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Assessment of ecological charcoal production and impact on the ecosystems of the Far North, Cameroon

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ABSTRACT

This article aims to assess the potential production of ecological charcoal (briquette) which is a combustible made from the agricultural residues, Agro-industrial and household waste in substitution of wood fuel in Far North Region of Cameroon. Fragile ecosystems of the Region incur in recent years a strong combined pressure by the local population, Nigerian refugees' demand of wood fuel and the exportation to Chad. The total demand is evaluated at 1.38million tons of wood fuel, the equivalent of 23,400 Terajoules (TJ). Whereas, the Region disposes mostly 800,000 tons of sustainably exploitable wood fuel. It therefore presents a deficit of approximately 580,000 tons of wood fuel. This deficit is closed by the uncontrolled levy right into the forest reserves and the national parks, exposing the whole Region to a true ecological disaster. A substitutional energy at low cost and accessible would be the ecological charcoal. The Region has an estimated annual production capacity at 2.65 million tons in average of ecological charcoal, the equivalent of about 60,000TJ. Such production could cover the annual needs of 10 million inhabitants right up to 2050 in the Region.

Keywords: Assessment, ecological charcoal production, impact, ecosystems, Far North Region, Cameroon

I. INTRODUCTION

During these last decades, the production of wood fuel or its replacement by other combustible has become a major stake for numerous developing countries (UNDP, 2015). The forests are in prey of an increasing demand for the expansion of agriculture, urbanization and wood production (HPLE, 2017). More than 2.4 billion of persons depend on wood fuel all over the world, including 65 million refugees (FAO, 2017). The rush after wood fuel in African continent represents 63% of world consumptions (FAO, 2018). In Cameroon, the pressure on wood resources appears more and more strong, whether for subsistence needs, wood fuel or for forest exploitation (Brangeon and Bonivard, 2017). The situation is more dramatic in the Far North Region where the insecurity reigns placed to Boko Haram terrorists' action which provoked the massive movement of refugees.

The high population density associated to ecological fragility of an area is a degradation factor of the environment and a source of conflicts with the indigenous population (Black, 1998). The incapacity to satisfy the demand in wood fuel of the population of the Region has intensified the pressure even on the wood species which were formally untouched. It is the case of *Bowellia dalsialllii*, *Combretum fragrans, Combretum mole, Commiphora africana, Calloptropis procera* which, due to their toxicity or their bad combustion, were not used as firewood sometimes (Seignobos and Olivier, 2000; CTFC, 2011).

The wood fuel, due to an increasing demand, consumer item acts as the source of conflict, therefore deserves special attention in the context of its sustainable management and its substitution by renewable energy (Ecological charcoal), especially in an arid Region where the

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populations are trapped by a vicious circle of poverty (Madi and al., 2003).

The agricultural residues, households waste and agro-industrial waste are known to continue to be an important source of alternative energy to wood fuel. In Far North Region of Cameroon, these wastes are not yet valued or recycled. Storage is the main method of waste disposal in this Region. They are stocked in the wild discharge, dumped in the river beds (Mayo) or rather filled in the holes. This expensive waste management method can lead to the degradation of the landscape, various forms of pollution, particularly the degradation of soil, runoff water and underground water and apart of toxic gases emitted into the atmosphere (Sharholy et al., 2008; OMS, 2013). The obstruction of gutters and the rivers is regularly at the origin of the flooding in the towns of the Far North Region. However, a good proportion of biomass constituting these residues could be subject to energy recovery and hence improved significantly the sustainable availability of the cooking energy source in the Region.

This study was initiated in view of evaluating potential biomass residues and energetic of vegetal wastes and similar waste in Far North Region of Cameroon. Its objective is to assess the potential production of ecological charcoal from this depositing order to consider the substitution capacity of wood fuel and, by extension, the safeguard of the remaining forest ecosystem.

II. MATERIAL AND METHODS

2.1. Description of area of study

The study area covers the Far North Region of Cameroon. The Region is so populated with around 4.9 million inhabitants apart of 114,000 Nigerians' refugees (UNHCR, 2020). The natural environment is characterized by unfavorable climatic conditions with a dry season of more than 7 months and high temperature reaching sometimes more than 45°C. The natural vegetation highly degraded by human action, consists of shrub islands and bushes. They are the only source of wood fuel and timber for more than 98% inhabitants in the Region (Tizé and al., 2020).

2.2. Assessment of the potential biomass residues in Far North Region

The methodology chosen consisted in administering the semi-structured questionnaires to 994 actors inquired, including, 167 wood fuel producers, 56 wholesalers and semi-wholesalers, 56 retailers, 387 household consumers of wood fuel, 170 micro-enterprises (fish and meat fucker, doughnut-makers, cafeteria, restaurants, *''bil-bil''* (traditional beer) brewer, blacksmith, etc.), 158 households of Minawao refugee camp and its surroundings on the adoption of ecological charcoal. The inquiries were completed by the in-situ measure to assess the potential biomasses (agricultural residues, household waste) at the duration of 10 years (2009 to 2018) according to the reports of the National Institute of Statistics of Cameroon. The species and the volumes of fire wood the most consumed by the households were equally inventoried. From the demand and supply, the energy balance was calculated from the formula 1.

$$Eb = WF\ Supply - (WF_{consum} + WF_{expo}) \quad (1)$$

Eb: Energy balance; WF_{consu}: wood fuel consumed; WF_{expo}: wood fuel exported. The supply of wood fuel was assessed by the Ministry of Forests and Wildlife (MINFOF, 2014), a quantity of wood fuel consumed in the Region was estimated at the basis of daily and annually consumptions by inhabitant, as well for the professional consumers of combustible in tons and those exported to Chad was equally evaluated by MINFOF (2014).

2.3. Assessment of the biomass potential energy

This is firstly to assess the calorific value of the quantified vegetal residues in the Region. Then, we proceeded as well with a determination of calorific value of different wood species the most consumed in the Region. The measurements were made using an automatic bomb calorimeter of the SPAN brand, model SABC-01R, in order to better compare and to determine the level of substitution. The energetic report of a carbonization of some wood species was determined from equation 2: -

$$Er = \frac{CVCharcoal}{CVwood} \quad (2)$$

Where,
Er: energetic report;
CV charcoal: charcoal calorific value (MJ/kg);
CV wood: wood calorific value (MJ/kg).

2.3.1. Raw materials

We have identified 13 trees species the most consumed as wood fuel thus the calorific values were determined. These species are *Balanites aegyptiaca; Ziziphus mauritania; Anogeissus leiocarpus; Gardenia sokotensis; Azadirachta indica; Acacia hockii; Cassia siamea; Acacia seyal; Isoberlinia doka; Acacia raddiana; Entada africana; Acacia ataxacantha; Prosopis africana*. As for residues, the calorific value of nine type of used biomasses for the production of ecological charcoal was determined, namely millet husk, rice husk, cotton stalk, corn cob, groundnut shell, sesame residues, households waste (*Azadirachta indica* leaves), straw. The samples of residues were collected before the production of the ecological charcoal.

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2.3.2. Proximate analysis of Calorific value (CV)

The CV of different sampling was determined by the bomb calorimeter according to American Standard Testing Methods (ASTM) D5865-10a. The sample to be burned is weighed on a precision electronic scale (0.0001g) and it is introduced into the bomb. An ignition wire (10 cm to 13 cm long) is attached to two electrodes of the bomb so that it touches the compacted and deposited sample in a crucible. Then, the bomb is hermetically closed and filled with oxygen at 30 atmospheres. A bomb is introduced into a thermostatic bath of distilled water. We waited 5 to 10 minutes for the stabilization of ambient temperature of the water before releasing the electric ignition of the sample. At the end of combustion, we have measured the remaining ignition wire and the rate of ash before calculating automatically the calorific value of combustible. For each sample, the test was repeated 4 times.

Photo 1: Bomb Calorimeter and its accessories

III. RESULTS AND DISCUSSIONS

3.1. Wood fuel requirement

In addition to the need of populations and professional consumers (fish and meat fucker, doughnut-makers, cafeteria, restaurants, *bil-bil* (local beer) brewering, blacksmith, etc.), there are also the Nigerian refugees' demand, and the exportation toward Chad of the wood fuel. Table 1 presents the detail on wood fuel requirement.

Table 1: Internal and External wood fuel requirement

Consumers of Wood-Energy	Wood-energy required	Rate of consumption (%)	References
Far North Region Population	1,220,000	88	This study
Professional consumer	120,000	9	This study
Nigerians' refugees	28,000	2	This study
Wood fuel exported to Chad	12,000	1	MINFOF, 2014
Total wood fuel requirement	1,380,000	100	This study
Total wood fuel supply	800,000	-	MINFOF, 2014
Balance	- 580,000	-	This study

Table 1shows that Nigerian refugees living in the Region increased wood fuel consumption by 28,000 tons/year (either 2%). From these 17,000 tons of wood fuel per year are collected from Zamay forest reserve, which has amplified its destruction up to 74.2% of its initial area and the Hina forest massive, located at 8 km and 18 km respectively from Minawao refugee's camp. Thus, the wood fuel balance indicates for the Region a deficit of 580,000 tons in 2021 or about 42% of the demand. In 2012, it was estimated to 346,836 tons (GIZ, 2012). In a space of nine years, the deficit has almost doubled. The wood fuel supply barely covers half internal and external demand. Faced with this situation, daily consumption per inhabitant has decreased over the years due to the scarcity of wood fuel. It was 2 kg/person/day (Tata, 1997), 1.65 kg for the household using only fire wood and who are supposed to prepare food trice a day, and 1.25 kg for the household using various energy sources (wood fuel, gas and kerosene) (Madi and al., 2003). Recent studies show it was 0.82 kg/person/day in 2011 (Madi, 2011), in 2012, it was 0.8 kg (GIZ, 2012) and 0.68 kg/person/day in 2021. To better understand the energy required, it was judicious to determine the calorific value of different trees species the most consumed in the Region as wood fuel.

3.2. Energy potential of the most consumed wood fuel species in the Region

Table 2 shows the Low Heating Value (LHV) of the most consumed wood species in the Far North region.

Table 2: Calorific Value of fire wood and of charcoal (MJ/kg)

Trees species		Low heating value (MJ/kg)
Local name (Fulfulde)	Scientific name	
Bulbe	*Acacia hockii*	16.507 ± 0.66
Korahi /Moraré	*Acacia ataxacantha*	17.825 ± 0.91
Djeloki/djilouki	*Acacia raddiana*	17.214 ± 0.77
Bidehi/Boulbi	*Acacia seyal*	13.661 ± 0.42
Kodjoli/kodjolé	*Anogeissus leiocarpus*	17.178 ± 0.56
Nim/gayné	*Azadirachta indica*	17.675 ± 0.38
Tané/tanni	*Balanites aegyptiaca*	17.436 ± 0.55
Foré	*Cassia siamea*	16.310 ± 0.56
Mbuda/faroanduki	*Entada Africana*	17.029 ± 0.14
Diengali	*Gardenia sokotensis*	17.593 ± 0.04
Kubadje	*Isoberlinia doka*	14.563 ± 1.4
Kohi/Kohé	*Prosopis Africana*	20.249 ± 0.19
Djabi/jabi	*Ziziphus Mauritania*	17.350 ± 0.85
Charcoal		
Charcoal of Prosopis Africana		32.185 ± 0.87
Charcoal of *Balanites aegyptiaca*		28.106 ± 0.72
Charcoal of *Anogeissus leiocarpus*		27.243 ± 0.85

It appears from table 2 that on average, the energy ratio of carbonization of these trees' species, is 1.59. Thus, it would also mean that for the energy contained in 1 kg of charcoal, is equivalent to an energy contained in 1.59 kg of wood of *P.africana*, 1.61 kg of wood of *B. aegyptiaca*, and 1.58 kg of wood of *A. leiocarpus*. Table 3shows the amount of energy that could be produced by the most consumed wood species in the Region.

Table 3: Total energy of the trees species in Terajoule (TJ)

Vegetal species	Consumption (in %)	Fire wood quantity (t)	LHV (TJ/t)	Average quantity of energy (in TJ)
Acacia hockii	5.1	70,380	0.016	1162
Acacia ataxacantha	1.8	24,840	0.018	443

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Acacia raddiana	1.2	16,560	0.017	285.1
Acacia seyal	3.3	45,540	0.014	622.1
Anogeissus leiocarpus	24.7	340,860	0.017	5855.3
Azadirachta indica	2.3	31,740	0.018	561
Balanites aegyptiaca	38.8	535,440	0.017	9336
Cassia siamea	0.2	2,760	0.016	45
Entada Africana	1.4	19,320	0.017	329
Gardenia sokotensis	0.1	1,380	0.017	24.3
Isoberlinia doka	9.8	135,240	0.014	1969.5
Prosopis Africana	1.2	16,560	0.020	335.3
Ziziphus mauritania	10.1	139,380	0.017	2418.2
Total	100	1,380,000		23,386

We note that the calorific value alone cannot justify the high consumption of certain trees species such as *Balanites aegyptiaca* (38.8%), *Anogeissus leiocarpus* (24.7%) and *Ziziphus Mauritania* (10.1%) by the production. The preference of the wood species also depends on the quantity of smoke produced, the more smoke is produced, the less it is consumed, of less ash production and especially its availability (Laouali and al., 2014). This would explain the low rate of Prosopis Africana in the global consumption, while it has the highest heating value (20.249 MJ/kg). This is also the case for the consumption of *Isoberlinia doka* (9.8%) which is more available in certain part of Mandara Mountains (Mokolo, Mogodé and Bourha) than *B. aegyptiaca* which is mainly found in the lowland of the Region.

3.3. Economic evaluation of wood fuel sector

In the Region, the price of a kilogram (kg) of firewood is in the range of 50 to100 FCFA and 200 to 310 FCFA for charcoal. Thus, the turnover of wood fuel sold in various towns, stands at 64.22 billion FCFA, and more than a half billion FCFA for charcoal exported to Chad.

3.4. Potential production of ecological charcoal from the residues

The different biomasses evaluated in the Far North Region that could be transformed into ecological charcoal are resumed in the table 4. The production and the surface areas of different speculations were estimated on the basis of the National Institute of Statistics (INS, 2011, 2013, 2015 and 2016, DR/MINADER/EN (2018) data from 2009 to 2018 for the Far North Region.

Table 4: Quantity of raw materials (tons)

Source of raw material	Production (t) or area (ha)	Raw materials (RM) issues	Quantity of biomass residues (t)
Sorghum	671,596 t	Millet husk	32,908
Paddy rice	108,348 t	Rice husk	40,089
Groundnuts	110,615 t	Groundnuts shell	56,983
Maize	126,992 t	Corn cob	40,973
Sesame	13,489 ha	Sesame residues	4,979
Soybean	4,979 ha	Soybean residues	4,249
Cotton	156,800 ha	Cotton stem	156,8
Forest formation	826,000 ha	Straw	4,130,000
Azadirachta indica	2,165,700 t/year	Leaves of A. indica	2,165,700
Total			6,632,681

From this table 4, it shows that the straw resulting from the forest formations, is the most important biomass in quantity. But it does other types of recovery, such as fodder for the animals, construction materials. In contrast, the cotton stem, the corn cob, the rice husk, groundnut shells are the residues sometimes used in rural zone to produce cooking energy or as heating energy. In summing the average quantity of the residues that the Region could produce a year and could serve for the manufacturing of ecological charcoal, we reach the approximative total of 6.6 million tons. To make 1 kg of ecological charcoal, 2.5 kg of biomass in average is needed. Indeed, all depends on the carbonization yield of biomass. And so, the table 5 illustrates the quantity of ecological charcoal that could be produced in Far North Region.

Table 5: Quantity of ecological charcoal (tons)

Biomass	Quantity of biomass in ton (t)	Carbonization yield	Quantity of carbonized biomass	Ecological charcoal (t)
Sorghum husk	32,908	42%	13,821	12,876
Rice husk	40,089	38%	15,234	14,192
Groundnuts shell	56,983	48%	27,352	25,481
Corn cob	40,973	52%	21,306	19,848
Sesame residues	4,979	37%	1,842	1,716
Soybean residues	4,249	39%	1,572	1,544
Cotton stem	156,800	42%	65,856	62,811
Straw	4,130,000	47%	1,941,100	1,808,305
Leaves of A. indica	2,165,700	37%	801,309	706,139
Total				2,652,912

By valuing all the indicated biomass in table 4, the Far North Region would have a production more than 2.65 million tons of ecological charcoal. The calorific value report of carbonized ecological charcoal on the uncarbonized ecological charcoal, ensures the one having more energy. The table 6 illustrates the different biomasses calorific value, the carbonization and the energy report.

Table 6: Calorific value of biomasses

Biomass	LHV for uncarbonized biomass (MJ/kg)	LHV for carbonized biomass (MJ/kg)	Report: LHV of carbonized charcoal/LHV of uncarbonized charcoal
Sorghum husk	16.64 ± 0.19	22.59 ± 0.43	1.36
Rice husk	10.99 ± 0.23	14.54 ± 0.55	1.32
Groundnut shell	19.07 ± 0.21	26.28 ± 0.55	1.38
Cotton stem	19.63 ± 0.79	21.69 ± 0.18	1.10
Corn cob	17.52 ± 0.11	21.93 ± 0.10	1.25
Sesame residues	15.52 ± 0.57	20.99 ± 0.12	1.35
Soybeans residues	17.78 ± 0.02	21.65 ± 0.03	1.22
Straw	13.13 ± 0.14	22.25 ± 0.35	1.69
Leaves of A. indica	22.65 ± 0.44	24.34 ± 0.04	1.07

Tableau 6 shows that the carbonized biomass contains more energy than they are not carbonized. Among the different biomasses used, the groundnut shell contains more energy (26,28 ± 0,55 MJ/kg), followed by the leaves of A. indica (24,34 ± 0,04 MJ/kg) and the rice husk is the one with the least energy (14,54 ± 0,55 MJ/kg). Table 7 gives the quantity of energy contained in the different biomasses used for ecological charcoal. The total energy of a biomass is the product of the quantity of biomass that multiplied by its calorific value.

Table 1: Total quantity of energy

Biomass	Quantity of biomass (t)	LHV (TJ/t)	Average total energy (TJ)
Sorghum husk	12,876	0.022	291
Rice husk	14,192	0.014	206
Groundnut shell	25,481	0.026	670
Cotton stem	19,848	0.022	1,362
Corn cob	1,716	0.022	33
Sesame residues	1,544	0.022	435
Soybeans residues	62,811	0.021	36
Straw	1,808,305	0.022	40,235
Leaves of A. indica	706,139	0.024	17,187
TOTAL			60,456

In considering the calorific value (in TJ/t) the carbonized raw materials (table 4) that multiplies the quantity of each biomass type (table 2). We obtained a total of 60,456 TJ. In average an individual needs 0.75 kg of ecological charcoal per day to cook, the equivalent of 16.35 MJ. Thus, the briquette made from different waste could cover the needs of 10 million inhabitants per year, either 2 times the needs of Far North populations for cooking fuel. Theoretically, the potential production of ecological charcoal in the Region could substitute 2,5 million tons of wood fuel in average. On the base of 2.63 tons of wood/ha (GIZ, 2012), the briquette could preserve 956,000 ha of forest in Far North. Since Far North in general has a total surface area of about 3,420,464 ha (MINFOF, 2014).

On behalf of an intensive sensibilization will be necessary on the adoption of charcoal (Mwampamba and al., 2013). If nothing will be done in the afforestation or reforestation and the promotion of alternative energy and if and only if the daily consumption per inhabitant will not fluctuate much, the quantity of exploitable wood fuel would hardly cover around 30% of population needs in 2050. So, the Region will be in deficit of 1.7 million tons of wood fuel which will be extracted from the national parks and forest reserves. Thus, the Region will be submerged in a catastrophic destruction of its ecosystems.

IV. CONCLUSION

This article was about determining the strong pressure exerted on the fragile ecosystems of the Region by internal and external demand for wood fuel and to assess the potential contribution of briquette to the production of energy and stabilization of the forest The Far North Region has a deficit of around of 580,000 tons of wood fuel in 2021. However, if the production and adoption of briquette made from biomass residues (household waste, agricultural residues and agro-industrial, etc.) were effective, the pressure on the fragile ecosystems of Far North will be less. In addition, briquette could contribute to improving the living conditions of the population and environmental conditions of the Region, and also, to create many jobs to the population who would be interested in it.

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REFERENCES

[1]. Black, R..1998. L'impact des réfugiés sur l'environnement écologique des pays d'accueil (Afrique subsaharienne) Autre part (7). 1998 : 23-42

[2]. Brangeon, S., et Bolivard, E., 2017. L'impact environnemental du camp de réfugiés de Minawao. AFD et groupe URD. Extrême-nord, Cameroun. urd@urd.org ; URL : www.urd.org;

[3]. CTFC., 2011. Etat des lieux sur les réserves forestières dans la Région de l'Extrême Nord. Rapport. 35P.

[4]. DR/MINADER/EN, 2018. Rapport d'activités de la délégation régionale de l'agriculture et du développement rural de

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 7 July 2021, pp: 3896-3904 www.ijaem.net ISSN: 2395-5252

l'Extrême-Nord, Cameroun. Campagne agricole 2018/2019, Pp. 42
[5]. FAO, 2017. Forêts et énergie. FAO (consultable à l'adresse URL : www.fao.org/3/a-i6928.pdf).
[6]. FAO,2018. La situation des forêts du monde 2018. Les forêts au service du développement durable. Rome. Licence : CC BY-NC-SA 3.0 IGO.
[7]. GIZ. 2012. Etude sur la situation de référence du bois-énergie dans la Région de l'Extrême-Nord. Cameroun. Par Madi Ali. 232 P.
[8]. HLPE. 2017. Gestion durable des forêts au service de la sécurité alimentaire et de la nutrition. Rapport du Groupe d'experts de haut niveau sur la sécurité alimentaire et la nutrition du Comité de la sécurité alimentaire mondiale. Rome
[9]. HLPE., 2017. Gestion durable des forêts au service de la sécurité alimentaire et de la nutrition. Rapport du Groupe d'experts de haut niveau sur la sécurité alimentaire et la nutrition du Comité de la sécurité alimentaire mondiale, Rome.
[10]. INS (2016). Atlas des statistiques de l'environnement. Yaoundé, Cameroun, 99 P.
[11]. INS, 2011. Annuaire statistique du Cameroun, chapitre 12. 440 P.
[12]. INS, 2015. Annuaire statistique du Cameroun, chapitre 14. 24P.
[13]. INS.2013. Annuaire statistique du Cameroun, 531P.
[14]. Laouali. A. Danguimbo. I., Larwanou. M., Inoussa. M.M., Mahamane. A. (2014). Utilisation de Prosopis africana (G. et Perr) Taub dans le sud du département d'Aguié au Niger : les différentes formes et leur importance. Int. J. Biol. Chem. Sci. 8 (3) : 1065-1074
[15]. Madi. A., 2011. Etude sur la situation de référence du bois-énergie dans la région de l'Extrême Nord. Rapport principal-provisoire. Tome 1. ProPSFE. 113 P.
[16]. Madi. A., HUUB. P. et Babani. S., 2003. La demande urbaine en bois énergie et la nécessité d'une gestion rationnelle des ressources naturelles : le cas de Maroua à l'Extrême-Nord du Cameroun. Actes du colloque. 27-31 mai 2002. Garoua. Cameroun. 9 pp.
[17]. MINFOF (2014). Stratégie de modernisation de la chaine de valeur bois-énergie dans la Région de l'Extrême Nord Cameroun.105 P.
[18]. Mwampamba T.H., Owen M., Pigaht M., 2013. Energy for Sustainable Development. 17 PP 158-170;
[19]. OMS.2013. Gestion des déchets solides en situation d'urgence : fiches techniques eau. Hygiène et assainissement en situation d'urgence (7). 4 P.
[20]. Seignobos, C., Mandjek, I., O.,2000. Atlas de la province de l'Extrême-Nord Cameroun, DOI : 10.4000/books.irdeditions.11540.
[21]. Sharholy. M., Ahmad. K., Mahmood. G., Trivedi. R.C..2008. "Municipal solid waste management in indian cities-A review". Waste management 28 (2). PP.459-467.
[22]. Tata, P. 1997. fuelwood scarcity and distance-price relationship: an economic feasibility study of a plantation establishment in the Maroua area. Pre-professional field report. Dschang, Cameroon, FASA, 18 p.
[23]. Tize, K. J., Ango J. M., Djoulde, D. R.Ngakou, A. (2020). Recovery of cooking energy from waste paper through the production of white coal. Int. J. of Eng. Sci. Inv. (IJESI) ISSN (Online): 2319-6734, Vol. 9 Issue 5 Series III, May 2020, PP 24-29.
[24]. TIZE. K. J., Ango. J.M., Darman. R.D., Ngakou. A. (2020). "Recovery of cooking energy from waste paper through the production of white charcoal." International Journal of Engineering Science Invention (IJESI). Vol. 09 (05). PP 24-29.
[25]. UNCHR (2020). Cameroun Extrême-Nord : statistiques des réfugiés et PDIs. URL:https://data2.unhcr.org/en/documents/details/79026
[26]. UNDP. 2015. About Malawi Online on URL: https://www.mw.undp.org/content/malawi/en/home/countryinfo.html;