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RESEARCH ARTICLE

SOCIO-CULTURAL INDICATORS OF THE CARBONIZATION SECTOR IN WEST AFRICA: CASE OF BENIN

Houénagnon Nestor Agbossaga Badoussi[1], Gildas David Farid Adamon[2], Jean-Louis Comlan Fannou[1], Macaire Agbomahena[3] and Codjo Roland Houéssouvo[3]

1. Laboratory of Engineering Sciences and Applied Mathematics (LSIMA) of the National University of Sciences, Technologies, Engineering and Mathematics of Abomey (UNSTIM), Abomey-Benin.
2. National Institute of Advanced Industrial Technology (INSTI) Laboratory of Processes and Technological Innovation (LaPIT) Lokossa-Bénin.
3. Laboratory of Electronics, Telecommunications and Applied Computer Science (LETIA), Polytechnic School of Abomey Calavi (EPAC/UAC)

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Abstract

In Benin, charcoal/firewood occupies an important place in the energy balance (i.e. 62%), with negative impacts on the environment. The objective of this work is to take stock of the carbonization sector in Benin, based on the development of socio-cultural indicators. To meet this objective, an inventory of the sector was carried out through a survey carried out in nineteen (19) municipalities in the country. From the data collected, it appears that only 36% have received training on improved carbonization technology and only 26.17% of them manage to actually use it during their activity. With an integration rate for women of around 7.97%, this sector capitalizes on several years of experience: more than 56.28% of artisanal charcoal makers have a seniority rate of more than 10 years. This work provides an overview of the carbonization sector in Benin and allows us to see the weakness of this activity on an environmental, economic, cultural and social level. This work provides an overview of the carbonization sector in Benin and allows us to see the weakness of this activity. Thanks to this work, it is possible to have, as precisely as possible, the challenges faced by the different players in the sector as well as some of the solutions that we propose.

Introduction:-

The crisis that is currently shaking the energy sector in the world and particularly in Benin constitutes a handicap for all sectors of activity and therefore for the development of the country. In 2022, theywere studying the importance of forests in combating climate change in southern Benin and the importance of protecting them. They concluded that South-eastern Benin is becoming increasingly arid in its subequatorial climate[1];this is an illustration of why solutions must be found.

In 2019, in the intervening years, they investigated, developed and deployed various bioenergy sources with the aim of limiting the impacts of climate change and improving the reliability of energy supplies [2]. To meet their energy

Corresponding Author:- Houénagnon Nestor Agbossaga Badoussi
Address:- Laboratory of Engineering Sciences and Applied Mathematics (LSIMA) of the National University of Sciences, Technologies, Engineering and Mathematics of Abomey (UNSTIM), Abomey-Benin.

needs, the people of Benin use charcoal. The production of this charcoal is mainly done by small-scale farmers who use timber obtained from non- sustainable resources and use ineffective charcoal burning methods, causing the depletion of the ecosystem [3]. The charcoal is usually obtained through the pyrolysis of firewood in a low-oxygen or oxygen-free environment. It is commonly used in both domestic and household cooking in agricultural and urban areas due to its high heating value and smokeless nature [4]. As the world faces the problems of climate change caused by deforestation and expanding industrialization, the production of charcoal while achieving a profitable carbon footprint is a beneficial business that deserves to be promoted. Such initiatives require the inclusion of all major actors in all aspects of efficient charcoal manufacturing and marketing [5].According to some authors, coal production is one of the largest emitters of greenhouse gases, and therefore, this activity must be properly controlled to reduce its impact [6].

However, the carbonization methods used by charcoal makers are the most archaic based on traditional millstones with low yields.The techniques used on carbonization sites in Benin are traditional, with very low yields, which contribute to deforestation [7]. At the advent of carbonization in Benin, charcoal makers for the most part did not master the process and used archaic technologies based on traditional millstones, with low yields (less than 15%). Many research projects are investing through training on modern carbonization technologies with good yields and good process management for charcoal burners to correct this situation, which has enough harmful consequences for both operators and forests and the environment [8].

Furthermore, some work has also focused on the durability, safety and energy performance of coal stoves in Benin; at this level, it should be remembered that clay fireplaces have better energy performance compared to metal ones[9]. From 2020, several projects funded by the European Union and the United States Development Program have contributed to building the capacity of several artisan charcoal makers on modern carbonization techniques using highly energy-efficient grindstones. The objective being not only to improve the energy efficiency of carbonization, by reducing the strong pressure exerted on forest covers, but also and above all to contribute to the professionalization of the "wood energy" sector in Benin [10][11].

Carbonization therefore appears to be a threat to both forest resources and the environment. In the particular case of Benin, for example, the estimates of the environmental action plan of June 1993, which is still being updated, reveal that the forest is shrinking on average by 100,000 ha per year [12]. While charcoal manufacture is a leading cause of forest deforestation in most areas of Benin, their production differs significantly from that of other charcoal-growing regions in the country. The objectives of this work are to make an inventory of the sector of carbonization in Benin, to then propose an approach of solutions to all of the problems noticed in this study in order to enhance the charcoal production yield and reduce the environment impacts of the sector.

Methodology:-

The methodology used for data collection is based on a survey carried out on an average of four hundred (400) charcoal burners distributed in nineteen (19) municipalities located in six departments of the country including Atlantique, Couffo, Zou, the plateau, the Hills and the Donga. The various targeted municipalities were selected based on information received on their productivity in the carbonization sector. This information was obtained through a preliminary survey carried out among coal dealers in urban areas such as Cotonou, Abomey-Calavi, Porto-Novo and Bohicon as well as the drivers of large carriers transporting coal from the production sites to resellers. However, the production of coal in our various municipalities today depends on the availability of plant resources in them. Thus, we conducted our surveys in the municipalities of Zè, Allada, Toffo, Tori, Zogbodomè, Za-kpota, Covè, Zangnanado, Agbangnizon, Djidja, Klouékanmè, Dassa-zounmè, Savè, Bantè, Bassila, Savalou, Kétou, Glazoué and Ouesse. The data collected will then be used for experimental and analytical purposes. For an in-depth inventory of the carbonization activity, a survey was carried out in the departments and municipalities mentioned above with the charcoal burners. As a prelude to this survey, another was carried out among wholesale dealers and transporters of coal for an orientation of the survey proper which, which was carried out in nineteen municipalities, with a view to identifying on the one hand the different technologies used by charcoal makers, forest species as well as the different problems that govern the carbonization sector in Benin. The objective of this approach is to take stock of the situation, and then, based on the results of the survey, to propose possible improvements to the sector, with a view to the sustainable management of plant resources. Information is collected in the field from a survey sheet for both coal producers and transporters and retailers. For a good representativeness of the target population, an average number of twenty (20) charcoal burners is surveyed per municipality. Those surveyed do not produce less than two hundred (200) bags per year. This criterion means that in some of the targeted municipalities, the number of charcoal burners

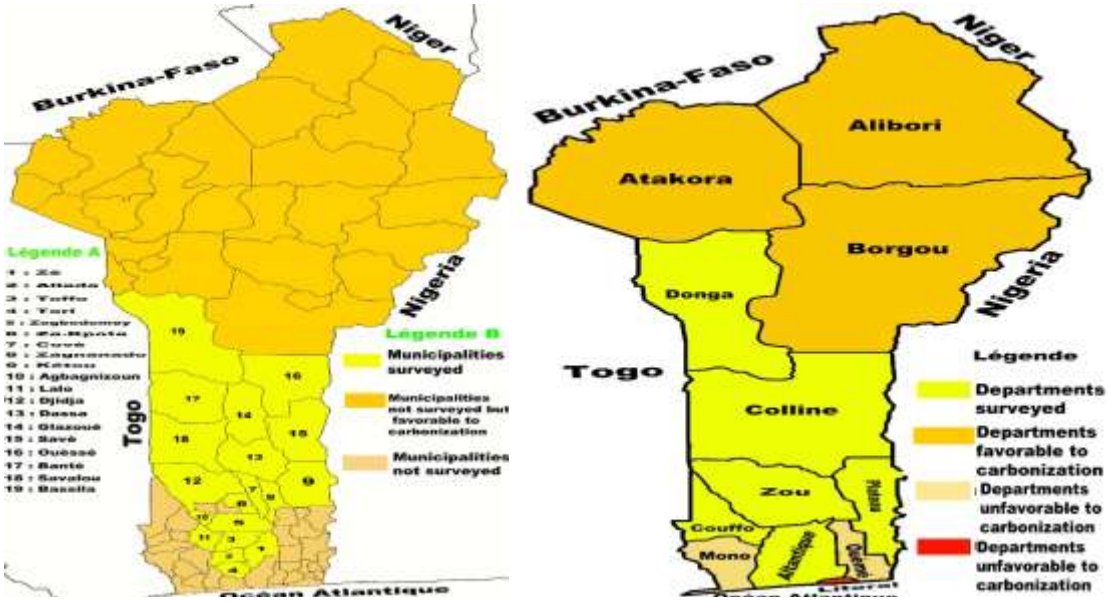
identified does not reach the average of twenty charcoal burners envisaged. On the other hand, in other municipalities it is above the average. As for the preliminary survey, it is conducted in urban and peri-urban areas with a high consumption of charcoal, such as Abomey-Calavi, Cotonou, Porto-Novo and Bohicon. In general, the data collected by the preliminary investigation focused on:

- Charcoal supply municipalities;
- The quantity of charcoal (number of bags) received at each supply;
- The periodicity of the supply;
- The average number of trips made in a month;

The investigation itself focused on:

- The number of years of experience of charcoal burners in the carbonization;
- The average annual production capacity;
- The coal production period;
- The gender approach in the carbonization sector;
- Any training received by the charcoal miner;
- The technology used: the type of millstone, the shape, the dimensions and the number of bags of charcoal produced on each occasion;
- The different forest species used and the one(s) which gives(s) good quality of charcoal;
- The products obtained at the end of carbonization;
- Difficulties encountered during the production;

The data collected by this approach are both quantitative and qualitative. Qualitative data will be directly analyzed while quantitative data will be processed by Matlab and Adobe Photoshop software for statistical purposes. The different municipalities surveyed and the state of carbonization in the departments are respectively as follows (Figure 1) below:



(a) (b)

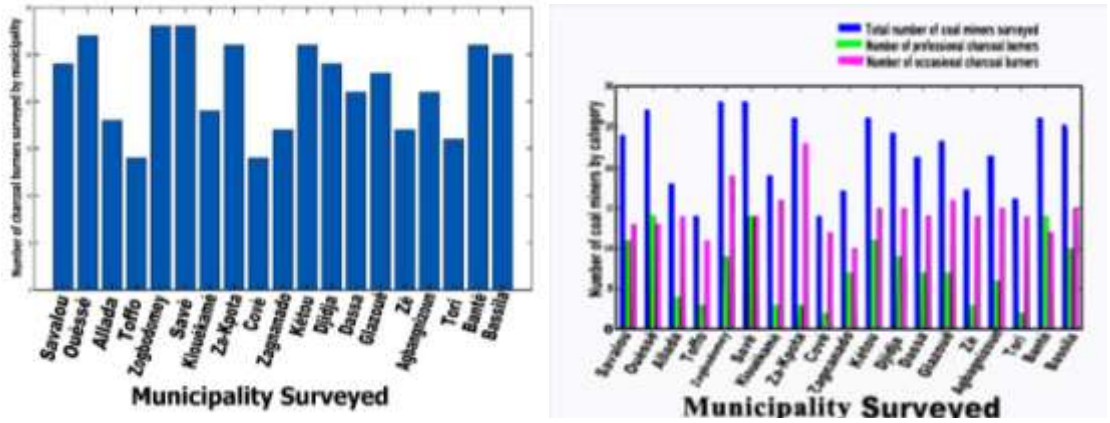
Figure 1:- Different municipalities surveyed (b) State of carbonization in the departments of Benin.

Results and Discussion:-

To immerse ourselves in the realities of the carbonization sector in Benin, our investigations were carried out in nineteen (19) communes of the country. In the different municipalities, we surveyed a total of 414 charcoal burners distributed in the nineteen (19) municipalities through the histogram below. The charcoal makers surveyed in each municipality have at least ten years of professional experience in the carbonization sector with an average annual production of at least two hundred bags. The highest number, i.e. 28 charcoal burners, was obtained in the municipality of Zogbodome while the lowest number, i.e. 14 charcoal burners, was recorded in the municipalities of

Cove and Toffo (Figure 2.a) below. We are now interested in the distribution of charcoal burners by municipality and by category. This will allow us to ensure the quality and veracity of the data collected (Figure 2.b).

These first results obtained are similar to those obtained by Dominique in 2000. In fact, for the latter, most of the charcoal producers came from further north, mainly in the Zou province, due to the shortage of production areas[13].



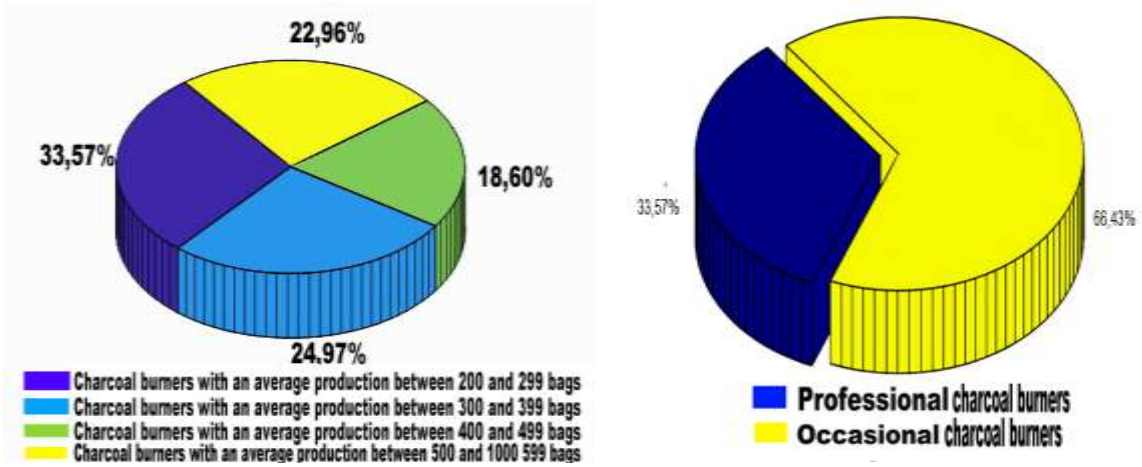
(a) (b)

Figure 2:- (a) Histogram of distribution of charcoal burners surveyed by municipality;
(b) Distribution of charcoal burners by category and by municipality.

In this work, we investigate also on the proportion of the occasional charcoal burners and the professional charcoal burners. We found that the occasional charcoal burners largely exceed the professional charcoal burners (Figure 3.a). Out of a population of 414 coal workers surveyed, 275 (nearly two-thirds) or 66.43% are occasional workers against 139 professionals who constitute 33.57% of the total workforce. The communes of Zogbodomey, Kétou, Bantè, Savè, Ouèssè, Djidja, Zagnanado, Savalou and Bassila therefore constitute the center of carbonization compared to the rest of the communes surveyed. This situation can be explained by some key factors for the carbonization activity. In fact, occasional charcoal burners are neither sufficiently supervised nor trained in technologies likely to bring significant added value to their activity. The results obtained in (Figure 3.a) are consistent with those obtained by Gautier et al. in 2009. In fact, they noted during a study that the number of occasional charcoal burners is greater than that of professionals[14].

Moreover, forest resources already in short supply are still overexploited; producers are therefore oriented towards other activities in order to ensure their financial balance. An overall distribution according to seasonal production capacity is shown in the figure below (Figure 3b). In fact, one hundred and thirty-nine (139) charcoal makers out of four hundred and fourteen (414) have an average annual production of between 200 and 299 bags, 103 have their average annual production of between 300 and 399 bags, 77 have their annual production between 400 and 499 bags and 95 charcoal burners each have an average annual production of between 500 and 1000 bags. It should be noted that the average annual charcoal production is low in the communes of Zè, Tori, Toffo, Covè, Allada, Agbangnizoun and Klouékamè. In these municipalities, the majority of charcoal makers are occasional workers due to the shortage of the most appropriate wood species for carbonization in order to have reliable information at the end of our investigation, our investigations are based on charcoal burners having at least ten (10) years of experience in the activity of carbonization. In doing so, we hope to have information for at least the last ten years on the wood carbonization sector in Benin. These data, obtained on a small scale, illustrate the extent to which charcoal is widely used in households in Benin.

These results match those found in a study carried out by the Energy Information System in 2020. In this report, in Benin, the biomass consisting essentially of charcoal (mostly) and firewood, represents approximately 62 % [15]. Even in 2022, according to the European Union, charcoal consumption has further increased according to the second forest inventory, further increasing the degradation of forest cover [16].



(a) **(b)**

Figure 3:- (a): Overall distribution of charcoal miners by category.
(b): Overall distribution of coal miners by annual production capacity.

Thus, we distinguish twelve (12) charcoal makers who have been in this sector of activity for at least forty years, forty-one (41) charcoal makers have an experience of between thirty and forty years excluded. The majority (56.28% corresponding to a workforce of 233 out of 414) of the sample is located in the first interval class and have at least ten years' experience in carbonization and finally 30.92% of the he samples, for a workforce of 128 out of the 414 coal miners surveyed, have professional experience of between twenty (20) and forty (40) years excluded. It is therefore a population of coal miners quite experienced in the exercise of the activity of carbonization that we investigated during our investigations in the field. The information collected at the end of this survey seems to us relevant and reliable with regard to a comparison made with that available in the literature.(Figure 4) presents a distribution of coal workers by class of professional experience. In each interval, we have the number of charcoal burners in each of the 19 municipalities. It can be seen that the workforce is practically decreasing when the number of years of experience increases. The less experienced with at least 10 years of professional experience are therefore predominant in all municipalities.

In 2021, P. Olenga et al. carried out many studies in the same area by working on the years of experiences of charcoal makers. They obtained a similar result on two categories of years of experience (less than 5 years and greater than or equal to 5 years of experience in the charcoal industry): they conclude that the average seniority as charcoal burner was 8.1±3.5 years old [17].

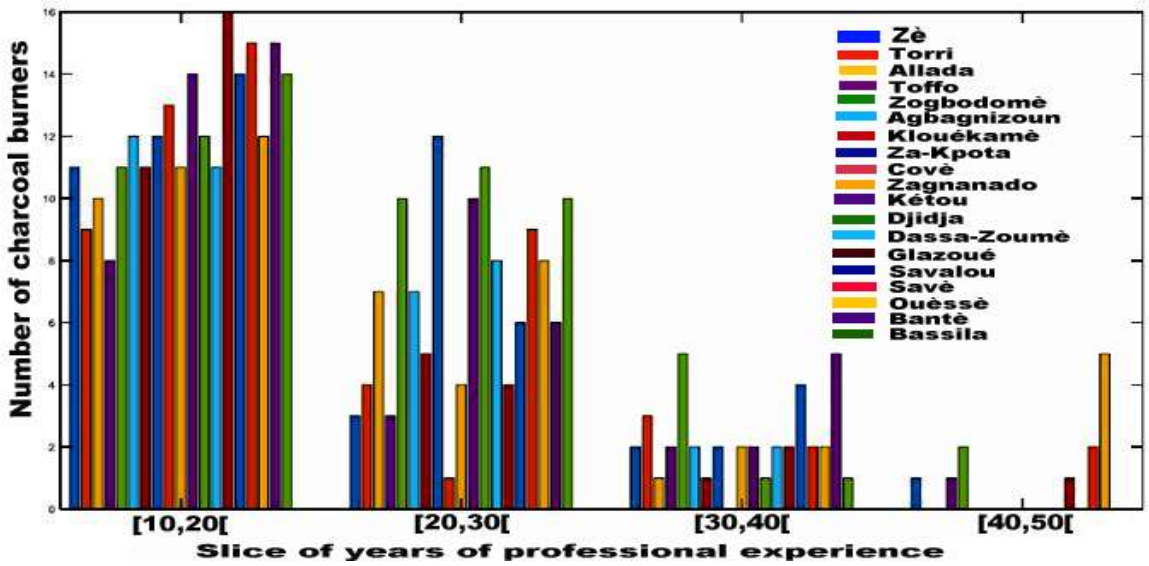
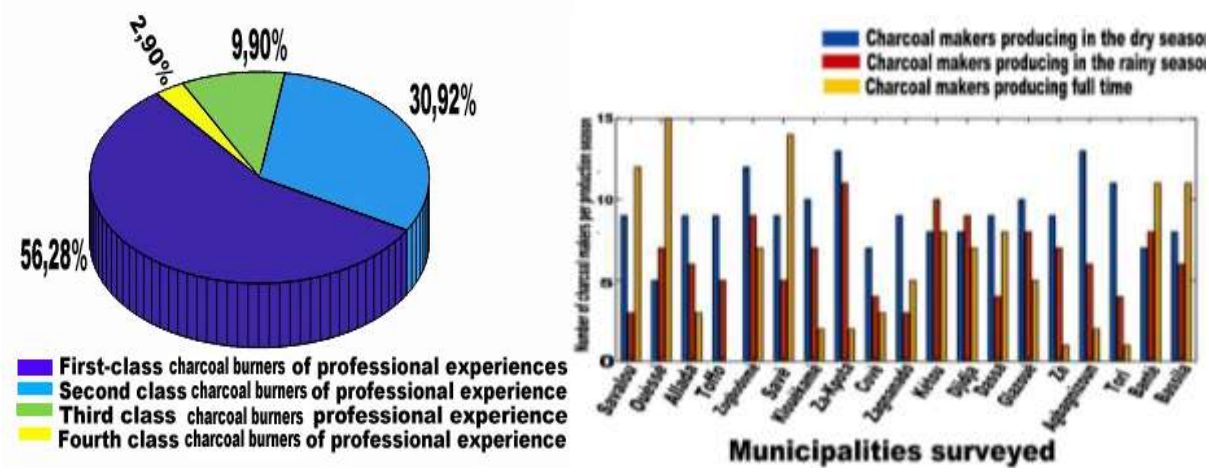


Figure 4:-Distribution of coal miners according to their seniority in the sector.

These data are reinforced by the results shown in (Figure 5.a). While (Figure 5.b) is showing the distribution of charcoal burners by production period and by municipality, (Figure 5.a) shows the overall distribution of coal workers by class according to their professional experience: First class(10-20 years), second classs(20-30 years, Third class (30-40 years, and fourth classs (40 -50 years).

On the question of knowing the favorable period for carbonization, from one municipality to another, the results of the charcoal burners surveyed vary according to three modalities: dry season, rainy season and full time. According to the charcoal makers, the production of charcoal in the dry season is very difficult due to the shortage of water. Indeed, the sand is dry and becomes unstable to ensure the closing of the grinding wheel before ignition and during carbonization. Continuous monitoring is essential for producers (even during the night) to prevent a collapse of the layer of sand serving as cover for the load, which can cause complete combustion.Under these conditions, a large quantity of ash is obtained instead of coal. As a result, the efficiency of the operation weakens with high losses in mass of coal. On the other hand, in the rainy season, water is available and the soil is wet. As a result, the sand taken to close the loaded wheel is stable. Although monitoring is always necessary, it is not necessarily as frequent as it is in the dry season.

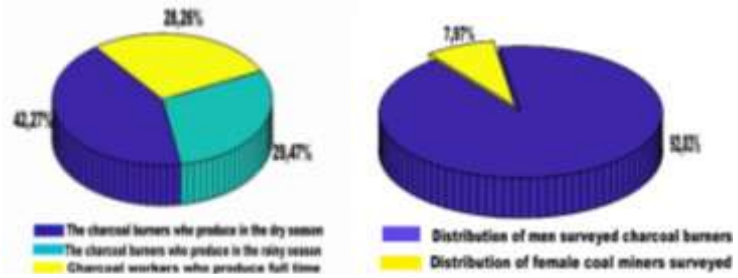


(a) **(b)**

Figure 5:- (a) Overall distribution of charcoal burners by seniority in the wood carbonization sector**. (b)**Distribution of charcoal burners by production period and by municipality.

The distribution of charcoal burners by production season is done independently in order to make an objective and relevant analysis. Indeed, the charcoal makers who practice the activity full time are practically made up of entrepreneurs in the carbonization sector, that is to say the charcoal makers with production sites with workers who work their full time. For those who work seasonally, it's a mix of professionals and amateurs (occasional charcoal burners). Overall, it can be seen on (Figure 6.a) that charcoal makers who carry out the activity in the dry season are predominant with 42.27% for a workforce of 175. The latter are followed by charcoal makers who produce only in the rainy season with 29.47% for a workforce of 122 and finally, the charcoal makers who produce at any time come in last place with 28.26% for a total workforce of 117. Those who produce only in the dry season are mainly made up of occasional charcoal makers, in particular low-income farmers converted to charcoal makers during their period inactive. Despite the difficulties associated with carbonization in the dry season, the latter are forced to engage in this activity for economic reasons. The (Figure 6.a) below is only an overall breakdown of the results presented by municipality.

The activity of carbonization is quite difficult in terms of the physical effort required. However, we have identified according to (Figure 6.b), a few rare women in the workforce of charcoal burners in the field in a few municipalities, notably in Covè, Zagnanado, Savè and Ouèssè. The (Figure 6.b) shows the integration rate of women in the carbonization sector.



(a) (b)

Figure 6:- (a). Overall distribution of charcoal makers by production period.
(b). Global distribution of charcoal burners according to the gender approach.

The activity of carbonization is mainly carried out by men. Indeed, out of 414 coal miners surveyed, 381 are men for a percentage of 92.03% against a workforce of 33 for women with an integration rate of around 7.97%. This low rate is explained by the difficulties related to the exercise of the carbonization activity. These female great titans, mostly made up of occasional great titans, are found in the communes of Covè, Zagnanado, Savè, and Ouèssè. In the other communes, the women encountered are not actually great titans. They assist their husbands in the field of carbonization by drawing water to moisten the sand or by preparing meals for the workers and sometimes by helping to transport pieces of wood cut to the carbonization sites.

In comparison to the work carried out by Ihalainen M. et al. in 2021, the proportion of women in charcoal production in Benin is relatively low compared to that observed in Kenya. Indeed, they noted that the rate of integration of women in the "charcoal" sector varies depending on the regions and socio-economic conditions, between 17% and 55%, compared to around 8% in Benin. Although this rate remains low, the gap can be explained by the extreme poverty which affects the female population, in addition to the arduousness of the various carbonization tasks, which makes this activity masculine [18].

In the (Figure 7) below, we present a comparative study based on coal miners who survived training or not by municipality and on the total number surveyed. From one commune to another, the charcoal burners surveyed in various proportions received training at least on the control of driving and the improvement of the efficiency of the carbonization process. In the light of the results of the (Figure 7), it can be seen that only 36% of the coal miners surveyed have taken capacity building training on improved carbonization techniques. On the other hand, the observation on the ground is not satisfactory.

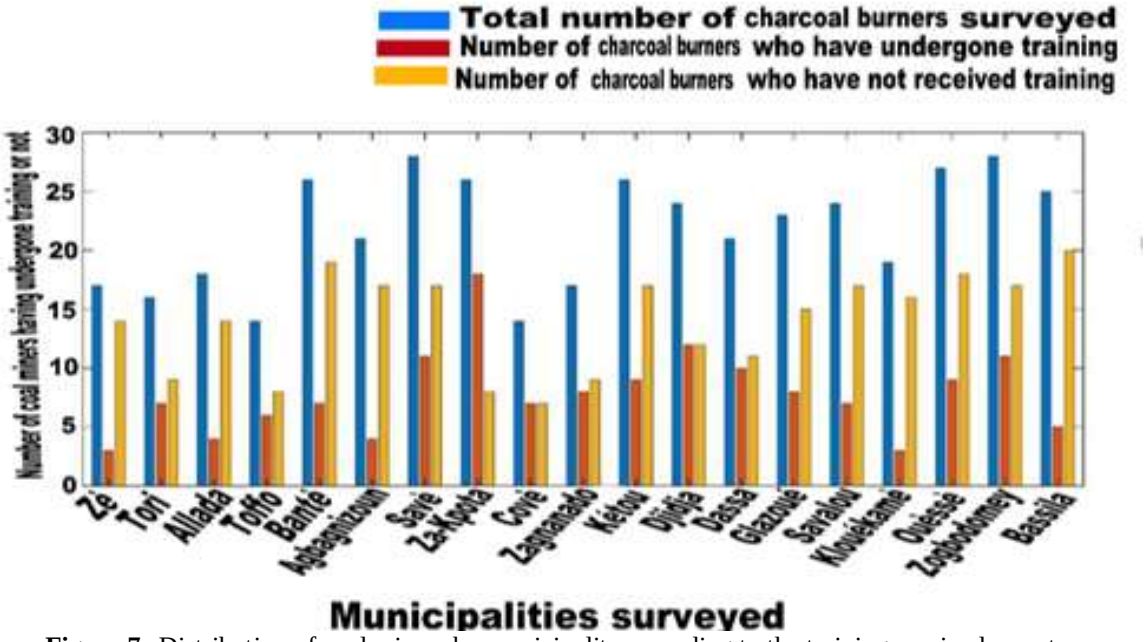


Figure 7:-Distribution of coal miners by municipality according to the training received or not.

In fact, out of a workforce of 149 charcoal makers trained in improved grinding wheel technology, more specifically in the "Casamançaise GV-type grinding wheel", only 39 charcoal makers (i.e. a rate of 26.17% from those who had undergone training in less) or overall 9.42% of the total number of coal workers surveyed, use the technology resulting from the training for the benefit of their daily activity (Figure 8).

In 2020, the study of GIZ in collaboration with ECO consult has showed that the adoption of the Casamance millstone is more limited in areas where charcoal burners have been trained in the technology.They recommended to increase the rate of training[19].

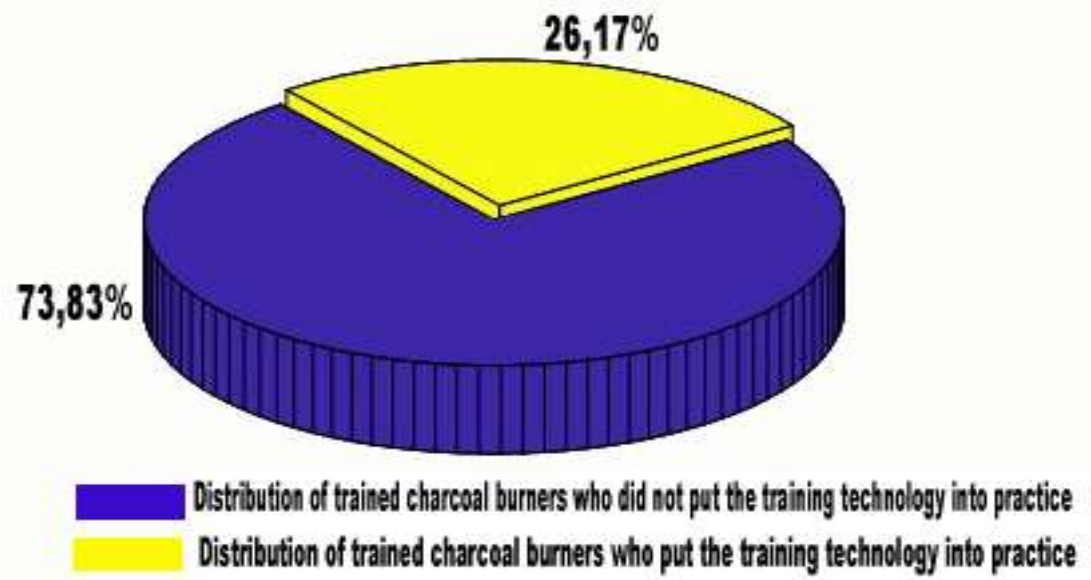


Figure 8:- Distribution of trained coal miners according to the adoption or not of improved technologies.

According to the qualitative data collected, the objective targeted by most charcoal burners who have taken the training is different: that of receiving training bonuses. The latter think for the most part of the possible remuneration at the end of the training. In addition, there are also many who believe that the Casamance grinding wheel of the “GV” type is difficult to assemble, and that they would be ready for a grinding wheel with high energy efficiency, easy to assemble and maintain.Our different methods of investigation: visit to carbonization sites, survey questionnaires for wholesale coal dealers, transporters and coal makers have enabled us to take stock of the organization of the sector in Benin. The analysis of the data collected made it possible to make the diagnosis. In view of this diagnosis, we have considered approaches to solutions. It's about:

- to offer a grinding wheel with high energy efficiency, robust and easy to assemble and maintain;
- focus on capacity building for improved carbonization technologies on the basis of well-defined criteria, with rigorous monitoring of the change in technological practices;
- to promulgate the decree which will rule on the exercise of carbonization;

In view of this study, which we qualify as a diagnostic study, which is only our modest contribution to the sustainable management of the wood carbonization sector in Benin, we believe that it is important that other studies contribute to the resolution of the problem posed. It will therefore be a question of realizing and experimenting with a new improved carbonization technology that meets the conditions mentioned above.

Conclusion:-

In short, Charcoal production in Benin is growing and demand for charcoal is increasing exponentially. There is therefore an urgent need to improve production techniques in order to increase charcoal yields and reduce environmental impact. We notice that the technologies used in charcoal production in Benin are still archaic and have lower efficiency and negative impact in environment. The integration of women in the sector is still difficult. Many coal miners don’t have access to good training on the modern technologies depending of the area of living. The technology based on traditional grinding wheels remains today the technology used by more than 90% by the producers surveyed. However, more than 30% of these charcoal burners have been trained in the use of improved technologies based on Casamance grinding wheels with variable geometry (Casa-GV) with better yields. The

novelty of this work is that it highlights the strengths and weaknesses of the carbonation sector in order to provide specific recommendations for improving the process. In addition, this work provides a clear mappingof the charcoal makers in Benin with their monthly production to help any future work to know with as much accuracy as possible, where they can act to have a good result and a real impact.

To make this sector of activity more efficient, it will be necessary to build the capacities of charcoal makers in modern process management techniques and encourage them to put these techniques into practice in order to improve performance and professionalize them.

Particular attention from the Ministry of Social Affairs must be paid to these women to alleviate their economic difficulties a little. Added to all recommendations, many studies need to be carried out to develop news technologies of carbonization more adapted to Benin realities.

References:-

[1] Kingbo A, Teka O, Aoudji AKN, Ahohuendo B, Ganglo JC. Climate Change in Southeast Benin and Its Influences on the Spatio-Temporal Dynamic of Forests, Benin, West Africa.Forests. 2022, vol. 13, No. 5.https://doi.org/10.3390/f13050698.

[2] HammarT,Stendahl J, Sundberg C, Holmström H, Hansson PA. Climate impact and energy efficiency of woody bioenergy systems from a landscape perspective. Biomass and Bioenergy.2019, vol. 120, 189–199. https://doi:org/10.1016/j.biombioe.2018.11.026.

[3] Mensah KE, Damnyag L, Kwabena NS. Analysis of charcoal production with recent developments in Sub-Sahara Africa: a review.AfricanGeogr. Rev.2022, vol. 41, N°1, 35–55.https://doi:org/10.1080/19376812.2020.1846133.

[4] Schure J, Ingram V, Sakho-Jimbira MS, Levang P, Wiersum KF. Formalisation of charcoal value chains and livelihood outcomes in Central- and West Africa.Energy Sustain. Dev. 2013, vol. 17, N°. 2, 95–105.https://doi:org/10.1016/j.esd.2012.07.002.

[5] Andaregie A, Worku A, Astatkie T. Analysis of economic efficiency in charcoal production in Northwest Ethiopia: A Cobb-Douglas production frontier approach.Trees, For. People. 2020, vol. 2.https://doi:org/10.1016/j.tfp.2020.100020.

[6] Sovacool BK, Bazilian M, Griffiths S, Kim J, Foley A, Rooney D.CDecarbonizing the food and beverages industry: A critical and systematic review of developments, sociotechnical systems and policy options.Renew. Sustain. EnergyRev. 2021, vol. 143. https://doi:org/10.1016/j.rser.2021.110856.

[7] YakoubouIssifou A, Fifamè Murielle Féty TONOUEWA J, Sorotori Honoré BIAOU S, Dèhouégnon HOUEHANOU T, Idrissou Y. Technique de carbonisation du bois au Nord-Ouest du Bénin, Afrique de l'Ouest.AfriqueSci. 2020, vol. 16, N°. 2, 49–59.Available from: http://www.afriquescience.net

[8] Steckel JC, Hilaire J, Jakob M, Edenhofer O. Coal and carbonization in sub-Saharan Africa.Nat. Clim. Chang. 2020, vol. 10, N°. 1, 83–88. https://doi:org/10.1038/s41558-019-0649-8.

[9] Ekouedjen E, Fagbemi L, Zannou-Tchoko S, Bakounoure J. Energy performance, safety and durability of charcoal cooking stoves commonly used in West Africa: Benin case study.AIMS Energy. 2021, vol. 9, N° 1, 68–95.https://doi:org/10.3934/energy.2021005.

[10] RECASEB. RECASEB. 155 new type charcoal makers trained.In Capacity building for artisanal charcoal makers in energy efficiency. 2020.

[11] PNUD.Training of coal miners on new ecological technologies. 2022.

[12] Promdee K, Chanvidhwatanakit J, Satitkune S, Boonmee C, Kawichai T, Jarernprasert S, Vitidsant T. Characterization of carbon materials and differences from activated carbon particle (ACP) and coal briquettes product (CBP) derived from coconut shell via rotary kiln.Renew. Sustain. Energy Rev. 2017, vol. 75, 1175–1186.https://doi:org/10.1016/j.rser.2016.11.099.

[13] Dominique JB. Firewood and charcoal: Evolution of production during the 20th century in southern Benin.A. CORVOL, Wood as a source of energy: then and now. 2000, Study book N°10 Forest, environment and society, CNRS, 30-38.

[14] Denis G, Ouedraogo G, Zacharie B. Support for the definition of development strategies for the agro-sylvo-pastoral and fisheries sectors selected in the regions of intervention of PADAB II, Support Program for the Development of Agriculture in Burkina Faso, Phase II Component N° 2: Decentr.Wood energy Sect. report. 2009, Center-East Reg.Available from:
https://hal.science/hal-01091673/document.

[15] System E. Directorate General of Energy Resources of Benin. Key figures 2021.Energy Balanc. Indic. 2020.
[16] RECASEB. National Forest Inventory 2 TDR:093-RECASEB-AT-IFN2: Technical Assistance as part of the support institutional and capacity building players in the energy sector in Benin: Energy potential of basins supply of wood energy from the Benin. 2022.
[17] Pierre O, Vuvu L, Augustin R, Buhendwa H, Bikuku N, Claude K, Augustin M. Respiratory risk behavior, prevalence and determinants of bronchial obstruction among charcoal workers in Kinshasa.Ann. Afr. Med. 2021, vol. 14, N° 4, 34–45.https://doi:org/10.1103/PhysRevB.60.4675.
[18] Ihalainen M, Awono A, Banda E, Moombe K, Mwaanga B, SchureJ.Women and this persistent anomaly in the coal sector timber: gender mainstreaming approaches for results more inclusive, equitable and sustainable.Sustain. Wood Energy. Indones. 2021, Nairobi, Kenya CIFOR-ICRAF. N° 2.[Online]. Available from:https://www.cifor.org/publications/pdf_files/Brief/8282-SWB-Brief-2.pdf
[19] Consult G. Improved coal production from Capitalization Models scrap from sawmills in the East-Cameroon region. 2020.