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Socioeconomic impacts of sand harvesting along the Sanaga River in Nkol'Ossananga locality (Yaounde-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 construction and building engineering. The activity produces incomes to all actors of the value chain and government. Income generated are used by artisans to build their houses, buy some electronic devices, and take care of their families or to finance their business ventures. In spite of the positive impacts presumed, Nkol'Ossananga sand harvesting also stands as the origin of cultural brewing, delinquency and precocious abandon of studies. The paper there suggests that, for sustainable exploitation to be achieved, a mechanized operation has to be implemented. This kind of exploitation is the one that will improve the working conditions, increase production and income of workers as well as that of government, and also reduce negative impacts.

Key words: Nkol'Ossananga, sand harvesting, social live, incomes, mechanized operation, government.

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 avoisine 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 importants 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 du brassage culturel, de la délinquance juvénile et de l'abandon précoce des études. 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 négatifs.

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

1. Introduction

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

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], irrespective of

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]. 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 the 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. Prior to addressing this aspect in this study, the proposed site construction model (Annex 1) 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. Justification of the choice of the study area and sampling technique

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

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. Two parts among the above five mentioned parts focused on cleanliness and equivalent sand were not dried before used in analysis. The others three parts 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 was 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 Eq.1 below. In Eq.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 (Eq.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

Eq.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, discussions and recommendations

3.1. Results and discussions

Result of laboratory analysis of our samples at the *Sol Solution Afrique Central* laboratory is indicated in Table II 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.

In other to get the social and economic impacts of Nkol'Ossananga sand harvesting in the Sanaga River, we carried field investigation. During the field investigation phase, we faced several difficulties. First, the refusal of communication from the population surveyed. This was due to two fundamental reasons. For the craftsmen, they suspected that the investigators could be members of the government and in particular of the taxation domain who can be asking questions aimed at creating a daily tax on artisans, an amount to be paid to the government as a tax on artisanal sand harvesting in the Sanaga River. For the others, on the other hand (municipal employees, police, etc.), the survey could be a government survey assessing the quality of services provided to neighboring populations and to the government. In addition, the majority of divers were foreigners (Chadians, Congolese, Central Africans and Malians to cite a few) who had difficulty expressing themselves in French. The above mentioned raisons made investigations difficult. Another difficulty encountered during the

collection of field data is the lack of time by the population surveyed. No matter the category of our sample, we noticed in the field a strong commitment of surveyed population by their activity, preventing them from answering the questions which were put to them or completing the questionnaire which was given to them. As a result, only 68.92% of the surveyed population was able to complete the questionnaire (Table III).

Data analysis has shown that the yearly production of sand in Nkol'Ossananga increases progressively. This is due to 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 for sand further. In the Centre 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 types of sand. This explains the up-growing of Sanaga sand demand.

The potentialities offered by the artisanal sand harvesting constitute favorable assets that requires active 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 revealed by Ekengoue et al. (2018). Exploitation of Sanaga sand generates income at the national level at the different phases of the activity. These include exploration, exploitation and commercialization. In the first two phases, the competent administration collects revenue through the concession of prospector's card and business license. 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 a year, considering data collected from the Obala weighbridge.

Besides, other income sources that accrue directly or indirectly to the government as a result of artisanal harvesting of Nkol'Ossananga sand are road toll gate and police taxes. 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 cost of 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 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 artisanal sand harvesting generates to artisans, this activity has several other impacts, especially with regard to the occupation and the remuneration for jobless as have suggested [Sen and Fukuda-parr, 1989]. Nkol'Ossananga sand exploitation activity improves the standard of life of artisans considerably. With the income that it provides, they can realize construction of new houses, often equipped with electronic devices and other needs such as televisions, computers, smart phones, and motorcycles to cite a few. Others use their income to finance their business ventures and to take care of children's school fees.

An estimation of artisan's incomes for a period of five years is presented in figure 2. 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 activity to government such as 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 artisanal harvesting to the semi-mechanized exploitation. On the site, we observed other economical activities developed by inhabitants of Nkol'Ossananga locality such as the merchandising of current consumption products including bread, palm wine, alcoholic drink, meat and food. This type of activity has also been mentioned by [Razack, 2012] for gold exploitation. Even clothes are commercialized in the site. Finally, sand harvesting at Nkol'Ossananga does not only constitute an efficient means of struggle against poverty, but also a source of income. The activity can have enough geographical impacts coupled with the fact that the storekeepers sometimes get a stock in the distant villages and cities.

Despite its wide range positive impacts such as improvement of peoples lives and contribution to 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 done. 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 peculiar 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 fact, some artisans do spend their incomes 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 constitute a young population. 25% of the population is less provided with schooling. This value is because students abandon their studies very early for the profit of sand harvesting in the Sanaga River. The abandonment 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 important impact induced by Nkol'Ossananga sand harvesting activities concerns abandonment of agriculture. As a consequence, women are taking part in farming work just to maintain and take care of their families.

3.2. Recommendations

Results of Nkol'Ossananga sand samples analysis at the *Sol Solution Afrique Central* laboratory indicates that Nkol'Ossananga sand is pure and clean sand, most appropriate for house constructions and building engineering. This explains the reason why the population of the Capital city of Cameroon (Yaounde) and neighboring towns are mostly interested to the Sanaga sand. The exploitation of Sanaga sand stands as origin of several positive social and economic impacts to all actors of the value chain and government. In contrast, the activity also stands as a sources of many negative impacts including cultural brewing, delinquency, precocious abandon of studies, abandon of agricultural activities to cite a few. For the activity to be most profitable to both artisans and local community and government, we propose a mechanized operation for Nkol'Ossananga sand harvesting. 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 is the operational technique that can improve the

working conditions, increase production and incomes of workers as similar as that of government, and also reduces negative environmental impacts. The figure 3 depicts therefore the organization of the Nkol'Ossananga sand harvesting site based on mechanized operation.

4. Conclusion

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 constitutes the main source of income for many habitants of the locality. 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 such income, artisans build their houses and buy electronic devices. No matter its importance either for income generation 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. For sustainable exploitation, we propose a mechanized operation. This kind of exploitation technique is the one which can improve the working conditions, increase production and incomes of workers as similar as that of government, and also reduces negative environmental impacts. The finding in this research work ends up with a perspective that the investment cost of the proposed mechanized operation has to be investigated in order to have a lucid idea on both the payback period and financial profitability.

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Tables

Table I: Distribution of questionnaires to actors in the Sanaga sand production chain for the 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

Table II. 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

Table III: Distribution of survey sheets to actors in the Sanaga sand production chain for the 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
Number of responses	43,44%	20,68%	3,44%	0,68%	0,68%	68,92%

Figures

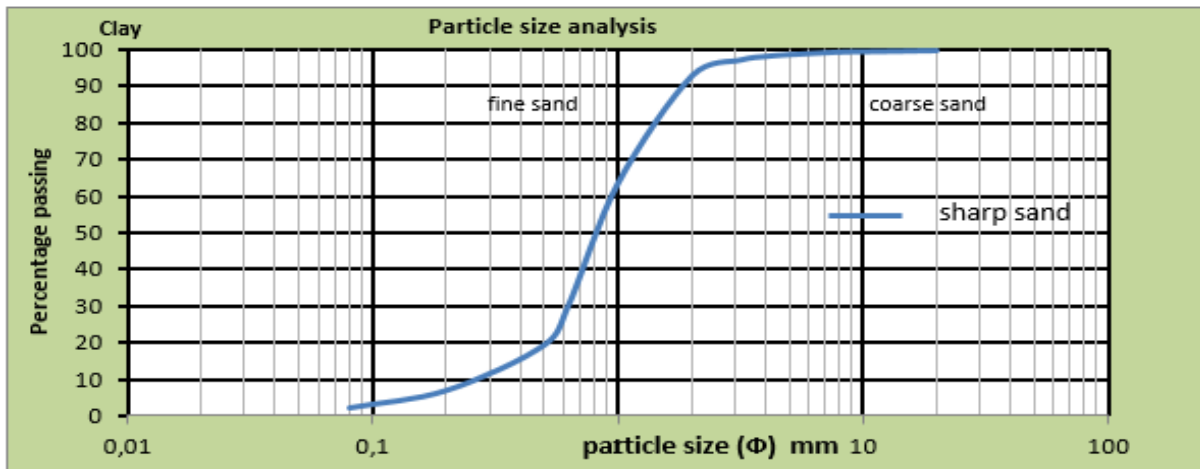


Figure 1. Sanaga River sand granulometric analysis curve.

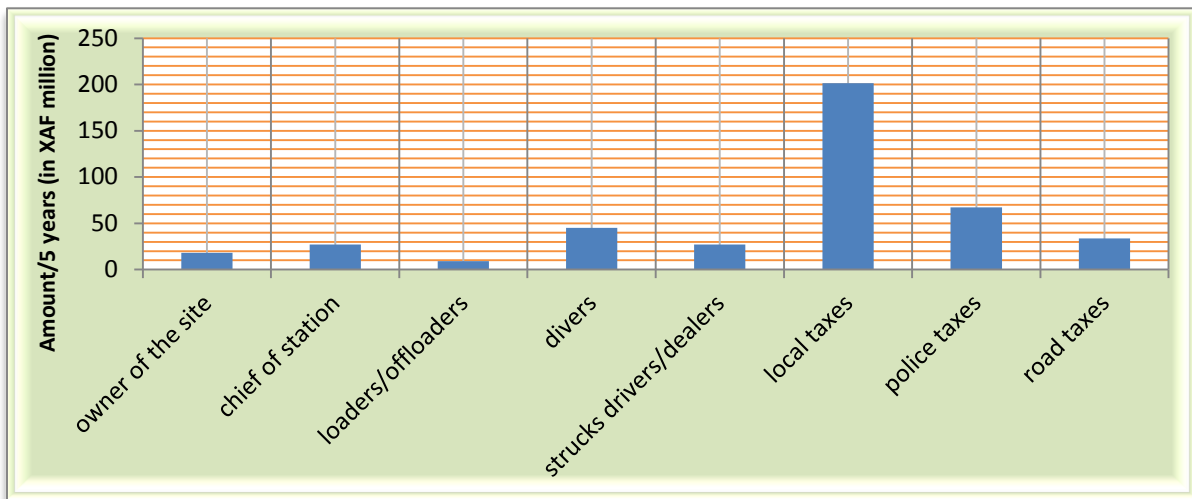


Figure 2. Evaluation of the incomes of elements of the value chain of exploitation of the sand in Nkol'Ossananga



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

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 : Questionnaire

I. INFORMATION NOTE

This questionnaire is a field data collection tool, produced by William Happi Tientcheu and his collaborators, Mining and Petroleum Engineer Student. It is therefore a didactic tool, necessary for the realization of purely academic research and this within the framework of the drafting of the dissertation at the end of professional training at the University of Dschang. is not binding. On the other hand, it is desirable to answer the various questions which are asked there. On the other hand, anyone investigated should be reassured that no information about the latter will be released. The data entered there will remain confidential and will only be used for statistical purposes.

II. PROSPECT IDENTIFICATION

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

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? _____ _____ _____		
Provide your daily, monthly and yearly incomes Daily incomes _____ XAF; Monthly incomes _____ XAF; Yearly incomes _____ XAF		
Provide in detail what do you do with incomes generated by the sand harvesting activity in		

Sanaga River at Nkol'Ossananga locality.		
<hr/>		
<hr/>		
<hr/>		
Do you have additional(s) activity		Yes <input type="checkbox"/> No <input type="checkbox"/>
If so, please to list some of them:		
1. <hr/>		
2. <hr/>		
3. <hr/>		
Do you face difficulties within the activity?		Yes <input type="checkbox"/> No <input type="checkbox"/>
If yes, please to list them:		
1. <hr/>		
2. <hr/>		
3. <hr/>		
4. <hr/>		
5. <hr/>		
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. <hr/>		
2. <hr/>		
3. <hr/>		
4. <hr/>		

IV. SECTION RESEVED FOR LOCAL COMMUNITY AND GOVERNMENT EMPLOYEES 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			
<hr/>			
From who do you collect the above mentioned taxes?			
What is the amount of taxes collected?			
Share with us the total daily income <i>(please to specified the amount depending on the category of craftsman)</i>		1. <hr/>	
		2. <hr/>	
		3. <hr/>	
		4. <hr/>	
		5. <hr/>	

What could be the use of the money collected from Nkol'Ossananga sand harvesting Craftsmen?		

Do the Nkol'Ossananga sand harvesting activity possesses positive impacts toward the inhabitants of Nkol'Ossananga locality?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
If yes, mention some specific ones		
1. _____		
2. _____		
3. _____		
4. _____		
5. _____		
The Nkol'Ossananga sand harvesting activity do not possesses negative impacts in Nkol'Ossananga locality?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
If you there are negative impacts due to the Nkol'Ossananga sand harvesting activity, please to provide a list		
1. _____		
2. _____		
3. _____		
4. _____		
5. _____		
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?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
If no, please to give your reasons:		
1. _____		
2. _____		
3. _____		
4. _____		
5. _____		
If yes, what are your advices?	1. _____	
	2. _____	
	3. _____	
	4. _____	
	5. _____	
Your comment here if any		