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Environmental Impact of Wood-Energy Consumption by Households in Democratic Republic of the Congo: A Case Study of Gbadolite City, Nord-Ubangi

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Abstract

In tropical Africa, wood-fuels remain the main source of energy for many people because of their availability. The purpose of this study was to evaluate the environmental impact of the consumption of these biofuels by households in the city of Gbadolite. The survey was conducted among 100 households using a survey questionnaire. The real quantitative need of households for fuels and its impact on the peri-urban environment was assessed after slaughter of *Zanthoxylum gilletii* and manufacture of embers. Results indicate that the majority of households in the city of Gbadolite (84%) use the embers fuel (charcoal) as the main source of energy; 25% of households have a monthly income between 100,000 CDF and 150,000 CDF while only 17% of households receive more than 200,000 CDF (46% of our respondents are civil servants/government functionary); The manufacture of charcoal is a profitable activity (profitability: 47.368%) and 93% of households use at least one bag of embers per month. To meet the energy needs of households in Gbadolite, 1,714 trees must be felled each month (equivalent to 1.5 hectares of forest devastated each month, i.e. 18 hectares of peri-urban forest in one year and 90 hectares in five years). It is therefore desirable that this informal sector be taxed and that the use of improved stoves is used on a large scale. In addition, it is also essential to set up a company specializing in the creation of artificial forests (reforestation or restoration of woody vegetation) in order to sustainably support the city's supply of wood fuels.

Keywords

Ember Fuel, Deforestation, Improved Stoves, Environment, Sustainable Development

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1. Introduction

The Democratic Republic of Congo (DRC) covers 60% (about 130 million hectares) of all the forests in the Congo Basin [1], which is the second largest dense humid forest cover in the world after the Amazonian forest. In addition to this dimensional importance, there is biological diversity [2-6]. In these forests, the importance of forest products is not to be demonstrated. It is well established that these products supplement household agricultural production by providing them with essential nutritional products, medicinal products,

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etc. but also sources of wood fuels [7-11]. It is estimated that wood energy covers 92% of the country's energy consumption. However, its exploitation and production are largely artisanal and are concentrated in peri-urban areas, leading to an increased decline in forest resources. The lack of stable incomes would be one of the reasons why people are turning to this less expensive/cheaper and more available form of energy [12]. In Gbadolite, as in other cities in the country and in Africa, low shousehold income means that more than 90 to 95 percent of the population uses wood fuels (biomass) to meet their energy needs [13-15]. Their accessibility and the prohibitive cost of other energy sources, such as gas and electricity, contribute to their untimely use in urban and rural areas. It was reported that the uncontrolled use of wood for cooking and heating results in environmental degradation [16]. Indeed, it is well established that in the DRC, the exploitation and production of wood energy is largely done in a traditional way and is concentrated in peri-urban areas, causing deforestation and forest degradation around large cities [17].

In DRC as well as in many countries in Sub-Saharan Africa such as Nigeria and Tanzania, there is low energy consumption among household and this makes them too heavily dependent upon wood fuels (charcoal, firewood and other wood-derived fuels like wood residues) for their energy survival. Charcoal constitutes the primary urban fuel in most of Africa and is a major source of income. It growing demand has resulted in accelerated deforestation of periurban forests. Indeed, commercial fuel wood extraction such as charcoal production requires a large amount of wood, which lead in the depletion of tree stocks causing deforestation [18-20]. Thus, little is known about environmental impact of ever-growing cities in many part of African continent due to charcoal production and use.

However, based on current knowledge, there are no data available for Nord Ubangi Province in DRC. The aim of this study, which is the first, is to assess the environmental impact of wood energy consumption by households in the city of Gbadolite. The specific objectives of this study are:

To identify the different types of wood fuels used in households in the city of Gbadolite and quantify the one most used;

To evaluate the monthly income of these households;

To evaluate the number of trees cut (felled) to meet the energy needs of households in Gbadolite and the cost of making the embers fuel.

The interest of this study is obvious because it allows appreciating the impact of the embers manufacturing on the ligneous resources in order to raise awareness among the populations.

2. Material and Methods

This study was carried out in Gbadolite (Nord-Ubangi Province, Democratic Republic of the Congo). Gbadolite city is located in the Ubangian eco-region, a subgroup of *Northeastern Congolian lowland forests* [21]. This eco-region is one of the 200 globally priority terrestrial eco-riogins known as the "G200" [22].

To collect the data, a sample of 100 households was drawn in four neighborhoods in Gbadolite city, including: Mbanza (35), Lite (35), Pangoma (15) and Moanda (15). Respondents were questioned individually based on a survey questionnaire. The main data collected during the survey are related to gender, household size, monthly income, wood fuel consumption, type of cooking equipment and knowledge about the improved stove.

In order to evaluate the real quantitative need of Gbadolite households for ember fuels and its impact on the peri-urban environment, embers were produced by pyrolysis (carbonization) after felling of a tree (*Zanthoxylum gilletii*: Syn. *Fagara macrophylla*, Family Rutaceae: 12 m high and 60 cm diameter).

Figure 1 shows the steps involved in making (the manifacture of) embers *in situ*.

(a) Slaughtering/felling (b) sizing

(c) Assembly/Collection (d) Pyrolysis

Figure 1. Steps in the manufacture of embers.

Deforestation of the peri-urban forest of Gbadolite can be estimated by the number of cut trees (NAC) to produce embers. This number is calculated from the following relation:

$$NAC = \left(\frac{NBU}{NTB}\right) * N \quad (1)$$

Where NAC is the number of cut trees per month; NBU, the average number of embers basin used per household; NTB, the total number of ember basins produced per tree (10 bags or 40 basins) and N, the size of the population of Gbadolite in 2017 (13,711 inhabitants). To validate this relationship, the following conditions were fixed such as if NAC ≥ 1600 trees that correspond to the destruction of one hectare of forest in *Tectonia grandis* (an artificial forest). By analogy, 1,714 trees cut monthly in Gbadolite peri-urban forest would correspond to one and a half hectares of a natural forest.

3. Results and Discussion

Figure 2 shows the distribution of respondents by gender.

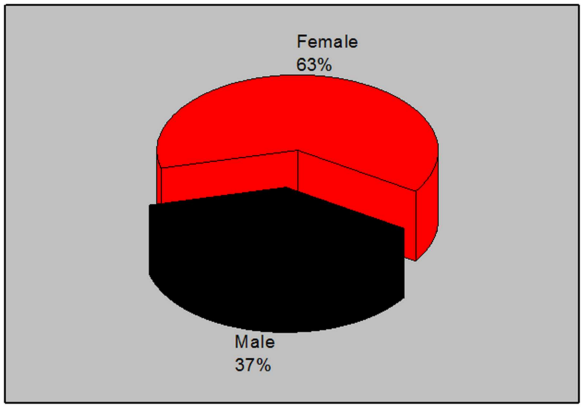

Figure 2. Gender of respondents.

Our results indicate that 63% of our respondents are female and 37% male (Figure 2). The majority of these live in the Mbanza and Lite neighborhood (35% respectively), followed by the Pangoma and Moanda neighborhoods (15% respectively).

Figure 3 shows the distribution of our respondents by household size.

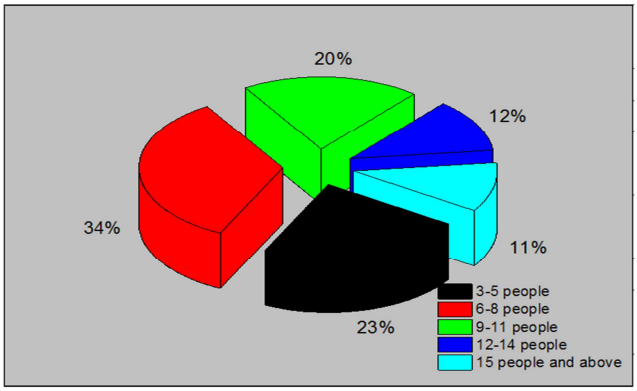

Figure 3. Household size.

Figure 3 shows that 34% of households have 6-8 people, 23% have 3-5 people, 20% have 9-11 people, 12% have 12-14 people and 11% have 15 or more people.

Figure 4 shows the distribution of our respondents (by occupation)/ according to their profession

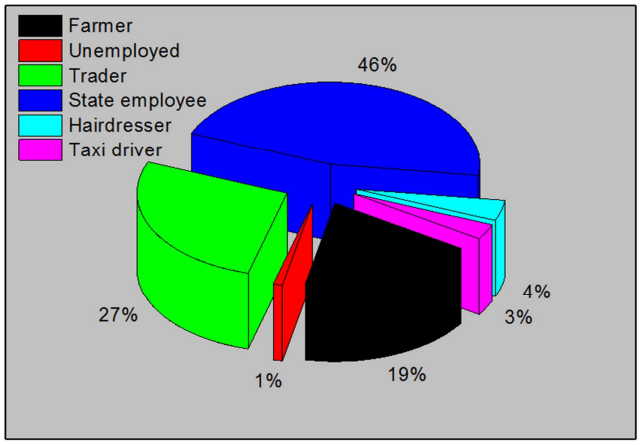

Figure 4. Respondents' Occupation.

Figure 4 shows that 46% of our respondents are state employees; 27% are traders, while 19% of those surveyed are Farmers. This shows that Gbadolite is an urban-rural town. The other categories make up 8% of all surveys.

Figure 5 shows the distribution of our surveys by monthly income.

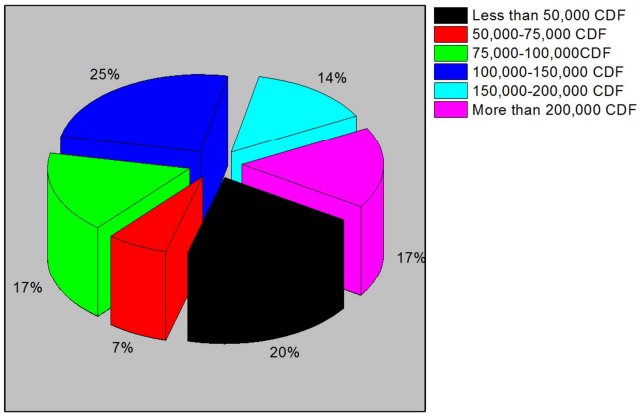

Figure 5. Monthly income of households surveyed (Exchange rate: 1665 CDF: 1 USD).

This figure shows that 25% of households earn between 100,000 and 150,000 CDF, 20% earn less than 50,000 CDF, 17% receive more than 200,000 CDF, 17% have 75,000 to 100,000 CDF, 14% receive between 150,000 and 200,000 CDF and 7% between 50000 and 75000 CDF.

Figure 6 shows the type of fuels used by the households surveyed.

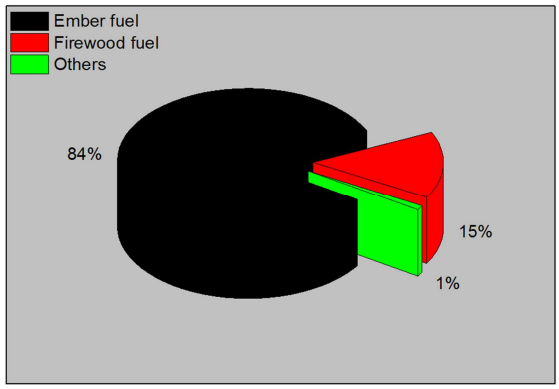

Figure 6. Types of fuel used.

The figure shows that 84% of the surveys interviewed use ember fuel, 15% use firewood fuel and only 1% use wood residues from carpentry workshops as fuel.

Figure 7 gives the picture of these wood fuels.

(a) Packaged charcoal (for whole seller) (b) Sale of charcoal in detail (for retailer)

Figure 7. Picture of wood fuels.

Regarding the respondents' accessibility to wood fuels all unanimously confirmed the accessibility of charcoal and firewood because of their low cost. However, the respondents deplore the high price of electric hobs.

Figure 8 shows the monthly ember consumption of the households surveyed.

Regarding this chart, the results reveal that 55% of respondents use a bag, 31% use two bags a month, 7% use less than one bag, 5% use more than three bags and 2% use three bags.

Figure 9 shows the type of equipment used by the respondents.

This figure shows that 84% of respondents have blaze, 15% use tripod and 1% uses the oven. It should be noted that the lack of electric plates (hobs) in several households is explained by a lack of electricity during the entire period of the investigation/survey.

Figure 10 gives the pictures of different models of equipment used by the respondents.

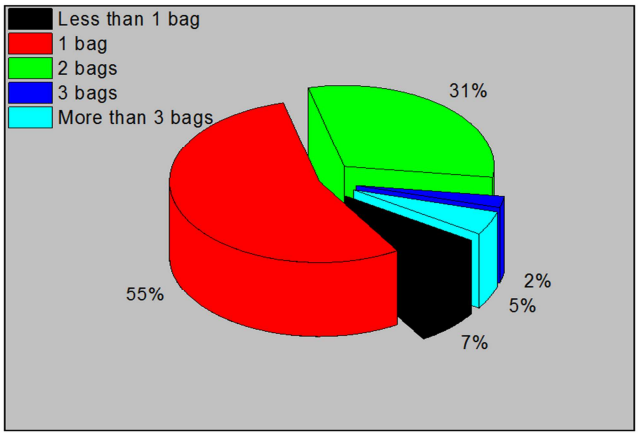

Figure 8. Monthly embers' consumption.

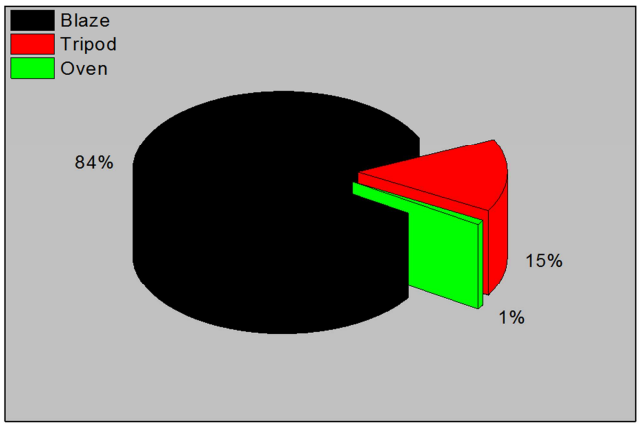

Figure 9. Type of equipments.

Figure 10. Typical Models of Equipment Used for cooking in Gbadolite.

Figure 11 gives the picture of an improved stove.

Figure 11. Typical model of an improved stove.

Regarding the improved household (Figure 11), 100% of respondents are unaware of its existence, however, they agree to stock up (buy it) in case of its availability on the market.

The domestic energy issue remains a major concern for developing countries where wood fuels such as firewood and charcoal cover about 80-95% of households' household' domestic energy needs [14, 15]. Indeed, in tropical Africa, wood fuels remain the main source of energy for many people because of their availability; and their cost is relatively low and therefore easily accessible.

In this study, the entire ember fuel making (manufacturing) process cost 95,000 CDF and the embers obtained were estimated at 140,000 CDF (10 bags or 40 basins). That is a profit of 45,000 CDF, which corresponds to a profitability of 47,368%. As charcoal production is a profitable activity, the destruction of forest resulting can cause ecological imbalance in the absence of a forest management and restocking policy. As is the case elsewhere in the North Ubangi province in the Democratic Republic of Congo where, despite the Mobayi-Mbongo hydroelectric dam, access to electricity becomes almost impossible in Gbadolite after every four to six months per year. This situation exacerbates (aggravates) the anthropic pressure on peri-urban forest ecosystems and fragments wildlife habitats: it is estimated that 90% of the population depend exclusively on the dendro-energy in Gbadolite.

The present study demonstrated in its experimental part that for a tree sample of 60 cm of diameter and 12 m high, pyrolysis produces 10 bags of ember fuel or 40 basins. For an average consumption of 5 basins per household, we can estimate 1,714 cut trees per month in order to meet the energy needs of 13,711 inhabitants of Gbadolite.

The number of cut trees corresponds to 1.5 Ha of forest devastated each month, or 18 Ha of peri-urban forest in one year (year 2017). By maintaining this rhythm, 90 Ha of forest will be destroyed within 5 years (in 2022). Since the wood fuel' consumption exceeds their renewal rate, we should expect a scarcity of lineal products which would aggravate the households' poverty, starting point of a collective awareness for the protection of the remaining forests by the different actors involved (producers, sellers, consumers and the specialized services of the provincial Ministry in charge of the Environment).

By comparing the present survey to a study carried out on socio-economic impacts of charcoal production in Nigeria, results revealed that 74% of the respondents were male while 26% were female (in the present survey, 63% of respondents are female and 37% male). In the case study of Nigeria, household having a size of 5-10 persons displayed higher percentage of frequency (93%) while in Gbadolite city, household with 6-8 persons represent 34%. As for Gbadolite city in DRC, energy provision in Nigeria is a basic household need and consumption is closely related to the level of a country's development. It was discovered also in Nigeria that about 74.4% of people implicated in the wood energy production sector are farmers which is contrary to the present finding who reported that most of the respondents are state employees (46%) while farmers represent 19% [18].

In Tanzania, it was reported that the increasing production and use of wood energy (charcoal) along the Dar es Salaam-Morogoro highway and the surroundings areas has negative impact on environment through woodland clearing and soil erosion. As for periurban forest of Gbadolite in DRC, the forecast of an area of about 1524 Km^2 was estimated to be cleared in a period of 35 years if current deforestation continues. This should serve as an early warning of the bleak future society may have to face [20]. The results of the present study show that the environmental negative impact of an ever-growing city in developing world likes Africa necessitate new policies on utilization of natural forests.

4. Conclusion

1. The present study was carried out with the aim of evaluating the environmental impact of wood-energy consumption by households in the Gbadolite city. The results revealed that:
2. The majority of households in the Gbadolite city (84%) use ember fuel as a source of energy;
3. 25% of households have a monthly income between CDF 100,000 and 150,000 while only 17% of households receive more than CDF 200,000 (46% of our respondents are state employees);
4. The manufacture of charcoal is a profitable activity (profitability: 47.368%) and 93% of households use at least one bag of embers per month.

5. To meet the households' energy needs in Gbadolite, 1,714 trees must be felled each month (equivalent to 1.5 Ha of devastated forest each month, or 18 Ha of peri-urban forest in one year and 90 Ha in five years).

5. Suggestions

It is therefore desirable that this informal sector be taxed and that the use of improved stoves is used on a large scale. In addition, it is also essential to set up a company specializing in the creation of artificial forests (reforestation or restoration of woody vegetation) in order to sustainably support the city's supply of wood fuels. To this end, the "Makala" project initiated by the European Union in Kinshasa is eloquent to realize this and should therefore serve as a model for the Nord Ubangi Province.

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References

[1] Debroux L, Hart T, Kaimowitz D, Karsenty A, Topa G, 2007. Forests in Post-Conflict, Democratic Republic of Congo: Analysis of a Priority Agenda. Center for International Forestry Research: Jakarta.

[2] Asimonyio JA, Ngabu JC, Lomba CB, Falanga CM, Mpiana PT, Ngbolua KN, 2015. Structure et diversité d'un peuplement forestier hétérogène dans le bloc sud de la réserve forestière de Yoko (Ubundu, République Démocratique du Congo). International Journal of Innovation and Scientific Research 18 (2): 241-251.

[3] Baelo P, Asimonyio JA, Gambalemoke S, Amundala N, Kiakenya R, Verheyen E, Laudisoit A, Ngbolua KN, 2016a. Reproduction et structure des populations des Sciuridae (Rodentia, Mammalia) de la réserve forestière de Yoko (Ubundu, RD Congo). International Journal of Innovation and Scientific Research 23 (2): 428-442.

[4] Baelo P, Kahandi C, Akuboyi J, Juakaly JL, Ngbolua KN, 2016b. Contribution à l'étude de la biodiversité et de l'écologie des Araignées du sol dans un champ cultivé de *Manihot esculenta* Crantz (Euphorbiaceae) à Kisangani, RD Congo. International Journal of Innovation and Scientific Research 23 (2): 412-418.

[5] Kambale J-LK, Asimonyio JA, Shutsha RE, Katembo EW, Tsongo JM, Kavira PK, Yokana EI, Bukasa KK, Nshimba HS, Mpiana PT, Ngbolua KN, 2016a. Etudes floristique et structurale des forêts dans le domaine de chasse de Rubi-Télé (Province de Bas-Uélé, République Démocratique du Congo). International Journal of Innovation and Scientific Research 24 (2): 309-321.

[6] Kambale J-LK, Shutsha RE, Katembo EW, Omatoko JM, Kirongozi FB, Basa OD, Bugentho EP, Yokana EI, Bukasa KK, Nshimba HS, Ngbolua KN, 2016b. Etude floristique et structurale de deux groupements végétaux mixtes sur terre hydromorphe et ferme de la forêt de Kponyo (Province du Bas-Uélé, R. D. Congo). International Journal of Innovation and Scientific Research 24 (2): 300-308.

[7] Kambale J-LK, Feza MF, Tsongo MJ, Asimonyio JA, Salomo M, Nshimba H, Gbolo BZ, Mpiana PT, Ngbolua KN, 2016c. La filière bois-énergie et dégradation des écosystèmes forestiers en milieu périurbain: Enjeux et incidence sur les riverains de l'ile Mbiye à Kisangani (République Démocratique du Congo). International Journal of Innovation and Scientific Research 21 (1): 51-60.

[8] Ngbolua KN, Ngemale GM, Konzi NF, Masengo CA, Gbolo ZB, Bangata BM, Yangba TS, Gbiangbada N, 2014. Utilisation de produits forestiers non ligneux à Gbadolite (District du Nord-Ubangi, Province de l'Equateur, R. D. Congo): Cas de *Cola acuminata* (P. Beauv.) Schott & Endl. (Malvaceae) et de *Piper guineense* Schumach. & Thonn. (Piperaceae). Congo Sciences 2 (2): 61-66.

[9] Ngbolua KN, Yabuda KH, Abia M, Bongo NG, Mabe K, Nzamonga GA, Masengo AC, Djolu DR, Likolo BJ, Ngemale GN, Molongo MM, Mangbukudua M, Kamienge KM, Gbatea KA, Bosanza Z, Mongeke M, Muanza LM, 2017a. Preliminary ecological study of plant species of Lokame Natural Forest (Nord Ubangi Province, Democratic Republic of the Congo): A special emphasis on Non-timber Forest Products. J. of Advanced Botany and Zoology 5 (2): 1-6.

[10] Ngbolua KN, Ambayi BS, Bongo NG, Masengo AC, Djolu DR, Likolo BJ, Gbolo ZB, Ngunde-te-Ngunde S, Iteku BJ, Mpiana PT, 2017b. Ethno-botanical survey and floristic study of medicinal plant taxa used by Traditional Healers in Gbadolite city (Province of Nord-Ubangi, Congo-Kinshasa). Journal of Modern Drug Discovery and Drug Delivery Research 5 (2): 1-7. doi: 10.5281/zenodo/1116857.

[11] Ngbolua KN, Ambayi BS, Bongo NG, Djolu DR, Nzamonga GA, Masengo AC, Koyagialo J-L, Gbatea KA, Ndaba MM, Kowozogono KR, 2017c. Preliminary survey on the bushmeat sector in Nord-Ubangi Province (DR Congo): Case of Gbado-Lite city and its surroundings. J. Advanced Botany and Zoology 5 (3): 1-7. doi: 10.5281/zenedo.1024570.

[12] Marien JN. Forêts périurbaines et bois énergie: quels enjeux pour l'Afrique centrale ? http://carpe.umd.edu/documents/2008/etat-des-forets_2008-13.pdf [Consulté le 29 Septembre 2018].

[13] Schure J, Mvondo SA, Awono A, Ingram V, Lescuyer G, Sonwa D, Olufunso S, 2010. L'état de l'art du bois énergie en RDC: Analyse institutionnelle et socio-économique de la filière bois énergie. Projet Makala, Kinshasa: République démocratique du Congo. http://projets.cirad.fr/makala.

[14] Chidumayo EN, Gumbo DJ, 2013. The environmental impacts of charcoal production in tropical ecosystems of the world: A synthesis. Energy for Sustainable Development 17 (2): 86–94. doi: 10.1016/j.esd.2012.07.004.

[15] Yameogo G, Yelemou B, Ouedraogo L, Kabore O, Traore D, 2014. Combustibles des ménages et modes d'utilisation à l'échelle du terroir de Vipalogo, en zone nord soudanienne du Burkina Faso Int. J. Biol. Chem. Sci. 8 (4): 1742-1756. doi: http://dx.doi.org/10.4314/ijbcs.v8i4.33.

[16] Anjorin M, Houngan CA, Awanto C, Fagbemi L, Feidt M, 2014. Étude économique des foyers domestiques par la technique d'ébullition de l'eau: cas du Bénin. Afrique Science 10 (2): 70 – 81.

[17] Binzangi K, 2000. L'approvisionnement de Kinshasa en énergie-bois: état de la question. ukuni Lwa Yuma, Revue Interdisciplinaire (Université Libre de Luozi) 3 (5): 24-35.

[18] Olasimbo O, Adeyinka OJ, 2018. Socio-economic impacts of charcoal production in Oke-Ogun area of Oyo State, Nigeria. Tropical Plant Research 5 (1): 46–52.

[19] Jamala GY, Abraham P, Joel L, Asongo A, 2013. Socio-Economic Implications of Charcoal Production and Marketing in Nigeria. IOSR Journal of Agriculture and Veterinary Science 5 (4): 41-45.

[20] Monela GC, Aku O, Kiwele PM, 2013. Socio-economic aspects of charcoal consumption and environmental consequences along the Dar es Salaam-Morogoro highway, Tanzania. Forest Ecology and Management 58: 249-258.

[21] Programme d'Appui au Réseau des Aires Protégées (PARAP), 2015. Evaluation du massif forestier du Nord-Ubangi. Rapport final, République démocratique du Congo.

[22] Olson DM, Dinerstein E, 1998. The Global 200: A representation approach to conserving the Earth's most biologically valuable ecoregions. Conservation Biol. 12: 502–515.