample collection and analysis

19 Samples of sand were collected for analysis to determine some physical properties of  
20 Nkol'Ossananga sand, including particle size analysis, sand equivalent and absolute and apparent  
21 volumetric mass. 5kg of fresh sand was collected on the site and were equitably divided into 5 parts of  
22 1kg each for various analysis. Two parts among the above five mentioned parts focused on cleanliness  
23 and equivalent sand were not dried before used in analysis. The others three parts were previously  
24 dried before being involved into analysis. The analysis where conducted in the *Sol Solution Afrique*  
25 *Centrale* Laboratory.

1 **Particle size analysis:** the aim of this analysis was to find out the distribution of grains according to  
2 their size percentage. Theoretically, the cumulative percentages (% *Cu*) of rejection from each sieve  
3 are obtained by Eq.1 below. In Eq.1, the quantities *M* and *M<sub>t</sub>* represent the cumulative mass of  
4 rejection at the corresponding sieve and the total mass of refusals respectively.

$$5 \quad \% Cu = \frac{M}{M_t} \times 100 \quad (1).$$

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

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

$$15 \quad \rho'_s = \frac{M}{V} \quad (2).$$

16 **Sand absolute volumetric mass:** this test is governed by the NFP 94-053 norm and is  
17 defined as the mass by unit of volume of the material constituting the aggregate without  
18 taking into account the voids that may result between grains. The formula used is given by Eq.3  
19 below. There, *M* is the material mass and *V<sub>2</sub>* (*V<sub>1</sub>*) the volume of the material (volume of voids).

$$20 \quad \rho_s = \frac{M}{V_2 - V_1} \quad (3).$$

21

22

### 1 3. Results, discussions and recommendations

#### 2 3.1. Results and discussions

3 Result of laboratory analysis of our samples at the *Sol Solution Afrique Central* laboratory is  
4 indicated in Table 14 below. The table well indicates that  $SE \phi 90\%$  . Results of particle size analysis  
5 (as shown in Figure 1) demonstrates that, the major part of Nkol'Ossananga sand consists of grains  
6 larger than 2mm, while only a few part consist of particles up to or greater than 0.063mm.  
7 Furthermore, Nkol'Ossananga sand is thin and dense and possesses some coarse particles, with nearly  
8 low porosity. Accordingly, the The requirement of the latest European standard (EN ISO 14688-2,  
9 2004) has established that pure sand includes sand, where larger than 2mm particles compose up to  
10 20% and smaller than 0.063mm particles compose up to 15% of total mass (Dundulis et al.,  
11 2010). Summarizing presented particularities of Nkol'Ossananga sand and According to the above  
12 mentioned European Standard and following the recommendations of (BAD, 2014), it may be stated  
13 that in particular, Nkol'Ossananga sand is pure and clean sand, most appropriate for house  
14 constructions and building engineering.

15 In other to get the social and economic impacts of Nkol'Ossananga sand harvesting in the Sanaga  
16 River, we carried field investigation. During the field investigation phase, we faced several  
17 difficulties. First, the refusal of communication from the population surveyed. This was due to two  
18 fundamental reasons. For the craftsmen, they suspected that the investigators could be members of the  
19 government and in particular of the taxation domain who can be asking questions aimed at creating a  
20 daily tax on artisans, an amount to be paid to the government as a tax on artisanal sand harvesting in  
21 the Sanaga River. For the others, on the other hand (municipal employees, police, etc.), the survey  
22 could be a government survey assessing the quality of services provided to neighboring populations  
23 and to the government. In addition, the majority of divers were foreigners (Chadians, Congolese,  
24 Central Africans and Malians to cite a few) who had difficulty expressing themselves in French. The  
25 above mentioned raisons made investigations difficult. Another difficulty encountered during the  
26 collection of field data is the lack of time by the population surveyed. No matter the category of our  
27 sample, we noticed in the field a strong commitment of surveyed population by their activity,

1 preventing them from answering the questions which were put to them or completing the questionnaire  
2 which was given to them. As a result, only 68.92% 79.31% of the surveyed population was able to  
3 complete the questionnaire (Table II). In contrast, some questionnaires were partially fulfilled by  
4 respondents. This, as we noticed above, due to lack of time for some respondents and language  
5 (French) problems for others.

6 Data analysis has shown that the yearly production of sand in Nkol'Ossananga increases  
7 progressively. This is due to the fact that Nkol'Ossananga sand is clean sand, well adapted for house  
8 and other engineering constructions. This result has been firstly demonstrated by (Mangaet al., 2013)  
9 who have clearly shown that in Cameroon, building constructions, particularly those in the urban  
10 centers, exert the greatest demand on sand and particularly River channel deposits. In the same way,  
11 (Ayenagbo et al., 2011) stated that the phenomenon of urban sprawl has increased the demand for sand  
12 further. In the Centre Region of Cameroon, people prefer Sanaga sand, no matter the distance and the  
13 cost, because of its quality and affordable rates creating competition with other exploited types of  
14 sand. This explains the up-growing of Sanaga sand demand.

15 The potentialities offered by the artisanal sand harvesting constitute favorable assets that require  
16 active involvement of the government and local collectivities for more lasting activities. Data  
17 investigation analysis showed that Nkol'Ossananga sand harvesting has a considerable positive  
18 contribution to both national and local level, as well as domestic, no matter the high risks due to the  
19 exploitation revealed by (Ekengoue et al., 2018). Exploitation of Sanaga sand generates income at the  
20 national level at the different phases of the activity. These include exploration, exploitation and  
21 commercialization. In the first two phases, the competent administration collects revenue through the  
22 concession of prospector's card and business license. Nkol'Ossananga sand commercialization activity  
23 generates an amount of XAF 3,000 (6 \$) FCFA per truck of elated sand from the site to the secondary  
24 selling places in the township of Nkol'Ossananga as local taxes. This represents a sum of XAF  
25 40,290,000 (80,580 \$) FCFA, for a year, considering data collected from the Obala weighbridge.



1 Besides, other income sources that accrued directly or indirectly to the government as a result of  
2 artisanal harvesting of Nkol'Ossananga sand are road toll gate and police taxes. The amount of XAF  
3 500 (1\$ FCFA) is paid twice at the toll gate. Investigations opened to the dealers and essentially the  
4 truck drivers reveal that the cost of a truck of Sanaga sand in general vary in the market depending on  
5 the season. Therefore, they vary between XAF 165,000 (330 \$) FCFA and XAF 230,000 (460 \$)  
6 FCFA for corresponding values of XAF 45,000 (90 \$) FCFA and XAF 80,000 (160 \$) FCFA, between  
7 dry and rainy season respectively. This represents an increase in margin of XAF 15,000 (30 \$)  
8 FCFA for the dealers per day, for a total of XAF 450,000 (900 \$) FCFA per month. In addition to the  
9 afore said incomes that artisanal sand harvesting generates to artisans/craftsmen, this activity has  
10 several other impacts, especially with regard to the occupation and the remuneration for jobless as  
11 have been suggested by Sen and Fukuda-parr, (1989). Nkol'Ossananga sand exploitation activity  
12 improves the standard of life of artisans/craftsmen considerably. With the income that it provides, they  
13 can realize construction of new houses, often equipped with electronic devices and other needs such as  
14 televisions, computers, smart phones, and motorcycles to cite a few. Others use their income to  
15 finance their business ventures and to take care of children's school fees.

16 An estimation of artisan's incomes for a period of five years is presented in figure 2. From the  
17 figure, it becomes evident that Nkol'Ossananga sand harvesting is more profitable to government than  
18 artisans/craftsmen who carry out the activity, and who are exposed to various risks which could lead to  
19 death. These revenues generated by the activity to government such as local taxes at the end of five  
20 years of exploitation, correspond to three times the necessary budget needed for the Nkol'Ossananga  
21 sand exploitation to jump from artisanal harvesting to the semi-mechanized exploitation. On the site,  
22 we observed other economical activities developed by inhabitants of Nkol'Ossananga locality such as  
23 the merchandising of current consumption products including bread, palm wine, alcoholic drink, meat  
24 and food. This type of activity has also been mentioned by (Razack, 2012) for gold exploitation. Even  
25 clothes are commercialized in the site. Finally, sand harvesting at Nkol'Ossananga does not only  
26 constitute an efficient means of struggle against poverty, but also a source of income. The activity can

1 have enough geographical impacts coupled with the fact that the storekeepers sometimes get a stock in  
2 the distant villages and cities.

3 Informations mentioned in the questionnaires filled both by craftsmen and government  
4 members have shown that, despite its wide range positive impacts such as improvement of people's  
5 lives and contribution to government finances, Nkol'Ossananga sand harvesting also stands as the  
6 origin of many negative impacts including demographic growth of the population which stands as the  
7 factor of the social imbalance. Nkol'Ossananga locality didn't escape the transfer of the populations  
8 from their area to Nkol'Ossananga locality where sand exploitation is ~~done~~ practiced. One attends then  
9 to a cultural brewing capable to succeed to a new system of cultural values. Yet, a village or a  
10 community is endowed with a particular tradition characterized by beliefs, ideologies and  
11 considerations peculiar to the inhabitants. Transformation of Nkol'Ossananga locality in a regrouping  
12 point of several cultures, ideologies and behaviors has as direct consequence, the new life style  
13 installation. This is how one attends to the development of prostitution, delinquency and the  
14 consumption of narcotic drugs (alcohol, cigarette and tramadol). For certain artisans, the artisanal sand  
15 harvesting activity in general, is considered like a "trap to poverty ", in spite of its potential effect for  
16 creation of employment. In fact, some artisans do spend their incomes in prostitution and alcohol,  
17 sometimes ending up getting into debt, mostly in the rainy season when the Nkol'Ossananga sand  
18 harvesting activity idled. Data analysis shows that Nkol'Ossananga sand harvesting involves both  
19 genders. Although the total activity of Sanaga sand exploitation is handled by men, women are  
20 involved most for food merchandizing. Nkol'Ossananga ~~artisans~~ craftsmen constitute a young  
21 population. 25% of the population is less provided with schooling. This value is because students  
22 abandon their studies very early for the profit of sand harvesting in the Sanaga River. The  
23 abandonment of studies is also the consequence of lack of school infrastructures in the locality. Sanaga  
24 sand harvesting possesses negative impacts on education of pupils in primary school in  
25 Nkol'Ossananga locality, since major part of those student are involved in sand harvesting activities  
26 during school hours. Another important impact induced by Nkol'Ossananga sand harvesting activities

1 concerns abandonment of agriculture. As a consequence, women are taking part in farming work just  
2 to maintain and take care of their families.

3

### 4 **3.2. Recommendations**

5 Results of Nkol'Ossananga sand samples analysis at the *Sol Solution Afrique Central* laboratory  
6 indicates that Nkol'Ossananga sand is pure and clean sand, most appropriate for house constructions  
7 and building engineering. This explains the reason why the population of the Capital city of Cameroon  
8 (Yaounde) and neighboring towns are mostly interested to the Sanaga sand. The exploitation of  
9 Sanaga sand stands as origin of several positive social and economic impacts to all actors of the value  
10 chain and government. In contrast, the activity also stands as a source of many negative impacts  
11 including cultural brewing, delinquency, precocious abandon of studies, abandon of agricultural  
12 activities to cite a few. For the activity to be most profitable to both artisans and local community and  
13 government, we propose a mechanized operation for Nkol'Ossananga sand harvesting. This is the type  
14 of exploitation that uses suction hopper dredger equipped with drag head as material. It is an  
15 exploitation method more effective and more efficient. It is the operational technique that can improve  
16 the working conditions, increase production and incomes of workers as similar as that of government;  
17 ~~and also reduces negative environmental impacts.~~ The figure 3 Annex 1 depicts therefore the  
18 organization of the Nkol'Ossananga sand harvesting site based on mechanized operation.

19

### 20 **4. Conclusion**

21 The artisanal harvesting of Nkol'Ossananga sand in the Sanaga stream is the most practiced  
22 exploitation activity of natural resources in the Central Region of Cameroon. This activity constitutes  
23 the main source of income for many inhabitants of the locality. It is an activity that has some  
24 considerable impacts on the national economy, from the incomes that it generates, but also contributes  
25 to the survival of increasingly numerous populations. Incomes earned by artisans/craftsmen are

1 sometimes invested in other business or for education as school fees for their children. With such  
2 income, artisans/craftsmen build their houses and buy electronic devices. No matter its importance  
3 either for income generation or for employment offered, artisanal sand harvesting remains a poor  
4 activity, which uses classical techniques and rudimentary tools. This constitutes the origin of low  
5 production. For sustainable exploitation, we propose a mechanized operation. This kind of exploitation  
6 technique is the one which can improve the working conditions, increase production and incomes of  
7 workers as similar as that of government, and also reduces negative environmental impacts. The  
8 finding in this research work ends up with a perspective that the investment cost of the proposed  
9 mechanized operation has to be investigated in order to have a lucid idea on both the payback period  
10 and financial profitability.

11

## 12 **References**

13 K. Ayenagbo., J. Gondwe., J. Ngui-Kimatu., and W. Rongcheng(2011). The Transportation and  
14 Marketing Implications Of Sand And Gravel And Its Environmental Impact In Lome-Togo.  
15 *Journal of Economics and Internal Finance*,3, 125-138. ISSN 2006-9812.

16 BAD (Banque Africaine de Développement)(2014). Cahiers des prescriptions techniques du génie  
17 civil. Annexe 1-RFP-Travaux d'extension du siège de la BAD à Abidjan, conception et  
18 réalisation du bâtiment annexe à l'immeuble siège de la BAD Abidjan-Plateau, dossier de  
19 consultation, 232p. Consulté en ligne le 10 Mars 2021, URL :  
20 [https://www.afdb.org/fileadmin/uploads/afdb/Documents/Procurement/Corporate-](https://www.afdb.org/fileadmin/uploads/afdb/Documents/Procurement/Corporate-Procurement/Annexe%201%20-%20RFP%20-%20Travaux%20d%E2%80%99extension%20du%20Si%C3%A8ge%20de%20la%20BAD%20%C3%A0%20Abidjan.pdf)  
21 [Procurement/Annexe%201%20-%20RFP%20-](https://www.afdb.org/fileadmin/uploads/afdb/Documents/Procurement/Corporate-Procurement/Annexe%201%20-%20RFP%20-%20Travaux%20d%E2%80%99extension%20du%20Si%C3%A8ge%20de%20la%20BAD%20%C3%A0%20Abidjan.pdf)  
22 [%20Travaux%20d%E2%80%99extension%20du%20Si%C3%A8ge%20de%20la%20BAD%20](https://www.afdb.org/fileadmin/uploads/afdb/Documents/Procurement/Corporate-Procurement/Annexe%201%20-%20RFP%20-%20Travaux%20d%E2%80%99extension%20du%20Si%C3%A8ge%20de%20la%20BAD%20%C3%A0%20Abidjan.pdf)  
23 [%C3%A0%20Abidjan.pdf](https://www.afdb.org/fileadmin/uploads/afdb/Documents/Procurement/Corporate-Procurement/Annexe%201%20-%20RFP%20-%20Travaux%20d%E2%80%99extension%20du%20Si%C3%A8ge%20de%20la%20BAD%20%C3%A0%20Abidjan.pdf)

24 P. Debreuil., J. Guiscafren., J.-F. Nouvelot., J.-C. Olivry (1975). Le bassin de la rivière Sanaga.  
25 OSTORM, (X)-350p, Monographies hydrologiques, 3. ISBN 2-7099-0361-X.

- 1 K. Dundulis., S. Gadeikis., S. Gadeikytė., D. Urbaitis., L. Prunskienė (2010). Problems of usage of  
2 soil classification system for sand soils of Lithuania. *Modern building materials, structures and*  
3 *techniques*, 1099-1103. 10<sup>th</sup> International conference paper. May 19-21, 2010, Vilnius,  
4 Lithuania. URL: [https://docplayer.net/62258665-Problems-of-usage-of-soil-classification-](https://docplayer.net/62258665-Problems-of-usage-of-soil-classification-systems-for-sand-soils-of-lithuania.html)  
5 [systems-for-sand-soils-of-lithuania.html](https://docplayer.net/62258665-Problems-of-usage-of-soil-classification-systems-for-sand-soils-of-lithuania.html)
- 6 C.M. Ekengoue., R.F. Lele., A.K.Dongmo (2018).Influence de l'exploitation artisanale du sable sur la  
7 santé et la sécurité des artisans et l'environnement : cas de la carrière de Nkol'Ossananga,  
8 Région du Centre Cameroun. *European Scientific Journal*, **15**, 246-268,  
9 <http://dx.doi.org/10.19044/esj.2018.v14n15p246>
- 10 EN ISO 14688-2 (2004). Geotechnical investigation and testing-identification and classification of  
11 soil-park 2: principles for classification. Brussels. 13p. URL :  
12 <https://www.iso.org/standard/34082.html>
- 13 R. L. Hooke (2000). On the History of the Humans as Geomorphic Agents. *Geology*, **28(9)**, 843-846,  
14 10.1130/0091-7613(2000)282.0.CO;2
- 15 W. H. Langer., V. M. Glanzman (1993). Natural Aggregate, Building America Feature. *Circular 1110*.  
16 *USGS Publications*. Accessed online on 22th January 2021, URL :  
17 <https://pubs.er.usgs.gov/publication/cir1110>
- 18 W.H. Langer (2003). A General Overview Of The Technology Of In-Stream Mining Of Sand And  
19 Gravel Resources, Associated Potential Environmental Impacts, And Methods To Control  
20 Potential Impacts, USGS Open-File Report OF-02-153. Accessed on 15 February 2021, URL:
- 21 E.V. Manga., C.M. Agyingi., E.A. Djieto-Lordon (2013). In-Channel Sand Extraction In River  
22 Mungo, Cameroon: Nature Effects And Concerns. *Artificial Neural Network Modeling*, N°,   
23 10.5675/ICWRER\_2013.

1 P.G. Muiruri., O.A. Meshack(2017). Social-environmental effects of River sand mining:case study of  
 2 Ephemeral River Kivou in Kitui Country, Kenya. *IOSR Journal of Humanities and Social*  
 3 *Sciences*, **22 (11)**, 31-37, 10.9790/0837-2211103137

4 A.A. Razack (2012). Proposition pour l’optimisation de la mine artisanale au Niger. Proposals for  
 5 Optimizing Artisanal Mining in Niger. *Pangea, HAL archives*. HAL id: insu-00947881

6 A. Sen., S. Fukuda-parr (1989). Development as Capacity Expansion. *Journal of Development*  
 7 *Planning*, **19**, 41-58, 10.1007/978-1-349-21136-4\_3

8 J.C. Tieguhong., V. Igram., J. Schure (2009). Impacts of Artisanal Gold and Diamond Mining on  
 9 Livelihoods and the Environment in the Sansha Tri-national Park Landscape. *CIFOR*, Bogor,  
 10 Indonesia, <https://doi.org/10.17528/cifor/003029>

11

12 **Tables**

13 **Table I:** Distribution of questionnaires to actors in the Sanaga sand production chain for the  
 14 Nkol’Ossananga sand harvesting site.

Designations	Permanent Craftsmen	non-permanent Craftsmen	Municipal Municipality	Police checkpoint	Road toll	Total
Number surveyed	80	50	15	3	2	145

15

16

17 **Table II.** Physical propertis of the Sanaga sand exploited from Nkol’Ossananga site

Physical properties	Minimal value	Mean value	Maximum value
Absolute volumetric	2560	2620	2880

mass $\rho_s$ ( $kg / m^3$ )			
<b>Apparent volumetric</b>			
mass $\rho'_s$ ( $kg / m^3$ )	1425	1509	1594
<b>Sand equivalent SE</b>			
(%)	95.3	95.8	96.3
<b>Water content W</b>			
(%)	3.1	3.2	3.3

1

2

3 **Table III:** Distribution of survey sheets to actors in the Sanaga sand production chain for the

4 Nkol'Ossananga artisanal sand mining site.

Designations	Permanent Craftsmen	non-permanent Craftsmen	Municipal Municipality	Police checkpoint	Road toll	Total	Total (%)
Number surveyed	80	50	15	3	2	145	100
Number of responses	43,44% 68	20,68% 37	3,44% 8	0,68% 1	0,68% 1	115	79,31

5

6 **Table III:** Distribution of survey sheets to actors in the Sanaga sand production chain for the

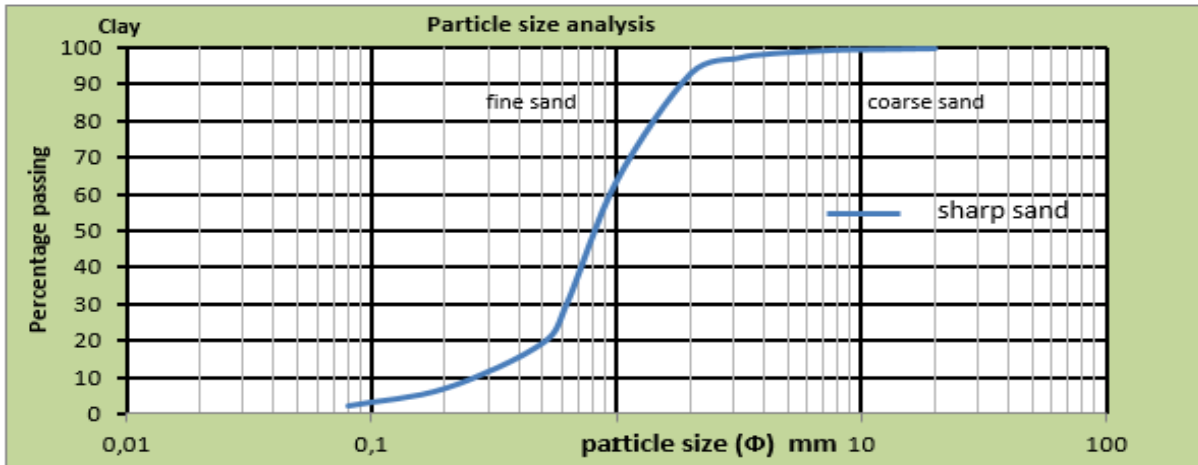
7 Nkol'Ossananga artisanal sand mining site.

Designations	Permanent Craftsmen	non-permanent Craftsmen	Municipal Municipality	Police checkpoint	Road toll	Total
Number surveyed	80	50	15	3	2	145

<b>Number of responses</b>	43,44%	20,68%	3,44%	0,68%	0,68%	68,92%
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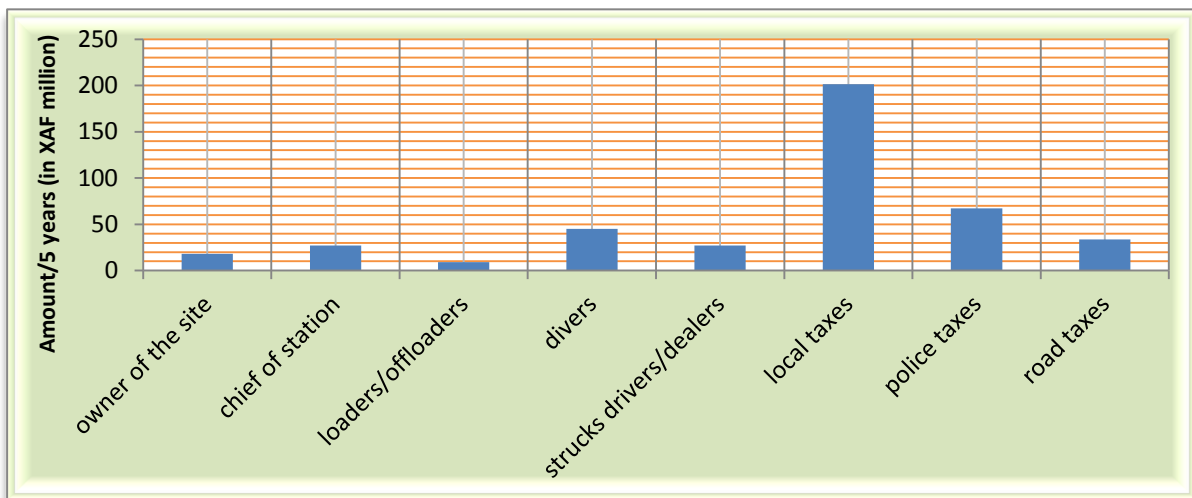
1

2 **Figures**



3

4 **Figure 1.** Sanaga River sand granulometric analysis curve.



5

6 **Figure 2.** Evaluation of the incomes of elements of the value chain of exploitation of the sand in  
 7 Nkol'Ossananga





1

2 **Figure 3: Proposed mechanized model (3D) of Nkol'Ossananga sand harvesting for sustainable**  
 3 **exploitation.**

4

5 **Research Highlights**

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

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

3

4 **Annexes**

5 **Annex 1: Proposed mechanized model (3D) of Nkol'Ossananga sand harvesting for sustainable**  
6 **exploitation.**



7

8 **Figure 3: Proposed mechanized model (3D) of Nkol'Ossananga sand harvesting for sustainable**  
9 **exploitation.**

10

11 **Annex 1 : Questionnaire**

12 **I. INFORMATION NOTE**

13 This questionnaire is a field data collection tool, produced by William Happi Tientcheu and his  
14 collaborators, Mining and Petroleum Engineer Student. It is therefore a didactic research tool,  
15 necessary for the realization of purely academic research and this within the framework of the drafting  
16 of the used in order to collect data based on Nkol'Ossananga sand harvesting activity. Data collected  
17 will be helpful in writing a Master of Engineering Sciences Degree Dissertation at the end of

1 professional training at the University of Dschang. ~~is not binding. On the other hand~~ Therefore, it is  
 2 desirable each respondent is invited to answer the various asked questions which are asked there. In  
 3 addition, each participant should be ~~sure~~ ensure that no information mentioned in the present  
 4 questionnaire ~~On the other hand, anyone investigated should be reassured that no information about~~  
 5 ~~the latter~~ will be released. Answers of each question below ~~The data entered there~~ will remain  
 6 confidential and will ~~only~~ be used for statistical purposes ~~only~~.

7

8 **II. PROSPECT IDENTIFICATION**

<b>Names(s) and surnames(s)</b>					
<b>Age</b>		<b>Gender</b>	Male	Female	
<b>Marital status</b>	<del>Célibataire</del> Single	<del>Fiancé(e)</del> Engaged	<del>Marié(e)</del> Married		
<b>Nationality</b>			<b>Level of education</b>		
<b>Function</b>	diver	Loader	Truck driver	Policeman	
	Municipal community employee			Road toll gate collector	
<b>Number of children</b>		<b>Contact(s)</b>			
<b>Email (if exist)</b>					

9 **III. QUESTIONS DIRECTED FOR CRAFTSMEN ONLY**

Do confirm your function here as craftsman in the Nkol'Ossananga sand harvesting site		
Diver <input type="checkbox"/> Loader <input type="checkbox"/> Truck driver <input type="checkbox"/>		
Have you done this task before?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Have you received training to practice your daily work in the quarry?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Do you know the mining code and its content?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
How long have you worked in sand mining?		
How many hours do you work per day?		
Do you live alone, with friends or with family?	Alone <input type="checkbox"/>	With friend <input type="checkbox"/> With family <input type="checkbox"/>

Provide your raisons why you are involved in Sanaga sand harvesting activity?

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Provide your daily, monthly and yearly incomes

Daily incomes **XAF** \_\_\_\_\_ **XAF**; Monthly incomes **XAF** \_\_\_\_\_ **XAF**;

Yearly incomes **XAF** \_\_\_\_\_ **XAF**

Provide in detail what do you do with incomes generated by the sand harvesting activity in Sanaga River at Nkol'Ossananga locality.

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Do you have additional(s) activity **(ies)**

Yes

No

If so, please to list some of them:

1.

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2.

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3.

Do you face difficulties within the activity?

Yes

No

If yes, please to list them:

1.

---

2.

---

3. _____		
4. _____		
5. _____		
Are you satisfy for your working conditions within the sand harvesting activity?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
If not, what are your proposition for the amelioration of the working condition?		
1. _____		
2. _____		
3. _____		
4. _____		

1

2 **IV. SECTION RESEVED FOR LOCAL COMMUNITY AND GOVERNMENT EMPLOYEES**

3 **ONLY**

Do you have any idea about the Nkol'Ossananga sand harvesting activity?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Do you collect any taxes to Nkol'Ossananga sand harvesting Craftsmen?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
If yes, do mention the type of taxes collected		
_____		
From who do you collect the above mentioned taxes?		
_____		
What is the amount of taxes collected?		
Share with us the total daily income (please to specified the amount depending on the category of craftsman)	1. _____	
	2. _____	
	3. _____	
	4. _____	

	5. _____	
<p>What could be the use of the money collected from Nkol'Ossananga sand harvesting Craftsmen?</p> <hr/> <hr/> <hr/>		
<p>Do the Nkol'Ossananga sand harvesting activity possesses positive impacts toward the inhabitants of Nkol'Ossananga locality?</p>	<p>Yes <input type="checkbox"/></p>	<p>No <input type="checkbox"/></p>
<p>If yes, mention some specific ones</p> <p>1. _____</p> <p>2. _____</p> <p>3. _____</p> <p>4. _____</p> <p>5. _____</p>		
<p>The Nkol'Ossananga sand harvesting activity do not possesses negative impacts in Nkol'Ossananga locality?</p>	<p>Yes <input type="checkbox"/></p>	<p>No <input type="checkbox"/></p>
<p>If you there are negative impacts due to the Nkol'Ossananga sand harvesting activity, please to provide a list</p> <p>1. _____</p> <p>2. _____</p> <p>3. _____</p> <p>4. _____</p> <p>5. _____</p>		

<p>In regard of both positive and negative impacts due to the Nkol'Ossananga sand harvesting in the Sanaga River at Nkol'Ossananga locality, do you think the possibility to think about a mechanized operation?</p>	<p>Yes <input type="checkbox"/></p>	<p>No <input type="checkbox"/></p>
<p>If no, please to give your reasons:</p> <ol style="list-style-type: none"> <li>1. _____</li> <li>2. _____</li> <li>3. _____</li> <li>4. _____</li> <li>5. _____</li> </ol>		
<p>If yes, what are your advices?</p>	<ol style="list-style-type: none"> <li>1. _____</li> <li>2. _____</li> <li>3. _____</li> <li>4. _____</li> <li>5. _____</li> </ol>	
<p>Your comment here if any</p>		