ESTIMATING NATIONAL CHARCOAL PRODUCTION IN GHANA

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Tropenbos Ghana

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K. S. Nketiah

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EXECUTIVE SUMMARY

Wood fuels, including charcoal, form an integral part of Ghana's energy mix. To meet its increasing energy demand, the country is not only devoted to the provision of clean energy, but also ensuring that wood fuels, especially charcoal is sourced, processed and traded in a sustainable manner. However, there is a dearth of accurate and up-to-date information on the quantities of charcoal produced annually. Policies are therefore built on guess-estimates. Thus, making available credible information on national charcoal production level is urgent and necessary to inform the country's efforts towards developing sustainable charcoal value chain to meet the country's growing energy demand and secure livelihoods.

Several past studies have attempted to provide statistics on charcoal production level; these include Nketiah *et al.* (1988), Anang *et al.* (2011) and the Energy Commission's (EC) energy projections. These however are either outdated, have limited scope or are based on weak assumptions; some also do not clearly outline the methodology used. The absence of more accurate and current estimates of national charcoal production level prompted this study to estimate the annual national charcoal production. It was carried out by Tropenbos Ghana under DANIDA funded project titled "Property, Access and Exclusion along the Charcoal Commodity Chain in Ghana", which is implemented in partnership with University of Ghana, Kwame Nkrumah University of Science & Technology and University of Copenhagen. The objective of the study is to establish credible estimates on national charcoal production to serve as basis for, and to inform, policy dialogue on developing a sustainable charcoal value chain.

The study consisted of three sub-studies: the first established the weight distribution of charcoal in Ghana by determining the mean weights of various charcoal bags in Ghana by taking sample bag weights from across the country. The second ascertained the carrying capacity (load) of various charcoal conveying vehicles and the third compiled and validated Forestry Commission's records on charcoal production quantities as captured by the charcoal conveyance certificates. The last sub-study included mounting four sentries, around the clock for two weeks, to gather primary data on charcoal in transit. Based on the established mean weights of the various charcoal bags and the quantities transported by the vehicles, an annual national production estimate could be established.

Main findings

- It is estimated that 590,000 metric tons of charcoal was produced in the year 2016 based on data recorded by the FC and adjusted by a correction factor to account for charcoal been conveyed without a charcoal conveyance certificate.
- Brong Ahafo, followed by the Northern, Ashanti and Eastern Regions were the major producing regions, accounting for 34.4%, 26.7%, 18.6%, 13.5% respectively. of the total production in 2016.
- With respect to forest districts, Kintampo is the highest producing area accounting for 22% of the total annual national production, followed by Bole and Atebubu accounting for 14% and 12% respectively.
- Charcoal is produced and transported throughout the year irrespective of the season (wet or dry); but transportation in the wet season is higher. The average monthly movement of charcoal was 49,000 metric tons, with the highest recorded in June (63,000 metric tons) and May (59,000 metric tons) each representing over 10% of the total annual national production February accounted for the least quantity, less than 40,000 metric tons.
- Three main bag sizes are used for packaging charcoal in Ghana: Mini, Maxi and Jumbo. However, for bulk commercial transactions the first two are mostly used due to ease of handling (loading and off-loading). These are mainly jute and poly-propylene sacks, the latter being the more preferred type because of its durability and lower water absorption properties.
- The mean weights of the three bag sizes of charcoal i.e. mini, maxi and jumbo were 37.9 53.8, and 82.0 kg respectively.
- In 2016, about half of the charcoal in Ghana was transported without a charcoal conveyance certificate, based on the collected sentry data

Conclusion

The FC has recently (since 2015) introduced a system of issuing conveyance certificates to cover charcoal in transit. The system can be improved to regularly capture accurate data on charcoal movements to the markets and by extension, charcoal production. Stronger collaboration between the FC and the Police Service at check points can help improve the system. This should be of interest to the Energy Commission and the Ministry of Energy. To confirm the reliability of such a system, the Energy Commission can conduct periodic sentry monitoring to validate routine data from the conveyance certificates. With the proposed improvements and adjustments, data from the FSD on charcoal conveyance could provide a convenient and relatively low cost means of collecting and updating charcoal production statistics.

ACRONYMS

AX	Access and Exclusion along the charcoal value chain
CCC	Charcoal Conveyance Certificate
CP	University of Copenhagen
DA	District Assembly
DEAR	Decentralized Environmental Action Research
EC	Energy Commission
FC	Forestry Commission
FSD	Forestry Services Division
GHA	Ghana Highway Authority
GHS	Ghana Cedis
HPC	Housing and Population Census
IEA	International Energy Agency
KNUST	Kwame Nkrumah University of Science and Technology
LPG	Liquefied Petroleum Gas
MEA	Millennium Ecosystem Assessment
TA	Traditional Authority
TBG	Tropenbos Ghana
TIDD	Timber Industry Development Division
UG	University of Ghana

CHAPTER ONE

INTRODUCTION

1.1 Background

Wood fuels (firewood and charcoal) fulfill the domestic energy needs of about half of the world's population and about 81% of sub-Saharan African households (World Bank, 2011). It is estimated that, over two billion people in developing countries rely on biomass energy in the form of firewood, charcoal, crop residues, and animal wastes to meet their cooking and heating requirements (MEA, 2005). With such reliance on biomass energy coupled with increasing population, the number of people relying on fuel wood is expected to increase; it is estimated that by 2030, about three-quarters of total residential energy in Africa will come from fuel wood (IEA, 2002). Again, there are other studies pointing to increasing global demand for wood fuels especially charcoal (Dzioubinski and Chipman, 1999; FAO, 1993; Broadhead *et al.*, 2001; IEA, 2006 & 2010).

Similarly, in Ghana, notwithstanding measures to promote substitution of charcoal with Liquefied Petroleum Gas (LPG), many urban households still rely on charcoal for cooking and heating (HPC, 2010, cited in Energy Commission, 2014). This high dependence on charcoal may be attributable to the relatively easy accessibility; it can also be purchased in small quantities - an important consideration for poor households (Mombu, 2009). Aside these, charcoal production also forms a key livelihood base for several rural households with an estimated 400,000 people and over a million dependents engaged in charcoal production in the northern and transitional zones of Ghana (Energy Commission, 2006). Furthermore, the trade is a source of revenue for district assemblies, traditional authorities and some government institutions like the Forestry Commission (FC) (DEAR, 2005; Brobbey *et al.*, 2015). The wood fuel sub-sector further supports many informal enterprises including bread-baking, processing of oil-palm, local brews, the traditional textiles industry, traditional soap making, fish smoking and local catering services.

Despite these contributions to national development, the charcoal sub-sector remains poorly regulated (Sawe, 2012), with its production tagged as unsustainable (UNDP, 2014b). However, debates on rationalizing the sub-sector are keenly contested considering its social, economic and environmental implications. Whereas some advocate for a total ban on charcoal production due to its perceived negative environmental impacts, others support the status quo mainly due to its social and economic importance, stressing that other causes rather than charcoal production may be contributing to the negative environmental impacts. (Asante, 2018).

It is important to have accurate and current data to come out with any policy decisions on charcoal. Few studies have attempted to quantify production levels; these include Nketiah *et al*, 1988, Anang *et al*, 2011 and projections by the Energy Commission (EC). The 1988 study is obviously outdated, since much has changed since. The second study was limited in scope; whilst the EC projections have no firm basis; it is not clear how the projections were arrived at. The absence of reliable and current data may be attributable to the high cost of national surveys for gathering such data and poor inter-sectoral coordination.

Given the complexities that surround the charcoal commodity chain in Ghana, coupled with its wider socio-political, economic and environmental dimensions, it is important to find more appropriate approaches and methodologies to estimate national production level more accurately. Such data will provide a strong basis for future studies and also inform policy discussions.

This study therefore identifies how accurate data on charcoal production can be collected at a relatively low cost, using existing practices and actions.

1.2 Problem statement

Whilst the charcoal sub-sector remains poorly regulated, there is a heavy and increasing household dependence on it as a major source of energy and a livelihood activity. Data on the actual level of production is rather thin, especially at the national level. The lack of information impedes informed decision making regarding policy interventions and management practices targeting production, trade and consumption. More accurate information on actual national charcoal production level is therefore needed to guide policy decisions and management practices.

1.3 Objective of the study

The study sought to provide information on the current national annual charcoal production level in Ghana, its distribution over the year and the main geographical production sites.

1.4 Research questions

The study sought to provide answers to the following questions:

- How much charcoal is produced in a year?
- What monthly or seasonal variations exist?
- What are the main production centers?

1.5 Outputs

The main output of the study is this report which gives estimates of the quantity of charcoal produced per annum (in 2016) with an indicative seasonal variation, the main production centres and a map of the charcoal production hotspots in Ghana. The report also proposes how to generate and update charcoal production statistics. The main findings of the report are captured in a policy brief.

1.6 Structure of report

The report is structured into five chapters. Chapter one is the introductory section. It presents the background and rationale for the study. It further spells out the objectives and outputs. Chapter two reviews the approaches used by various studies to quantify charcoal production. Chapter three details out the methodology used for this study. The findings are presented and discussed in chapter four, whilst the implications of the findings are discussed in chapter five with conclusions and recommendations.

CHAPTER TWO

LITEREATURE REVIEW

2.1 Overview of methods for estimating national charcoal production levels

This chapter reviews methods that have been used by earlier studies to estimate charcoal production levels. This was done to help identify best practices that could inform the current study.

Generally, the charcoal sub-sector in most developing countries is often unregulated. In cases where regulations exist, a significant illegal sector typically exist, which is neglected in charcoal production statistics (Mwampamba *et al*, 2013). The informal nature of the sector makes it difficult to capture accurate statistics (*Ibid*; Arayal, 1999; Falcão, 2008; Kisawuzi, 2015; Thrän, 2002; UN, 2014a). Further, lack of proper definitions, i.e. trade forms and properties, makes it difficult to aggregate data at both national and international levels (Trossero, 2002). Charcoal production level is mostly quantified as the number and weight of bags, but depending on how charcoal is produced and the tree species used, these figures will differ. Besides, there are no standard bag sizes; they vary within and across countries (Bekele & Girmay, 2014).

Studies to estimate national charcoal production levels have used different approaches including indirect methods like national energy consumption surveys, value chain analysis, the use of data from issued certificates and data from mounting sentries at both regional and national levels in the countries. These approaches have been used in Kenya (Mutimba & Barasa, 2005; MEWNR, 2013), Uganda (Kisawuzi, 2015), Rwanda (Blodgett, 2011; Munyehirwe et al., 2013), Malawi (Kambewa *et al*, 2007), Eritrea (Arayal, 1999), Cambodia (Francois *et al*, 2015), Haiti (Talter, 2016), Tanzania (Kilahama, nd.) and Ghana (Nketiah *et al*, 1988 & Anang *et al*, 2011).

Data from the FAO, i.e. FAOSTAT, includes a database of 'Wood Charcoal Production in tonnes' for 201 countries across the world, but this only includes production directly sourced from forests; it does not, for example, include charcoal produced from wood residues and farm wood (Whiteman *et al*, 2002).

2.2 The use of data from secondary sources

In countries where the charcoal sector is either regulated or have some form of institutional arrangements in place to monitor the production, studies have estimated production levels by taking secondary data from issued certificates and/or receipts. Since such monitoring and issuance of certificates usually involve payment of some fees, there is the likelihood of people scheming to avoid the payment of fees and hence the capture of their data. On the other hand, unscrupulous officials may connive with charcoal transporters to undercut the system. Such weaknesses may compromise the accuracy of data from such secondary sources. The system however is convenient and can be cheap, since no additional costs will be required to obtain the data.

2.3 The use of data from primary sources

Charcoal production levels have been estimated directly in the field, at the production sites. Based on the average production per producer, the rate of production and an estimated number of producers, the total production can be found. This approach however involves several assumptions. Due to the varying kiln sizes and the varied production practices, coupled with the fact that data on producers are seldom reliable, this is not a very practical option. The method can be used where production methods are standardised and reliable data on the number of producers exists.

Primary data has also been collected from transporters by mounting sentries on major charcoal routes, as charcoal is usually produced in rural areas and consumed in urban centres. Sentries are mounted 24-7 for periods ranging from one day to two weeks or longer. The longer the period, the more accurate will be the data, but costs also rise with duration. Two weeks have been proposed as optimum (Nketiah *et al,* 2000). All trucks passing the sentries during the period are stopped and the quantity, i.e. number of bags and/or weight, of charcoal accounted for. This method has been used in Tanzania (Kilahama, nd), Cambodia (Francois *et al.*), Haiti (Tarter, 2016), and in Ghana (Nketiah *et al,* 2000). For the study in Cambodia, the data collection period was only 24 hours; this however is on the low side and will obviously not reveal any daily fluctuation. The method is relatively accurate, barring any human lapses. However, to be effective and to capture any seasonal variations, the surveillance should be done both for the peak production season and for the lean season and the quantities captured are averaged. It is however expensive and can be tedious. It is therefore used mainly to validate data collected from secondary sources like that from conveyance certificates.

2.4 The use of national charcoal mass balance: Indirect method

National charcoal production levels have also been estimated indirectly from a National Charcoal Mass Balance, using the cross-border flows of charcoal and quantities consumed within the country. The **cross-border flows** are obtained from trade statistics, where they exist. The accuracy of the flow data will depend on how well one is able to identify (and quantify) the different flow-paths (imports and exports, including overland trade). Whiles overseas export (and import) trade data may be readily available and reasonably accurate, overland trade is often difficult to estimate, especially given the porous nature of the borders of most producer countries. Official national statistics seldom cover such trade.

The **national charcoal consumption** figure is obtained from national Energy Consumption Surveys. The accuracy in this case will depend on comprehensive identification and quantification of the different national charcoal usage, including commercial, industrial and domestic uses. Another factor that affects the accuracy of the consumption data will be the rigorousness of the sampling methods. This should allow for proper stratification to account for regional, socio-economic and seasonal differences in charcoal use. For example, it has been reported that during rainy seasons or in mountainous areas more fuel is used for heating (IFAD, 2008; Arayal, 1999; Kambewa *et al*, 2007; Kisawuzi, 2015; Anang *et al*, 2011; Nketiah *et al*, 1988). Again, the accuracy of consumption figures will lie in how well the interviewees (consumer) are able to estimate the amounts of charcoal used; this however might not always be the case (FAO, 2002). Again, this methodology assumes no stockpiling over time and that no quantities go to waste along the commodity chain, especially during loading, transportation and offloading. Then again, one must factor in all non-household use of charcoal e.g. that used by institutional kitchens and for industrial use by small and micro enterprises (Arayal, 1999; Kambewa *et al*, 2007; Nketiah *et al*, 1988).

In Malawi, projected population figures were used and weighted to estimate national consumption rates in different socio-economic zones from the findings of a consumption survey with questions on fuel use, quantities and prices as well as preferences (Kambewa et al., 2007). The accuracy of estimating national charcoal production from national consumption may be convenient if the former can be estimated accurately, through rigorous sampling techniques to fairly capture consumption across the different socio-economic strata of the population.

2.5 Estimations from mathematical models

In some cases, national charcoal consumption is estimated from mathematical models that depend on several parameters; projections are indexed to changes in key variables such as population growth, urbanisation and household energy use. The accuracy of the estimates will depend on the rigour in developing the model and the baseline information that informed the model. Nevertheless, well developed and robust models are useful in projecting consumption and trends.

CHAPTER THREE

APPROACH AND METHODS

3.1 Introduction

From the review in the previous chapter it follows that different methods have been used to estimate national and regional charcoal production, all with varying degrees of accuracy and reliability. Based on the review, and coupled with expert interviews with focal persons in charge of statistics within sector regulatory institutions in Ghana, the study methodology was defined.

3.2 Study area

The study was carried out in all ten regions of Ghana with focus on prominent charcoal producing districts. Sentries were mounted for data collection along four main charcoal routes.

3.3 Pilot activities

A reconnaissance survey was carried out in May/June 2016 to identify all areas with significant production and major charcoal transport routes. This also included a quick assessment of available records on charcoal production and transportation held by Metropolitan, Municipal and District Assemblies (MMDAs) and the Forest Services Division (FSD) of the Forestry Commission (FC). In addition, discussions were held with the Energy Commission (EC) on charcoal statistics and methods used for gathering and generating more reliable and accurate estimates of charcoal production.

3.3.1 Preliminary Findings

The reconnaissance survey revealed that the EC has some projection on national charcoal consumption levels based on household energy (charcoal) use patterns. The EC's projection is based on a model with several parameters including population growth and changes in income. From the MMDAs, it was acknowledged that their main interest is the revenue collected on the charcoal trade; no reliable data on production level is collected or held. With the FC, it was discovered that since December 2015, the it had put in place a system to issue Charcoal Conveyance Certificates (CCC) at a fee of fifty Ghana Pesewas (GHS 0.50) per bag. The fee was determined consultatively with relevant stakeholders. The certificates are issued at the FSD offices and at their checkpoints across the country. The fee is determined from standard loads of various truck types, i.e. there is no physical count of the number of bags on each truck. Transporters are required to send their charcoal load to the FSD offices for inspection, after which the requisite fee is paid and the CCC issued. However, the transporter can also obtain the certificate at the first FC-mounted check-point that is met; at the same fee. The FSD checkpoints are strategically positioned at the entry and exit points of major towns meaning that they are easily accessible to charcoal transporters/merchants.

3.3.2 Description and issuance of the CCC

The CCC holds the following data/information: date of issuance, source (actual production area), number of bags and estimated weight in kilograms (kg), vehicle details (model, registration number), destination and others. Each CCC has a unique identification number which can be traced to where it was issued. The issuer adds date and time of issue and an expiry date which in most cases is within 24 hours of issue. A maximum of 48 hours is permitted in situations where the transportation also includes ferrying across water bodies like the Volta lake before getting to the intended destination. This ensures that a certificate can only be used once.

The certificate is inspected at all FSD and Timber Industry Development Division (TIDD) mounted checkpoints en route from the production site to the final destination. Further inspections are conducted by security agencies (police) on highways during their routine traffic checks to ensure that charcoal in transit has the necessary documentation including CCC.

3.4 Methodology and implementation strategy

Based on the literature review and information from the reconnaissance survey, the study decided to collect CCC data from the FSD district offices. The study team initially visited some selected FSD district offices to assess the comprehensiveness of data captured on the CCCs and identify any weaknesses in the system.

3.4.1 Identified FSD District offices

For the main data collection, consideration was given to all FSD district offices across the country since CCCs can be issued at any FSD office or checkpoint irrespective of the production area or source. At time of the study, there were fifty-one (51) such offices in Ghana, categorised according to region (Table 3.1). For the purposes of this study, they were further classified under two zones from which data was collected (Table 3.2). Zone A comprised FSDs offices in Upper East, Upper

West, Northern, Brong Ahafo, and Ashanti regions while Zone B covered Eastern, Western, Central, Greater Accra and Volta regions.

Table 3.1 Forest districts categorized under their respective regions in Ghana

Regions	**FSDs**
Ashanti	1.Bekwai; 2. Juaso; 3. Kumawu; 4. Mampong; 5. New Edubiase 6.Nkawie; 7. Offinso; 8. Mankranso
Brong Ahafo	1.Atebubu; 2. Bechem; 3. Dormaa Ahenkro; 4. Goaso 5.Kintampo; 6. Sunyani
Central	1.Assin Fosu; 2. Cape Coast; 3. Dunkwa; 4. Winneba
Eastern	1.Akim Oda; 2.Begoro; 3.Donkokrom; 4.Kade; 5.Mpraeso; 6. Somanya
Greater Accra	1.Achimota; 2. Amasaman; 3. Tema/Ada
Northern	1.Bole; 2. Buipe; 3. Tamale; 4. Walewale; 5. Yendi; 6. Damango
Upper east	1.Bawku; 2. Bolgatanga; 3. Navrongo
Upper West	1. Lawra; 2. Tumu; 3. Wa
Volta	1.Ho; 2.Jasikan; 3. Nkwanta; 4.Denu; 5.Sogakope
Western	1.Asankragwa; 2. Bibiani; 3. Enchi; 4. Juabeso/Bia 5.Sefwi Wiawso; 6. Takoradi; 7. Tarkwa

Table 3.2 Forest districts categorized into two zones for data collection purposes

Zone A (Upper East, Upper West, Northern, Brong Ahafo & Ashanti regions)		**Zone B (Eastern, Western, Central, Greater Accra & Volta regions)**	
1. Bekwai 2. Juaso 3. Kumawu 4. Mampong 5. New Edubiase	14. Goaso 15. Bole 16. Buipe 17. Tamale 18. Walewale 19. Yendi	1. Assin Fosu 2. Cape Coast 3. Dunkwa 4. Winneba 5. Akim Oda 6. Begoro	14. Ho 15. Hohoe 16. Jasikan 17. Nkwanta 18. Sogakope 19. Asankragwa

6. Nkawie 7. Offinso 8. Mankranso 9. Atebubu 10. Bechem 11. Dormaa Ahenkro 12. Kintampo 13. Sunyani	20. Damango 21. Bawku 22. Bolgatanga 23. Navrongo 24. Lawra 25. Tumu 26. Wa	7. Donkokrom 8. Kade 9. Mpraeso 10. Somanya 11. Achimota 12. Amasaman 13. Tema/Ada	20. Bibiani 21. Enchi 22. Juabeso/Bia 23. Sefwi Wiawso 24. Takoradi 25. Tarkwa

3.4.2 Data collection procedure

3.4.2.1 Establishing mean weights of charcoal bags

Charcoal is sold through various measures: bags (including mini, maxi and mega), baskets, tins and in small piles. The weight depends on how it is produced, the wood species from which it is produced and the moisture content among other factors (Bekele & Girmay, 2014; Openshaw, nd). To be able to aggregate data, mean weights for the different bag sizes were established and the carrying capacity of charcoal trucks were validated.

The mean weights were established through data collection in four main charcoal markets and 37 satellite/roadside markets in Brong Ahafo region (Atebubu Amantin Municipal, Kintampo North Municipal, Pru District), Ashanti region (Ejura Sekyedumase District, Sekeyere Afram Plains District), Northern region (Central Gonja District, West Gonja District, Bole District), and Volta region (South Tongu District). Four major charcoal markets, two in Atebubu and one each in Ejura and Kintampo) with supplies from different producing areas were purposively selected. The remaining satellite/road side markets were randomly selected from the remaining districts. South Tongu is not a major charcoal producing area however the site was chosen since jumbo bags are used there. The main markets are characterised by being significant in size with large quantities of trucks loading from there, and the satellite markets being smaller in size and often found along road sides.

These sites were selected because of the huge quantities of charcoal being available for weighing; they also serve as collection points where charcoal produced from different locations, with different tree species under different production methods are brought together for bulk sales and/or transportation. These markets (main, satellite/roadside) were chosen also because here, the dealers remove any unwanted materials and soil from the charcoal and re-bag them for sale and/or transport. A CAMRY Mechanical Platform Scale with a maximum capacity of 200 kg and accuracy of 250 gm was used for the exercise. The scale was always placed on a hard-flat surface. The scale was first calibrated with a 25 kg dumbbell and any required adjustments made. A bag of charcoal at a time was carefully placed vertically on the scale and the weight recorded. To ensure the accuracy of the results, the scale was recalibrated at regular intervals.

3.4.2.2 Data collection from FSDs

At the FSD district offices, data was collected from the duplicate copies of all CCCs issued over the period. Information collected included date of issue, source of charcoal, vehicle model, size and number of bags, CCC identification number among others. Where the information was held in hardcopies (CCC booklets), photographs of all issued CCCs were taken using a camera (or I-Phone) and later entered in excel sheets. Where electronic versions existed, they were copied on pen drives, and some of the issued CCC booklets were randomly selected and checked to confirm that there were no transpositional errors. Data was collected simultaneously from the two zones by two separate teams, each consisting of one project officer, a field assistant and a driver.

3.4.2.3 Data collection by mounted sentries at selected police checkpoints

Sentries were mounted at police check points in the following forest districts as indicated on the map: Walewale (Northern region), Kintampo (Brong Ahafo region), Mampong and Asante Akim South (both in Ashanti region)- *(Plate 2.1)*. They were mounted at a distance from FSD checkpoints along four (4) prominent charcoal transporting routes. Each of the four checkpoints was manned by a team of four persons on shift basis, for 24 hours for 14 days continuously. The truck drivers and/or dealers who travel with the load were interviewed, using formats like those of the CCC (see Annex III). This was to allow for easy reconciliation of data from the sentries with that captured on the CCCs. The information gathered was then analysed, using Microsoft Excel to obtain the quantities of charcoal passing each check point. Other statistics like peak transporting times, daily average quantities transported, major charcoal production areas were computed.

3.4.2.4 Ascertaining carrying capacities of vehicles

Sample trucks from each category (stratified sampling) were monitored from the main loading (aggregation) centres; the actual number and category of bags conveyed by the truck were recorded. The template used for data collection is presented in Annex I. This was repeated for five trucks of each category and the average number of bags computed for each truck category.

Plate 3.1 Road map of Ghana showing checkpoints for primary data collection

3.4.2.5 Determining the bag dimensions and weight of charcoal bag categories

The dimensions of the bag types were determined by taking measurements as shown in the Plate 3.2 below. To establish the mean weight of the various bag categories (mini, maxi and jumbo) of charcoal, sample weights were selected randomly from 37 satellite/road side charcoal markets and four major charcoal markets from Northern, Brong Ahafo, Ashanti and Volta Regions. In total, 300 mini bags, 500 maxi bags and 14 jumbo bags were weighed.

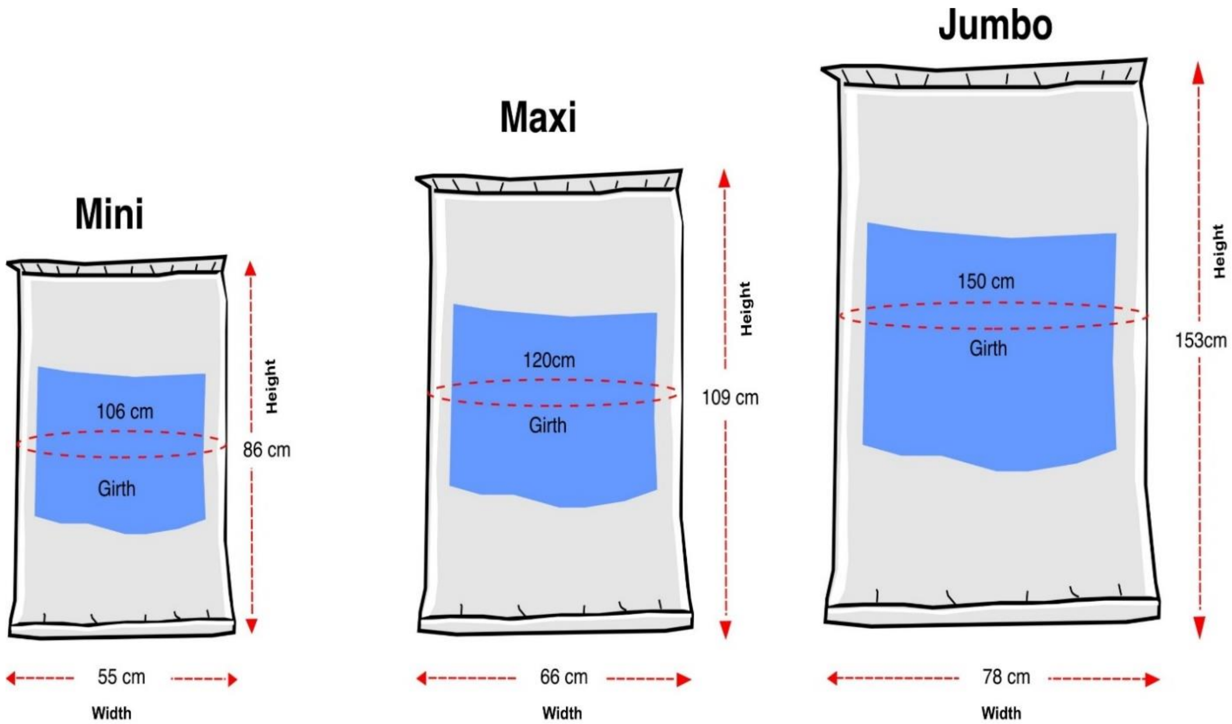


Plate 3.2 Dimensions (cm) of empty charcoal bags

Mean weight of mini bags of charcoal

In establishing average weight of mini bags of charcoal, sample weights were taken from two districts in the Northern region (Central and West Gonja), Atebubu in the Brong Ahafo region and Ejura in the Ashanti region. 60 mini bags of charcoal, i.e. 12 each from five roadside markets were weighed in the Central Gonja district. In West Gonja, sample weights of 40 mini bags, i.e. eight each from five roadside markets were taken.

In Atebubu, a sample of 100 mini bags was weighed with 50 from each of two main adjacent charcoal markets that receive supplies from different parts of the municipality and even beyond.

The same number of mini bags were weighed in Ejura from one main market unlike Atebubu where they were taken from two markets. See Table 3.3

Table 3.3 Sampling frame for determining the weight of mini bags of charcoal

Region	**District**	**Sample Size**
Northern	*Central Gonja*	*60*
	West Gonja	*40*
Brong Ahafo	*Atebubu*	*100*
Ashanti	*Ejura*	*100*

Plate 3.3 Taking sample weight of mini weights of mini bags at Atebubu market, Brong Ahafo Region

Mean weight of maxi bags of charcoal

Sample weights were taken from two districts in the Northern Region: Bole District, 60 maxi bags, twelve each from five road-side markets; West Gonja District: eight bags each from five roadside markets were weighed; three districts in the Brong Ahafo Region: Atebubu District, Pru and Kintampo; and two in the Ashanti region (Ejura and Sekyere Afram Plains), 20 bags each from five satellite/roadside markets were weighed, making a total of 100 maxi bags of charcoal.

The situation in Atebubu, Kintampo and Ejura were different from the above districts as sample weights were taken from main markets. Specifically, 100 maxi bags were weighed from the main market in Ejura. In Atebubu, sample weights of 100 maxi bags were taken from the two adjacent markets with 50 bags in each. From the Kintampo main market, 60 maxi bags of charcoal were weighed. Overall sample weights of 500 maxi bags were taken from different locations across the country.

Table 3.4 Sampling frame for determining the weight of maxi bags of charcoal

Region	**District**	**Sample Size**
Northern	*Bole*	*60*
	West Gonja	*40*
Brong Ahafo	*Atebubu*	*100*
	Pru	*40*
	Kintampo	*60*
Ashanti	*Ejura*	*100*
	Sekyere Afram Plains	*100*

Plate 3.4 Taking sample weights of maxi bags of charcoal at the Kintampo market, Brong Ahafo Region

Mean weight of jumbo bags of charcoal

For mean weight of jumbo bags of charcoal, sample weights of 14 bags were taken from two districts in the Northern region (West Gonja and Bole) as well as South Tongu in the Volta region. Due to its limited availability, a bag each was weighed at five different roadside markets in West Gonja and Bole districts. However, in South Tongu district, sample weights of four bags with two each were taken from two different roadside markets. In all, sample weights of 14 jumbo bags were taken from different sites as described above.

Table 3.5 Sampling frame for determining the weight of jumbo bags of charcoal

Region	**District**	**Sample size**
Northern	West Gonja	5
	Bole	5
Volta	South Tongu	4

Plate 3.5 Taking sample weight of jumbo bags of charcoal at roadside market, West Gonja-Northern Region

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Data analysis

The data was analysed using Statistical Package for Social Scientists (SPSS) to obtain descriptive statistics and the results presented in graphical (tables, charts and graphs etc.) and narrative formats. Each of the results is presented and discussed in the same Section, one after the other. We first determined the mean weight of a bag of each bag category of charcoal and then applied that information to both the primary data from the mounted sentries and that from the market and to the secondary data from the CCCs for further analysis. The total national charcoal production is estimated by aggregating the CCC data and applying a correction factor derived from the sentry monitoring data.

4.2 Packaging/bagging of charcoal

Two main types of bags were encountered in the field, those produced from jute fibre and those from woven polypropylene. The latter is mostly preferred due to its durability, low water absorption and retention capacities. The bags are filled such that they can stand upright with or without support if positioned vertically. The top is sealed with a piece of sack or in some cases with grass or palm fronds. They are then assembled according to the bag sizes for sale and/or transporting to urban centres.

4.2.1 Categories and dimensions of bags for packaging charcoal

Three bag sizes were found i.e. mini, maxi and jumbo; with the first two being the most preferred due to ease of handling. Within each category, the dimensions were uniform with less than a cm variation. The results are presented in Table 4.6 below.

Table 4.6 Dimensions (cm) of bags for packaging charcoal

Bag type	Width, cm	Height, cm	Girth, cm
Mini	55	86	106
Maxi	66	109	120
Jumbo	78	153	150

4.2.2 Dimensions of stuffed charcoal bags

Even though within each bag category, the empty bags were uniform in size, the stuffed charcoal bags do vary in width, overall height and girth depending on the shape and sizes of its individual contents i.e. pieces of charcoal. As shown in plate 4.6, the height of stuffed charcoal bags was determined by measuring from the base to the top opening while the overall height measures from the base to topmost resting point of the sealed bag irrespective of tapering anywhere. The difference between the overall height and height from the base to the top opening forms the height of the bag cover. The girth was measured around the middle of the bag of charcoal notwithstanding tapering elsewhere on the bag. The base width was determined from the widest points at the extreme ends at the base.

Fully packed and sealed, the mini bag of charcoal had an average height of 82.0 cm from the base to the top opening and an overall average height of 104 cm.   The base width measured 48.57 cm with a girth of 107 cm on average. Stuffed maxi bag of charcoal measured on average, 87.8cm in height from the base to the top opening and overall height of 109 cm with 54.3 cm base width and a girth of 122.1 cm on average. Fully packed jumbo charcoal bag has an average height of 131.9 cm and an overall height of 152.7 cm. The base measured 61.0 cm with a girth of 152.0 cm.

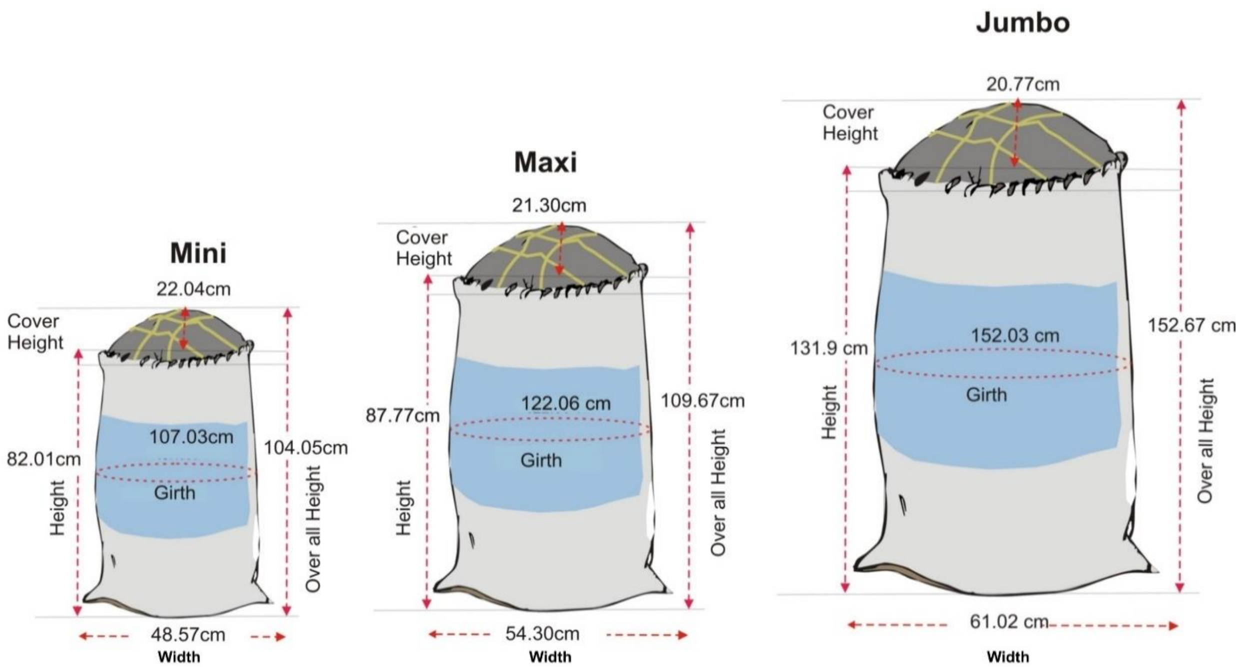


Plate 4.6 Average dimensions (cm) of stuffed charcoal bags

4.2.2 Other units of measure

The bags are mainly used at production sites, main markets and for wholesaling. The retail trade however, uses smaller units of measure and for packaging; these come in the form of polythene bags and tin cans (popularly called *Olonka).* The findings are in line with earlier findings by Nketiah *et al. (*2000).

4.3 Mean weights of charcoal

The highest and least recorded actual weights of mini bags of charcoal were 54.5 kg and 24.0 kg respectively, resulting in a mean weight of 37.9 kg for a mini bag of charcoal. The highest and the least recorded weights were 82.0 kg and 24.0 kg respectively, with a mean weight of 53.80kg for a maxi bag of charcoal. The highest recorded weight was 91 kg as against a minimum weight of 69 kg, with a mean weight of 82 kg for jumbo bag in the country. The results are summarised in table 4.7 below, with the mode, median, range and standard deviation of the various weight determinations. Maxi bags showed the greatest weight range, with a standard deviation of 11.5 kg. The variation is slightly less in the case of mini and jumbo bags with respective standard deviations of 5.89 and 7.16 kg.

Table 4.7 Weight (kg) distribution of various bags of charcoal (mini, maxi and jumbo) in Ghana

Bag Type	**Mini Bag**	**Maxi Bag**	**Jumbo Bag**
Mean Wt., Kg	37.9	53.8	82.0
Mode, Kg	36.0	59.0	82.5
Median Wt. Kg	38.0	54.3	82.5
Range, Kg	24-54.5	24-82	69-91
Standard Deviation	7.16	11.5	5.89

This study determined the average weights of different bag sizes of charcoal as a means of determining the quantities produced nationally. Thus, weight determination was not a direct subject of study. We therefore here discuss the findings mainly with this in mind.

The three main bag-types with charcoal, i.e. mini, maxi and jumbo had mean weights of 37.9kg, 53.8 kg and 82.0 kg respectively. For the mini bags, a wide weight range of 24.0 to 50.5 kg, with a mean of 37.9 kg and a standard deviation of 7.2 was found. The mean weight for a mini-bag of charcoal was found to be 25 kg from a range of 18 to 31.5 kg by Nketiah *et al*, 1988. In a study by the Energy Commission (EC) in 2014, the mean weights of mini bag of charcoal from 4 different sources ranged from 21.5 to 31.5 kg (Table 4.8). Even the highest mean weight of 31.5 kg for charcoal from acacia plantation was much lower than the overall average of 37.9 kg found by the current study. The EC highest figure was however comparable with the mean weight of charcoal from Ejura, which was 31.1 kg. But judging from the narrow weight ranges reported by the EC study, it is conceivable that only limited sample weights were taken for that study.

The mean weights for the 2014 study for the maxi bags ranged from 52.5 to 60.0 kg. Those for the current study ranged from 36.6 to 62.4 kg, with an overall average of 53.8 kg with a standard deviation of 11, this indicates that weights are appears comparable to 52.5 kg for charcoal from 'all other species' for the EC study (Table 4.8), and with the 50 kg as reported by Nketiah *et al* in 1988. The EC study specified the moisture levels of the charcoal, but the current study did not account for that, which makes it difficult to do any rigorous comparison, knowing that the level of moisture can significantly affect the weight of charcoal. The EC study also did not have any jumbo bags. Again, charcoal is produced with a mixture of tree species as they are not usually sourced from plantations, Therefore, establishing mean weight based on tree species has the tendency not to reflect the actual weight of charcoal produced and traded in the open market.

Table 4.8 Weight distribution of mini and maxi bags of charcoal determined by the Energy Commission- Ghana

Charcoal Source	Average Weights (kg)				Moisture Content
	Maxi Bag	Mean	Mini Bag	Mean	
1. Saw mill residue	44 - 45	**44.50**	21 - 22	**21.50**	Up to 40%
2. Savanna	55 - 60	**57.50**	30 - 32	**31.00**	Up to 20%
3. Acacia plantation	57 - 63	**60.00**	31 - 32	**31.50**	Up to 20%
4. All other wood	50 - 55	**52.50**	25 - 27	**26.00**	Up to 25%

4.4 Data compiled from the Charcoal Conveyance Certificates

The data from the charcoal conveyance certificates are presented per region in Table 4.9 below. The total annual quantity transported is 277,974 metric tons**.** Brong Ahafo Region emerges as the region with the highest amount of charcoal, accounting for 34.4% of the national total. This is followed by the Northern Region and Ashanti Region, accounting for 26.7% and 18.6% per cent respectively. The CCC data were lowest for Western, Greater Accra, Central and Upper East Regions; the four regions together accounted for less than one percent of the national total. Eastern Region accounted for 13.5% of the national total.

Table 4.9 Annual charcoal production per region in Ghana (CCC data)

Region	**Quantity Produced (tons)**	**Percentage %**
Brong Ahafo	95482	34.350
Northern	74320	26.740
Ashanti	51749	18.620
Eastern	37383	13.450
Volta	12285	4.420
Upper West	6433	2.310
Upper East	201	0.070
Central	100	0.040
Greater Accra	13	0.005
Western	9	0.003
National Total	**277975**	**100.000**

4.5 Results from the Sentry Data

For the 2-week monitoring period in September 2016, with around-the-clock enumeration, 819 charcoal conveying vehicles passed the four checkpoints, carrying a total of **8,824** metric tons of charcoal. The breakdown of the data for both charcoal quantities and the number of truck movements are presented in Tables 4.10 and 4.11 below.

Table 4.10 Quantities of charcoal traversing 4 checkpoints in a 2-week period as captured by CCC and field survey

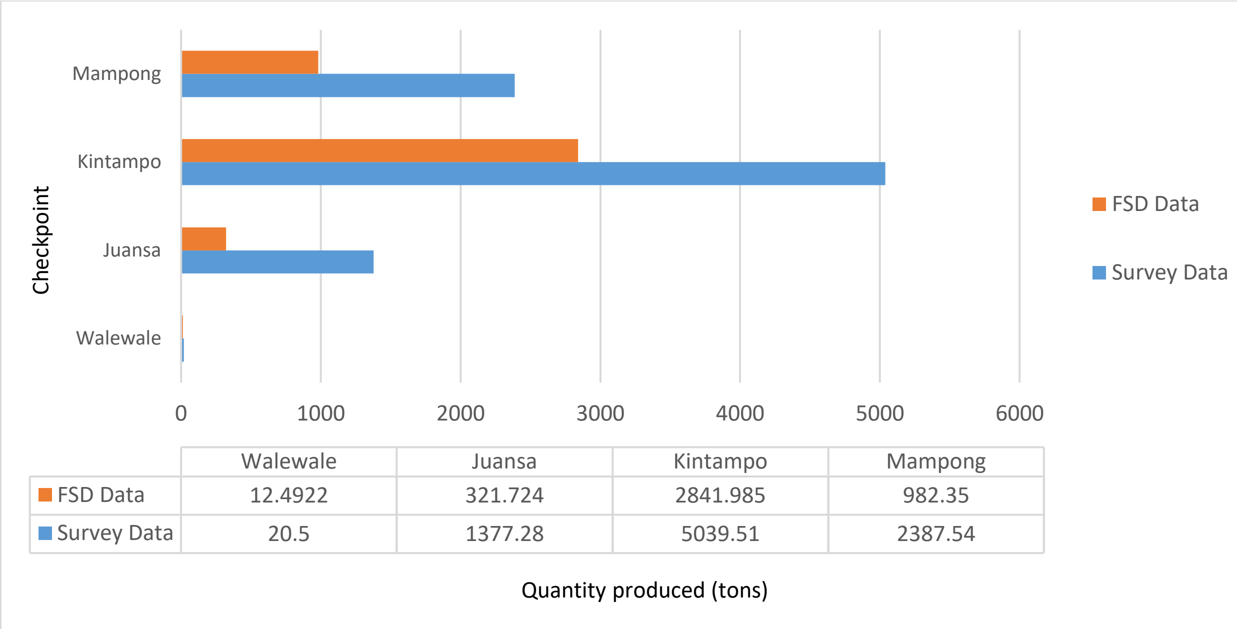
District	Survey Data Metric Tons	CCC Data Metric Tons	Ratio CCC data/survey data Metric Tons
Mampong	2387.54	982.35	2.43
Kintampo	5039.51	2841.95	1.77
Juansa	1377.28	321.72	4.28
Walewale	20.50	12.50	1.64
Totals	**8824.83**	**4158.52**	**2.12**

4.6 Comparison of sentry data with CCC data

From Tables 4.5 and 4.6, we notice a wide discrepancy between the CCC data and that from the survey, especially in the numbers of vehicles recorded for each locality. In both cases, the survey data was more than that from the CCCs; in the case of charcoal quantities, the differences ranged from a factor of 1.64 for Walewale in the Northern Region to a high of 4.28 at Juansa in the Ashanti Region, see Table 4.5. Also see Figure 4.1

Table 4.11 Comparative numbers of charcoal trucks passing the four checkpoints in 2 weeks

Name of Checkpoint	Number of Vehicles			Quantities Recorded (tons)		
	Survey Data (A)	FSD Data (B)	Ratios of A:B	Survey Data (C)	FSD Data (D)	Ratio of C:D
Mampong	267	125	2.14	2387.54	982.35	2.43
Kintampo	334	206	1.62	5039.51	2841.99	1.77
Juansa	117	25	4.68	1377.28	321.72	4.28
Walewale	101	80	1.26	20.50	12.49	1.64
Total	**819**	**436**	**1.88**	**8824.83**	**4158.55**	**2.12**



	Walewale	Juansa	Kintampo	Mampong
FSD Data	12.4922	321.724	2841.985	982.35
Survey Data	20.5	1377.28	5039.51	2387.54

Figure 4.1 Difference between survey data and FSD records on charcoal production

Overall, charcoal production recorded by FSDs through the issuance of CCCs from the four areas amounted to 4159 tons compared to 8825 tons realised from the primary survey. This indicates that, CCC records on charcoal production level represents about 47.12% of actual quantities transported or the CCC data should be multiplied by the average correction factor of **2.12** to obtain the actual transported amount. The difference between the two sets of data may be due to one or more of the following observations:

- the survey was conducted over 24 hours each day for two weeks, but the CCC data was collected only in the daytime. The CCC data may therefore not include charcoal transported in the night.
- Some charcoal conveying vehicles did not carry conveyance certificates. Out of 334 vehicles encountered at the Kintampo checkpoint, only 206 had conveyance certificates. In the case of Juansa only 25 of the 117 vehicles were covered with conveyance certificates. At the Mampong checkpoint, 125 out of 267 vehicles had certificates, while for Walewale, 80 out of the 101 vehicles/tricycles carried conveyance certificates. This indicates that quite substantial quantities of charcoal transported are not covered by conveyance certificates.

- Again, the survey relied on the number of bags conveyed per truck as reported whereas the CCC data relied on standardised carrying capacity of the various trucks. This indicates that the standardised capacities are likely to be on the low side. This is discussed below.

4.7 Carrying capacity of charcoal conveying vehicles

From the survey data on number of charcoal bags conveyed by truck category, on average, a Kia Mighty carried 162 mini bags or 140 maxi bags and a Kia Bongo carried 102 mini bags or 80 maxi bags. The number of mini bags carried by these two vehicle categories was close to the standardised capacities used for the issuance of CCC. It must be noted that for the standardised quantities, it is not explicit as to the bag size to which the figures refer, i.e. mini, maxi or jumbo bags; see Table 4.7. In the case of the articulated trucks, the standard load is closer to the maxi bag figure. But in general, the standard loads are lower than those in mini bags (except that for Kia Bongo) but are more than loads in maxi bags, except for Kia Rhino and articulated trucks.

The study estimated the weight of charcoal conveyed per truck, by multiplying the established carrying capacity of the trucks (average number of bags) by the mean weight of charcoal bags, see Table 4.13. This was subsequently compared with the allowable maximum gross weight of haulage vehicles as authorised by Ghana Highway Authority (GHA), cf. Plate 4.7.

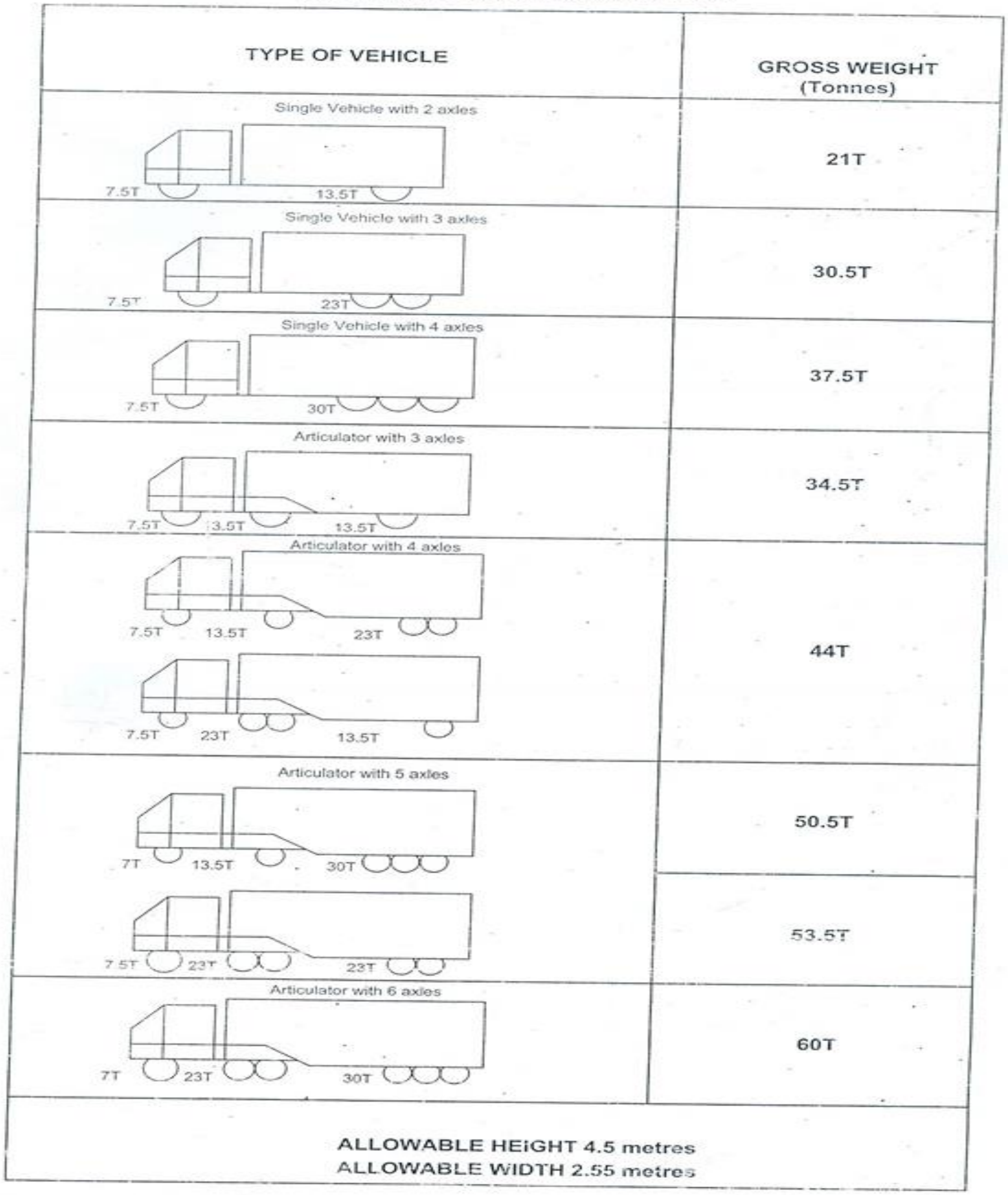
Table 4.12 FSD standardized versus actual number of bags of charcoal conveyed per truck/vehicle category

Model/ Type of vehicle	**FSD standardised carrying capacity (bags of charcoal)**	**Established average carrying capacity (bags) – field data**	
		Mini bags	**Maxi bags**
Kia Rhino	300	336	310
Kia Mighty	160	162	140
Kia Bongo	110	102	80
Double Axle (Benz, MAN, DAF, etc)	450	485	420

Articulated Truck (Benz, MAN, etc)	600	620	602

Table 4.13 Estimated quantity (tons) of charcoal conveyed per truck category

Carrying capacity of charcoal conveying vehicles		
Vehicle type	**Estimated carrying capacity (tons)**	
	Mini	**Maxi**
Kia Rhino	12.7	16.6
Kia Mighty	6.1	7.5
Kia Bongo	3.9	4.6
Double (+) Axle (Benz, MAN, DAF, etc)	18.4	22.5
Articulated Truck (Benz, MAN, DAF, etc)	23.5	32.2
Source: Based on field data		



ALLOWABLE MAXIMUM GROSS WEIGHT OF HAULAGE VEHICLES ON OUR ROADS

TYPE OF VEHICLE	GROSS WEIGHT (Tonnes)
Single Vehicle with 2 axles 7.5T 13.5T	21T
Single Vehicle with 3 axles 7.5T 23T	30.5T
Single Vehicle with 4 axles 7.5T 30T	37.5T
Articulator with 3 axles 7.5T 3.5T 13.5T	34.5T
Articulator with 4 axles 7.5T 13.5T 23T 7.5T 23T 13.5T	44T
Articulator with 5 axles 7T 13.5T 30T	50.5T
7.5T 23T 23T	53.5T
Articulator with 6 axles 7T 23T 30T	60T
ALLOWABLE HEIGHT 4.5 metres ALLOWABLE WIDTH 2.55 metres	

Plate 4.7 Allowable carrying capacity of trucks in Ghana (Source: Ghana Highway Authority, 2016)

4.8 Estimated annual national charcoal production

4.8.1 Assumptions

To obtain an estimate of the annual national charcoal production, the following assumptions are made:

1. Charcoal transported at any time, is equivalent to the production, i.e. over time, there is no stockpiling.

2. Charcoal used in the rural communities where it is produced will not be significant, in assessing the national production.

3. From the survey data, we note that only 47.12% of charcoal transported are captured by the CCC data, this gives a correction factor of **2.12.** This factor is therefore applied to the aggregated CCC data for 2016 calendar year to obtain the 'true' annual national charcoal production figure, according to the equation below.

4.8.2 Estimated national production

Total annual charcoal production, P = k x Aggregated annual figure from the CCC data, D

Where, k this is the correction factor.

$$P = k \times D = 2.12 \times 277{,}974 = 589{,}306$$

Thus, the total annual charcoal production to the nearest thousand, comes to **five hundred and ninety thousand (590,000) tons.** This will be the national charcoal production that enters the main charcoal commodity chain.

4.8.3 Discussion

The estimated national charcoal production of **590,000 tons** from the study is what enters the main charcoal commodity chain and does not include small-scale production which does not enter the commodity chain. This will include production from mill residues and 'subsistence' production. In the Central Region, for instance, it is known that some charcoal is produced from plantations of *Senna siamea (*Cassia), especially in the Winneba and Ntweaban areas. But these are not carted in designated charcoal trucks; their movements may also not traverse any FC checkpoints and therefore will not be captured by the FC. This will explain why the CCC data shows no record of charcoal transported from 13 out of the 51 forest districts nationwide. These are: Lawra in the Upper West Region, Kade in Eastern Region, Bekwai in Ashanti, Dormaa and Bechem in Brong Ahafo, Amasaman and Achimota in the Greater Accra Region, Winneba in the Central Region and Takoradi, Tarkwa, Bibiani, Asrankagua, Juabeso in the Western Region. To enhance the accuracy of the national production figure, a system should be devised to capture all the small-scale 'subsistence' as well as localised productions.

A study in 1988 estimated a national production figure of 468,000 tons (Nketiah *et al*, 1988). Taking account of population increase since then, rural-urban migration and notwithstanding energy sector interventions such as increased rural electrification and promotion of LPG usage, the 590,000 tons for 2016 may still be on the low side. Citing Energy Commission sources, the NAMA[1] for sustainable charcoal production (2013) quotes a national production figure of 950,000 tons. However, it is not clear how this figure was obtained. This then raises the need to further refine the national production figure obtained from the study.

4.8.4 Some implications

Using a conversion rate of 12 kg wood to 1 kg charcoal for the traditional earth-mound charcoal kiln, and a wood density of 700 kg/m^3, the conservative national production of 590,000 tons translates to 10.1 million m^3 of roundwood equivalent. Statistics on national charcoal production are rather scanty. The little data available are mostly estimates, with no firm or scientific basis. Moreover, those quoted in round wood equivalent (RWE), seldom make a distinction between charcoal and fuelwood. All these make it difficult to meaningfully discuss the findings of this study. For instance, the FAO in 1988 estimated that, Ghana consumed 15.9 million m^3 of fuelwood (FOSTAT, 2016); what is not clear is whether this is for fuelwood alone or in combination with charcoal. Ten years later (2008), the estimate was 20.6 million m^3 (Nyarko, 2011), an increase of roughly 30% within the period. The Energy Commission in 2001 estimated that charcoal production in Ghana was 950,000 tons (EC, 2013), almost twice of the 468,000 tons reported by Nketiah *et al* in 1988. This figure (950,000) was at that time, projected to be 1,416,000 tons by the year 2012, an increase of about 49.1% over a decade (UNDP, 2014). For the same period, the

[1] UNDP (2014): NAMA study for a sustainable charcoal value chain in Ghana. UNDP New York.

World Bank reported that fuelwood and charcoal production in Ghana in 2011 was 1,654,622 tons, contradicting the EC estimates and projections of 2013.

4.9 Charcoal production per forest district and production hotspots

It is to be noted that forest district boundaries do not coincide with administrative boundaries. A Forest District may straddle across more than one administrative district. The report deals more with the forest districts, since that was the basis on which the CCC data was collected. Figure 4.6 shows the estimated annual charcoal production recorded for each Forest District, adjusted by the correction factor. A total of 129,921.10 metric tons were recorded in Kintampo representing 22.05 % of the annual national production, followed by Bole (83,835.04 metric tons) and Atebubu (71,558.86 metric tons) representing 14.23% and 12.14% respectively. This is followed by Buipe (56,261.20 metric tons), Mampong (52,875.34 metric tons), Koforidua (39,194.66 metric tons) respectively contributing 9.55%, 8.97%, 6.65 % with the remaining Forest Districts accounting for the remaining 26.41%.

Based on the field data, the main charcoal producing hotpots are identified to be Kintampo, Bole, Atebubu, Buipe, Mampong and Koforidua Forest Districts. Other notable producing areas are Donkorkrom, Somanya, Nkwanta, Yendi and others. These are shown in Figure 4.2 and plate 4.8 below.

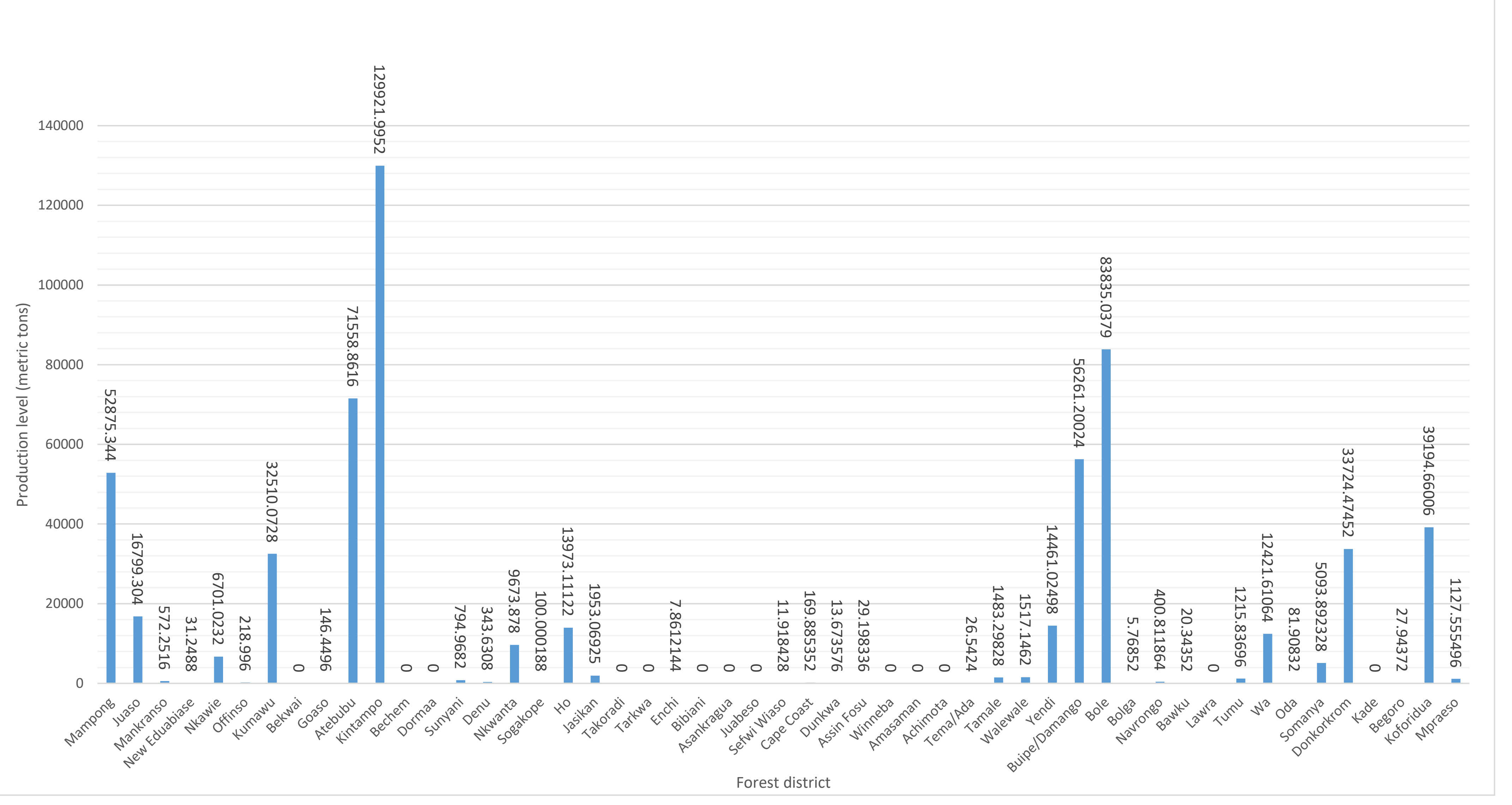


Figure 4.2 Charcoal production per forest district in Ghana

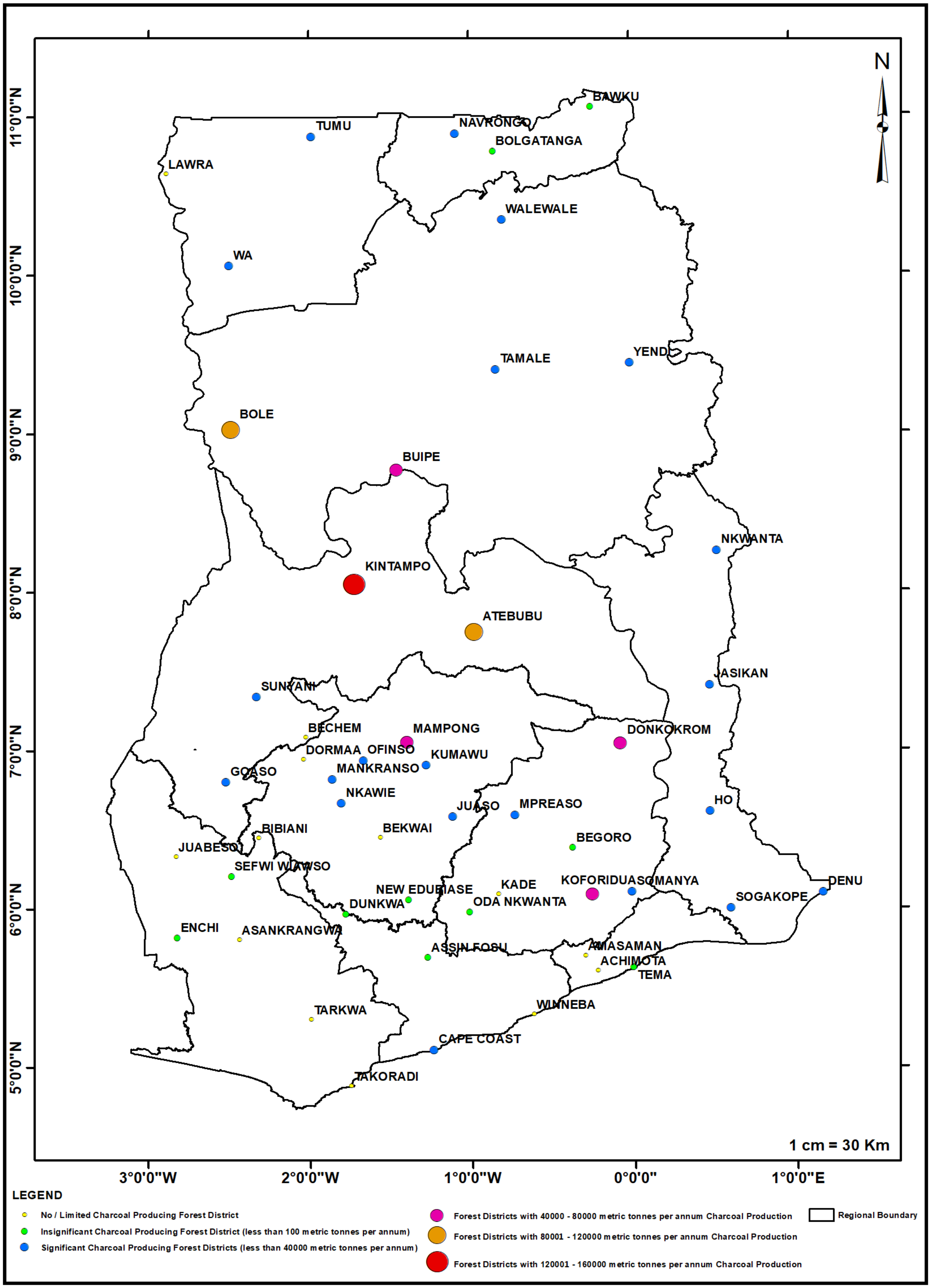


Plate 4.8 Map of Ghana showing major charcoal producing forest districts/hotspots in Ghana

4.10 Annual charcoal production per region

The Brong Ahafo Region emerged as the highest contributor to the national production, with 202,422 metric tons, representing 34.35%. This is followed by Northern Region with a total of 157,558 metric tons and contributing 26.74% of the national total. The Upper East, Central, Greater Accra, and Western Regions contributed only minimal amounts; together, their contribution still falls below 1% of the national total for the year. Other details of the regional production are presented in Table 4.14 and Figure 4.3.

Table 4.14 Annual charcoal production per region

Region	Quantity produced (tons)	Percentage %
Brong Ahafo	202,422.264	34.35
Northern	157,557.732	26.74
Ashanti	109,707.647	18.62
Eastern	79,251.133	13.45
Volta	26,043.691	4.42
Upper West	13,637.448	2.31
Upper East	426.714	0.07
Central	212.778	0.04
Greater Accra	26.543	0.005
Western	19.822	0.003
National Total	**589,305.773**	**100**

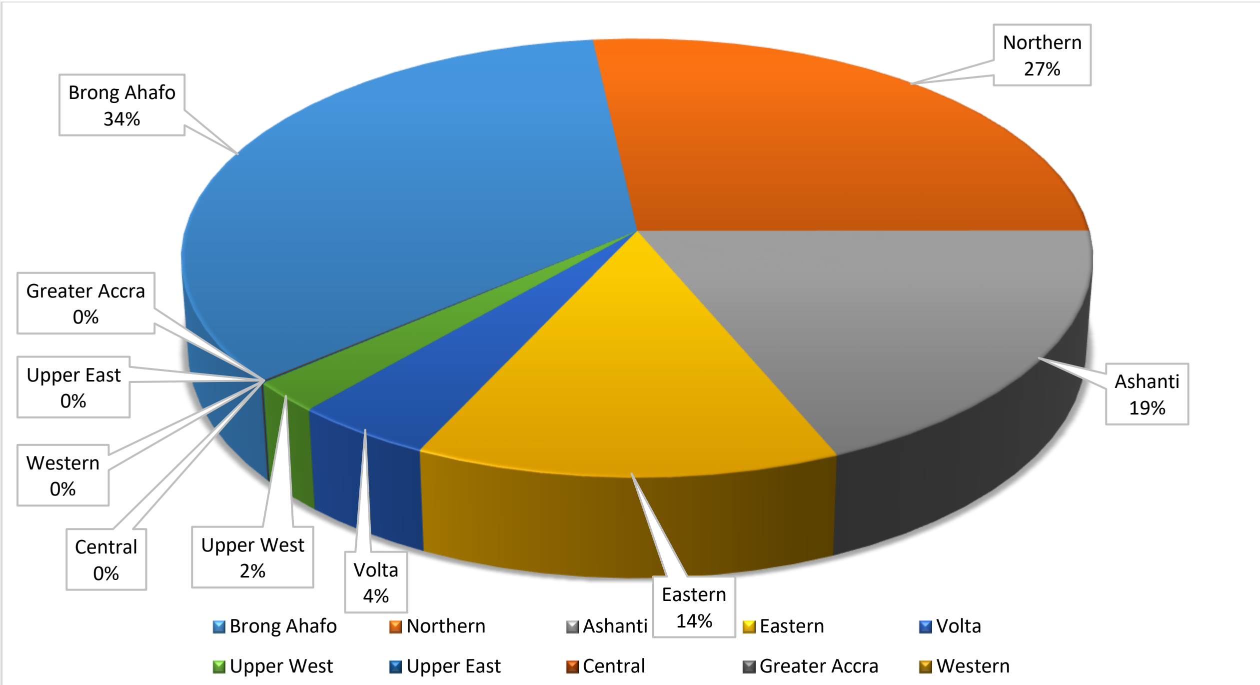


Figure 4.3 Percentage of annual charcoal production per region in Ghana

4.10.1 Discussion

With respect to production, charcoal is produced in all the ten regions of the country. However, Brong Ahafo Region emerges as the major charcoal producing region, followed by the Northern, Ashanti and Eastern in that order. This is in line with earlier studies (Nketiah *et al* 1988; Nketiah *et al* 2000). Preferred tree species for charcoal production are dense and slow-growing as occur in the dry and savannah forests. Besides the occurrence of preferred tree species, the stocking of the woodlands will also influence where charcoal is produced; it is known that in the absence of the preferred species, less preferred ones will be used (Nketiah *et al,* 1988). This explains why more charcoal is produced from Brong Ahafo and the Northern Regions which have relatively better stocking of the preferred tree species. The lack of jobs could also entice people into charcoal production; this situation will again favour more production in the Northern Region where jobs from other sources apart from farming, are very limited.

Key producing areas are within the transition and savanna zones of Ghana: they are Kintampo, Nkoranza, Atebubu, Ejura Donkorkrom, Damongo, Yendi and Bole-Bamboi. Other notable areas of charcoal production outside these zones are Nkwanta (Volta Region) and Drobonso Agogo, Mampong (Ashanti region).

4.11 Seasonal variation

An interesting observation from the study is that of the seasonal variation in charcoal production. It has long been held that charcoal production is minimal during the rainy season. The two reasons given for this notion is that rainy season is also the peak farming period therefore people producing charcoal as an off-season activity will rather go back to their farms. The other reason is that during the rainy season, charcoal production is rather difficult: wet wood is more difficult to carbonise, and rains physically hinder production which is invariably an out-door activity. On the other hand, it is also possible that charcoal demand is higher during rainy periods due to increased heating needs (for water); poultry farmers who rely on charcoal for heating the chicks also require more.

In this study however, charcoal movement was highest during the rainy months (May and June). It is instructive however to note that the peak rainy period in the Savannah zone (August-September) does not coincide with that peak periods in the forest zone (May-July, and September-October (Nkrumah *et al.*, 2014). Thus, production still goes on in the Savannah zone during the wettest periods in the forest belt, where there may only be limited production. Charcoal movement was also high in November and January. We note however that the study covered only one year and therefore the observed trend is only indicative; a longer-term study (time-series data) will be necessary to confirm any seasonal variations in charcoal production.

4.11.1 Monthly distribution of national charcoal production

The data was reclassified to reflect the monthly production per region; this is presented in Figure 4.4 and Table 4.15. The aggregated showed a generally high monthly figures with May and June having the greatest charcoal movements of 59,032 and 63,028 tons respectively. The other peaks occurred in August, November and January, with total quantities of 55,694; 53,390 and 47,403 respectively. The lowest amount, 39,736 tons, was registered for the month of February, followed by April, March and September, with the respective figures of 44,156 tons; 44,365 tons and 41,888 tons.

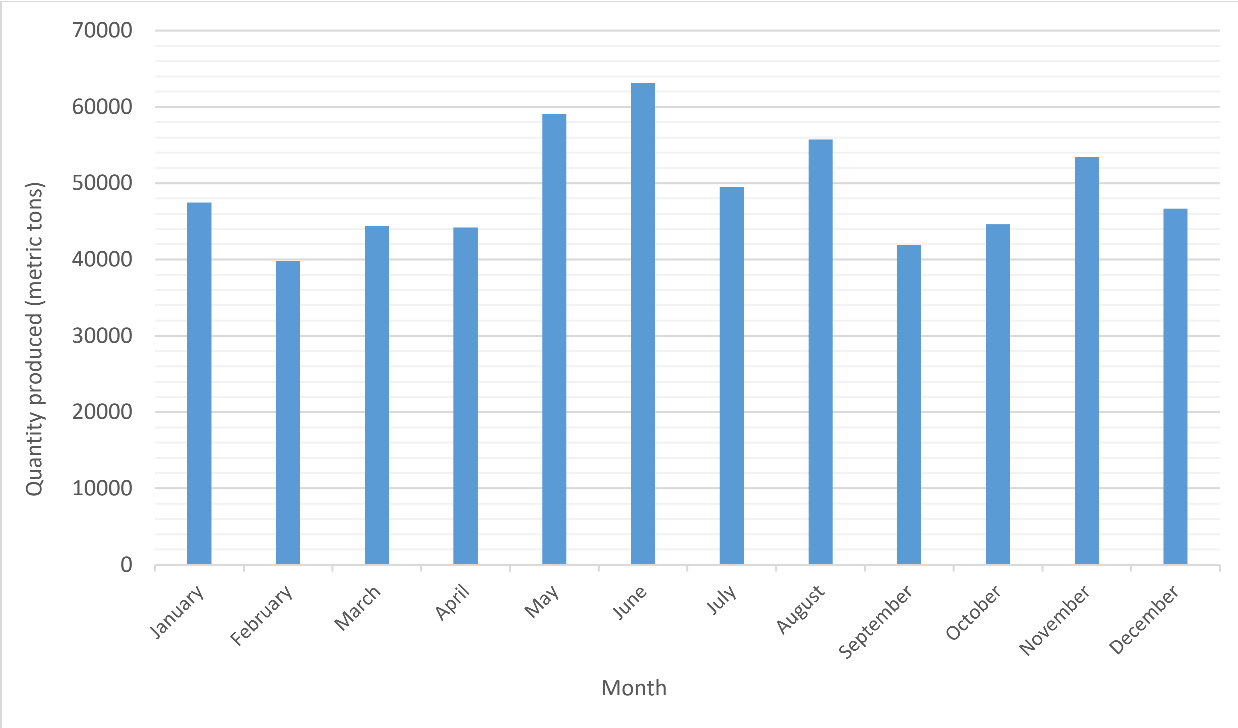


Figure 4.4 Annual national charcoal production per region

4.11.2 Monthly charcoal production per region

Detailed breakdown of the monthly production for the respective regions are graphically presented in table 4.11. Ashanti, Brong Ahafo, Volta, Upper West, Eastern and Northern Regions are the six major regions that recorded charcoal production every month of the year, though there were variations in the monthly production figures.

Table 4.15 Monthly charcoal production per region (metric tons)

Region	January	February	March	April	May	June	July	August	September	October	November	December
Ashanti	9799	7281	9050	11436	9740	8984	9261	11756	6761	6337	10873	8429
Brong Ahafo	18074	13446	13037	9470	19468	23089	16607	20000	15398	16350	18383	19101
Volta	800	1312	2196	1364	3539	3299	2710	1719	1693	1664	2488	3259
Western	0	0	0	0	8	0	11	1	0	0	0	0
Central	18	10	16	11	9	6	16	45	25	15	35	9
Greater Accra	0	16	10	0	0	0	0	0	0	0	0	0
Northern	9424	9537	11406	14109	17037	17351	13195	15754	12840	14619	14571	7716
Upper East	15	33	28	42	38	44	37	37	41	47	29	36
Upper West	375	511	333	1548	1180	2964	1665	241	330	405	2447	1639
Eastern	8898	7589	8288	6177	8014	7292	5938	6141	4801	5127	4564	6420

As shown in Figure 4.5, Brong Ahafo Region has the highest monthly average production of 16,868 metric tons followed by the Northern region realising 13,129 metric tons. Next with much higher monthly average production after these two regions is the Ashanti region. Eastern Region, followed by Volta, Upper West, Upper East, Central, Greater Accra and Western Region recorded lower monthly averages.

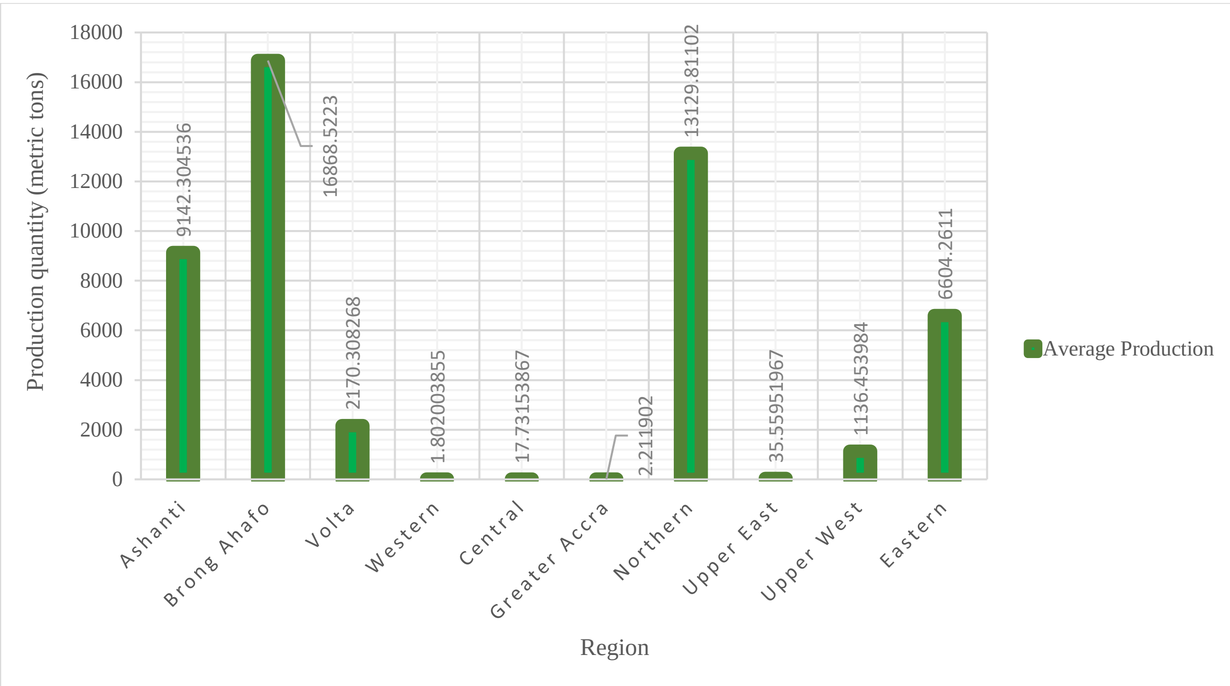


Figure 4.5 Regional monthly average charcoal production

The Central and Upper East Regions recorded charcoal production in every month of the year, but at much lower rates. Greater Accra and Western region were the only region that did not realise production in some months. Production occurred in July and August in the case of Western Region and in the Greater Accra Region, production was in February and March (See Figure 4.6 & 4.7).

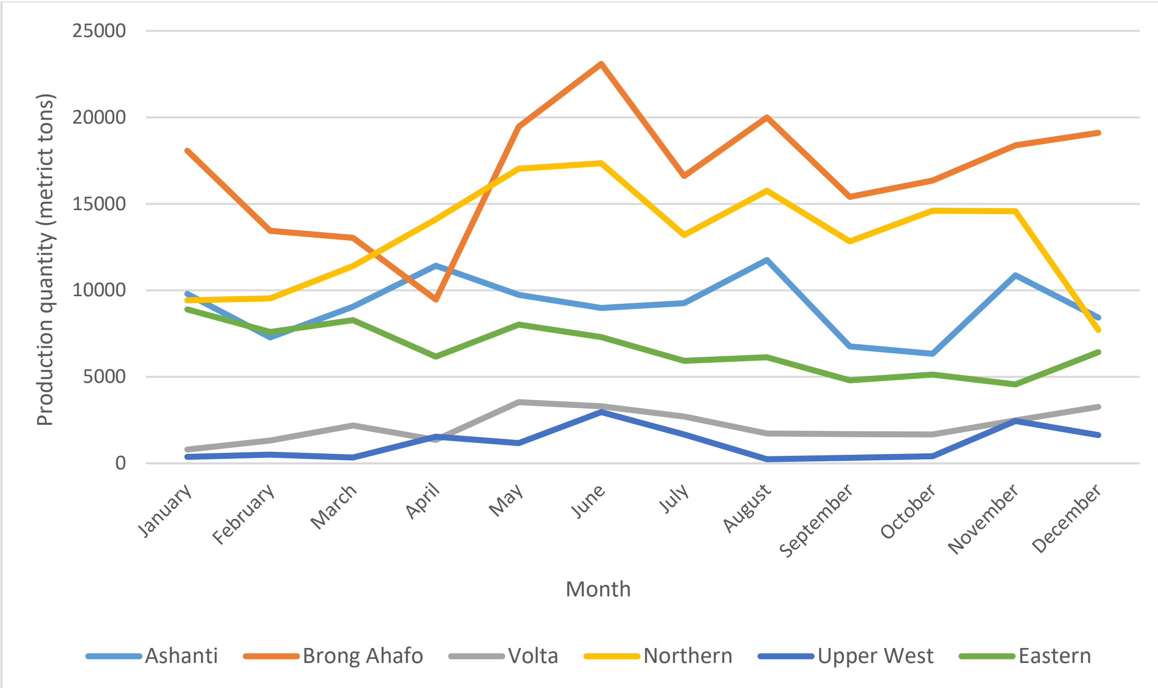


Figure 4.6 Monthly distribution of charcoal in major charcoal producing regions in Ghana

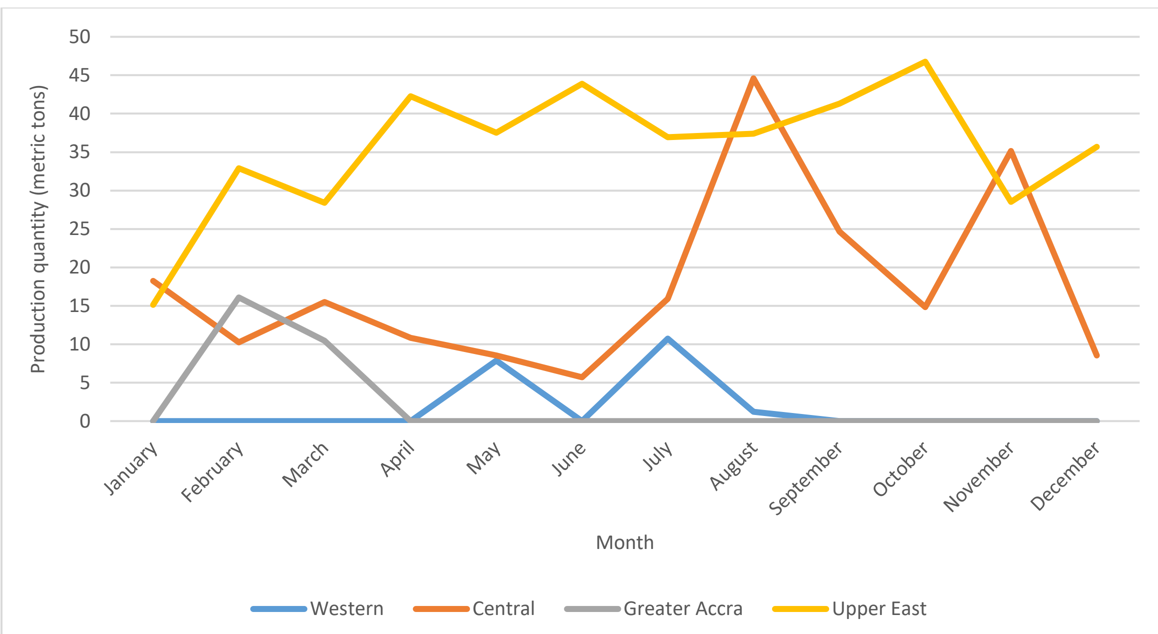


Figure 4.7 Monthly distribution of charcoal production in low producing regions in Ghana

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The main conclusions of the study are listed below:

1. This study estimated that a total of **590,000 tons** of charcoal was produced in the year 2016. Charcoal is produced throughout the year irrespective of the season (wet or dry) though differences exist in the quantities produced per month.
2. The Brong Ahafo region, followed by the Northern, Ashanti, Eastern and Volta regions in that order, account for most of the national production. Major producing areas fall under Kintampo, Atebubu, Bole, Buipe and Mampong Forest Districts.
3. More charcoal was carted in the rainy months as against the dry ones. This gives a notional variation in production with seasons; but longer time-series data is necessary to confirm these findings.
4. The mean weights of the charcoal bag types were: Mini-bag – 37.9 kg; Maxi-bag – 53.8 kg; Jumbo-bag – 82.0 kg.
5. The Forestry Commission has a system in place to capture data on charcoal transportation; but the system, as currently deployed, captures less than half the actual quantities transported. It also does not capture the small-scale and 'subsistence' as well as localised productions.
6. The standardised capacity of the charcoal conveying vehicles as used by the FC in their data capture are reasonable as averages; the recorded figures appear slightly high with respect to number of mini-bags of charcoal, but for maxi-bags, they appear slightly low.

5.2 Recommendations

- A stronger institutional collaboration between the FC and the Energy Commission should be fostered to enhance the robustness and efficiency of the system of data collection, using the Charcoal Conveyance system. Some collaboration with the police will also be helpful. The FSD could position some of its staff at Police checkpoints on the charcoal routes.

- The method used for the study can be improved and adopted to provide regular and cost-effective charcoal statistics at all levels.

5.3 Proposed methodology for future charcoal statistics

The methodology for this study has mainly relied on data collected routinely by the Forestry Commission in the issuance of Charcoal Conveyance Certificates (CCC). Some weaknesses have however been identified with respect to that system; the key ones are listed below:

1. Conveyance certificates are normally issued during the working hours; this means that charcoal movements outside working hours including weekends are not captured.
2. Charcoal produced in close vicinity of major consumption centres hardly enter the main commodity chain and are not captured in the FC database.
3. To improve on the comprehensiveness of the CCC data, a system must be devised consultatively with all stakeholders to capture all data.
4. The system of issuing the CCC could be enhanced and broadened to cover around-the-clock monitoring. Alternatively, movements of charcoal trucks can be restricted by legislation, to only to the daytime (6am to 6pm) and the monitoring hours extended to cover that period.

As a means of validating the CCC data, it will be necessary at least twice each year (at different seasons), to mount 24x7 surveillance for a minimum of 14 days to collect comprehensive data on charcoal movements. From the data, a correction factor can be calculated to adjust the CCC data. In this way, a more comprehensive and reliable data can be collected annually for the annual charcoal database. The proposed system is presented schematically in Figure 4.8 below.

Innovative schemes will also need to be devised to fund the scheme. For instance, the Energy Commission should be interested in putting resources to fund the scheme. Since the database is crucial to planning, it will also not be out of place to allocate a fraction of the myriad energy sector levies to fund the scheme.

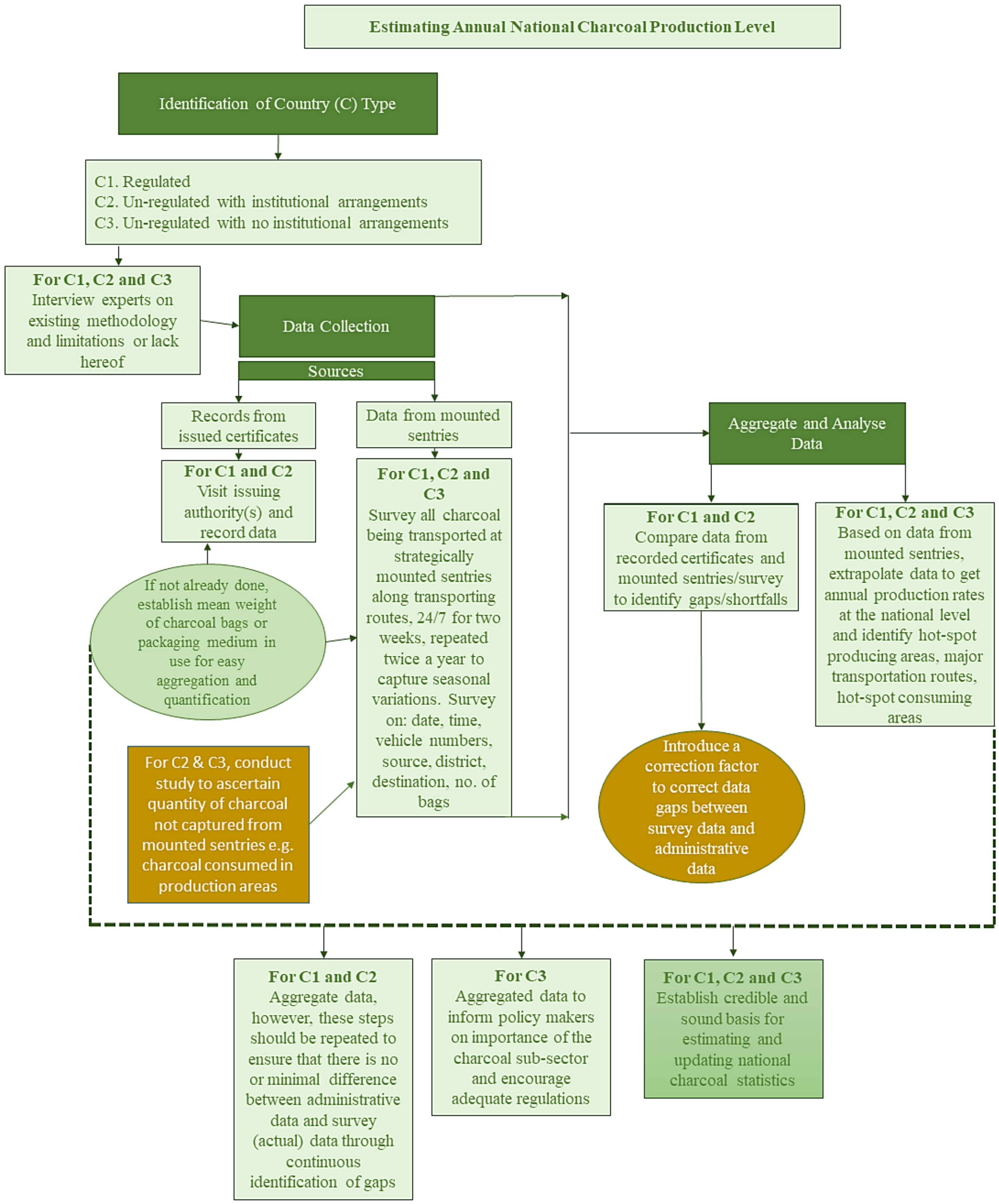


Figure 4.8 Methodological framework for estimating national charcoal production

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ANNEXES

Annex I: Work Plan

ACTIVITY	DURATION											
	June 2016	July 2016	Aug 2016	Sept 2016	Oct 2016	Nov 2016	Dec 2016	Jan 2017	Feb 2017	Mar 2017	Apr 2017	May 2017
1.Desk study and expert interviews to identify available data and approaches for data collection												
2.Design methodology for collecting data from FSD district offices												
3.Pretest the methodology by collecting secondary data from FSDs for the study												
4.Mount four (4) sentries to collect primary data												
5. Market study to ascertain average weight of charcoal bags and number per truckload, including data processing												
6.Collect secondary data from all FSDs issuing CCC across the country												
7.Organize and enter data												
8.Final Data Analysis and Report Writing												

Annex II: Template for Primary Data Collection

ESTIMATING CHARCOAL PRODUCTION LEVEL FROM MOUNTED SENTRIES

Region:

Name of Checkpoint:

Date:

No.	Date and time	Type / Model of Vehicle	Vehicle Registration Number	Source /Location of Wood or charcoal	District Assembly	Destination	No. of bags	Estimated Weight (Kg)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Annex III: Template for Primary Data Collection

ESTIMATING NUMBER OF CHARCOAL BAGS PER TRUCK LOAD

Region:

Name of Market:

District Assembly:

No.	Date	Type / Model of Vehicle	Vehicle Registration Number	Capacity of truck/ Tonnage	Source of load	Bag category Mini/medium/ maxi	No. of bags	Remarks
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Annex IV: Template for Secondary Data Collection

ESTIMATING CHARCOAL PRODUCTION LEVEL FROM FSD

Region:

Name of Checkpoint:

Date:

No.	Date and time	Type / Model of Vehicle	Vehicle Registration Number	Source /Location of Wood or charcoal	District Assembly	Destination	No. of bags	Estimated Weight (Kg)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Annex V

Template for Primary Data Collection

ESTABLISHING MEAN WEIGHT OF CHARCOAL BAG CATEGORIES

Region:

Name of Market:

District Assembly:

No.	Date	Source of charcoal	Bag type	Actual Weight per bag (Kg)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Annex VI

Contacted FSDs

FSDs Visited

Forest District	Contact Person	Position	Contact/Phone
Offinso FSD	Vida Twumwaa	Range Supervisor	208149445
Bekwai FSD	Framis Baawuah	Manager	244184945
Kumawu FSD	Mr. Adomako	Manager	246355220
Juaso FSD	Rebecca	Manager	
Mankranso FSD	Yaw Opare Addo	Assistant Manager	276263788
New Edubiase FSD	Emmanuel Owusu Nkwantabisa	Manager	243444278
Nkawie FSD	Mark Aidoo	Assistant Manager	0244617888/0207111288
Mampong FSD	Donkor Tweneboah	Manager	244467020
Bechem FSD			
Goaso FSD	Godfred Quashiga	Manager	0243014595/0268881415
Dormaa Ahenkro FSD			
Sunyani FSD	Ntiamoah	Manager	244479442
Atebubu FSD	Ebenezer	Manager	208342857
Kintampo FSD		Manager	
Assin Fosu		Assistant Manager	
Cape Coast	Asiedu Okrah	Manager	543771313
Dunkwa	Atta George	Assistant Manager	243986048
Winnba	Dorothy	Manager	244527088
Asankragua	John Kofi Agyapong	Assistant Manager	0246916063/0502707393
Bibiani	Micheal Kofi Benni	Assistant Manager	244515172
Enchi	Lawrence Fosu	Manager	0506331876/0244581957
Juaboso	Henry Kudiabor	Manager	244861850
Sefwi Wiaso	Wilson Owusu-Asare	Manager	244204791
Takoradi	Kofi Aseno	Manager	241423950
Tarkwa	Emmanuel Ntiako	Manager	244551230
Akim Oda	Abrokwah	Assistant Manager	244635068
Begoro			
Donkorkrom	Obour	Manager	203224597/0244835497
Kade	Samuel Opoku	Manager	244618120
Mpraeso			
Somanya		Accountant	242813487
Amasaman	Ntiamoah Edward Kofi	Manager	279331541
Tema/oda	Nimo Amoah	Manager	303203382
Regional	Atuahene Nyarko	Regional Manager	245157399
Bole	Mawuko George	Manager	208175168
Buipe	Kyei Kofi	Manager	202808945
Tamale	Gloria Aba Aikins	Assistant Manager	244126629
Walewale	Stephen	Manager	0208888828/0544194574

Yendi	Kusi Frimpong	Manager	208354246
Upper East	Akwetia	Assistant regional manager	244276801
Bawku		Manager	
Bolgatanga	G.N Agana	Manager	208150382
Navrongo	Agbrutor Regand	Assistant Manager	0244540124/0209161881
Upper west	Adonteng	Regional Manager	0207241718/0244465180
Lawra	Brobbey Francis	Manager	
Tumu			
Ho	Joseph Osei Sekyi	Assistant Manager	247705183
Jasikan	Samuel Badu Dwomoh	Manager	244524208
Nkwanta	David Kwaku Appiagyei	Manager	244871661
Sogakope	Catherine Amankwaa	Assistant Manager	243921234
Denu	Peter Adjei Yeboah	Manager	208632668