THE SOCIO-ECONOMIC IMPACT OF CHARCOAL PRODUCTION ON THE LIVELIHOOD OF LOCAL PRODUCERS IN KITUI COUNTY, KENYA

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Abstract: A survey was conducted among 95 randomly selected respondents drawn from 12 Charcoal Producer Associations in three sub counties of Kitui County namely: Kitui East, Mwingi and Kitui South using a pre-tested semi structured questionnaire. Past studies have indicated that there is inadequate information on the social economic contribution to the livelihood of charcoal producers thus the need to undertake this study. The objectives of this study were to: assess the socio-economic characteristics of the charcoal producers; document the preferred charcoal species; assess the main technologies used in charcoal production and analyze the socio-economic contribution to the livelihood of local charcoal producers. The findings show that charcoal was mainly produced using the traditional earth kiln with the main charcoal producing species were Acacia tortilis, Terminalia prunoides, Cassia abbreviata, Balanites aegyptica, Acacia mellifera, Acacia nilotica, Terminalia brownii and Acacia gerradii in the order of priority. The findings of this study show that the process of devolution had slowed down legislative reforms on charcoal production, trade and transportation, operationalization of the Charcoal Production Association and sensitization of the stakeholders. Therefore, there is need for training and awareness creation on sustainable charcoal production techniques, make it easy to access credit, undertake policy reforms at the County level, work with the local communities in diversifying their sources of income.

Keywords: Sustainable, Fuelwood, Charcoal, Producer association

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INTRODUCTION

In developing countries about 2 billion people rely on fuelwood for cooking, lighting and heating (FAO, 2005; FAO, 2010). In Kenya, the ASALs occupy 89% of the country and are home to about 14 million people (25% of the total population) that continue to increase due to influx of settlers from high potential areas. Approximately 70% of the national livestock can be found within the ASALs which are characterized by their aridity. Annual rainfall in arid areas ranges between 150mm and 550mm per year and in semi-arid areas between 550mm and 850mm per year. Temperatures in arid areas are high throughout the year causing high rates of evapo-transpiration (GoK, 2012). The ASAL of Kenya produces 75% of 2.6 million tons of charcoal annually using unsustainable production methods thus posing great danger to the national socio-economic and bio-physical environment (Practical Action - EA, 2010, Danida and Relma, 2003). Charcoal is the cheapest urban household cooking fuel costing about KSh.12,000 (USD 100) at the farm gate or KSh. 51,000 (USD 460) through charcoal vending at the local market. The main charcoal producing species were Acacia tortilis, Terminalia prunoides, Cassia abbreviata, Balanites aegyptica, Acacia mellifera, Acacia nilotica, Terminalia brownii and Acacia gerradii in the order of priority. The findings of this study show that the process of devolution had slowed down legislative reforms on charcoal production, trade and transportation, operationalization of the Charcoal Production Association and sensitization of the stakeholders. Therefore, there is need for training and awareness creation on sustainable charcoal production techniques, make it easy to access credit, undertake policy reforms at the County level, work with the local communities in diversifying their sources of income.
centers such as Nairobi. Fuelwood is estimated to meet over 93% of rural household energy needs whilst charcoal is the dominant fuel in urban households (MoE, 2002; Theuri, 2002; Kituyi, 2008; Oduor et al., 2012). Charcoal is estimated to provide 82% urban and 34% of rural domestic energy in Kenya (Danida and Relma, 2003; Gathui et al., 2012). Low incomes and frequent food shortages are common among the communities forcing them to look for alternative source of livelihood to supplement the low output from their farms and livestock production (Muok et al., 2007). The charcoal industry employs over 700,000 people who support over two million dependents generating an annual income of over KSh. 40 billion (USD 481,927,711 at an exchange rate of 1USD to KSh. 83), nearly equivalent to the Tea industry (GTZ, 2007; ESDA, 2005; Oimeke, 2012). Ninety nine percent of charcoal is produced largely through traditional earth kilns characterized by poor charcoal recoveries of less than 30 percent (Kareko and Githiomi, 2001).

About a quarter of household income in Kenya is spent on wood fuel, usually regarded the poor person’s energy source, since the alternative energy sources are beyond the means of most Kenyans (Kituyi, 2002). Furthermore, fuelwood is an important energy source for small-scale rural industries such as tobacco curing, tea drying, brick making, fish smoking and bakeries (Githiomi, 2010; Githiomi et al., 2012; Githiomi and Oduor, 2012). Therefore, the continued use of fuelwood affects the performance of other public sectors such as environment, public health, rural development, employment and even foreign exchange. In the past decade, policies to encourage the use of renewable energy have grown in importance as part of the effort to reduce dependence on non-renewable energy sources such as fossil fuels and as part of strategies to address global warming (Trossero, 2002). In Kenya, wood energy sector issues are addressed by Kenya Forest Service (KFS) in the Ministry of Environment and Forestry (MEN&F), Renewable Energy Division of Ministry of Energy and Petroleum (MoE&P) and Agroforestry Unit of Soil and Water Conservation Branch (SWCB) in the Ministry of Agriculture and Livestock Fisheries (MoA&LF). In Kenya, the main ecosystems where charcoal is produced include woodlands, bushlands, woody grasslands and farmlands with an estimated productivity of 0.64, 0.44, 0.25, and 1.44m³/ha/year respectively (MoE, 2002). The concept of sustainable charcoal production has been embraced to achieve social goals such as poverty alleviation and subsistence needs of the community without compromising the needs of the future generation. This can be achieved through using improved charcoal production methods such as the improved earth kiln and casamance kiln that incorporate chimneys for better air circulation and control. Other sustainable methods are the metal, drum and brick kilns. Therefore, to meet the goals of sustainable charcoal production, there is need to comply with The Charcoal Rules (LN no. 186 of 24th Dec. 2009) revealed to Forest Conservation Management Charcoal Regulations, 2016), maintain sustained yield of charcoal production, monitor the effects of charcoal production to minimize adverse effect to the environment, involve communities in developing sustainable resource management plans and ownership strategies and carry out social impact assessment on natural resources. Past studies on sustainable charcoal production shows that, there is inadequate information on the social economic contribution to the livelihood of charcoal producers. Therefore, this study was designed to develop strategies to improve charcoal producer's livelihoods through sustainable charcoal production by adoption of improved charcoal production technologies. The overall objective of this study was to contribute to the improved charcoal producer livelihoods through sustainable charcoal production in Kitui County. The specific objectives were to: assess the socio-economic characteristics of charcoal producers in the study area; document the preferred charcoal species in the study area; document the preferred charcoal production technologies and analyze the socio-economic contribution of charcoal into the livelihood of charcoal producers in the study area.

**EXPERIMENTAL**

This study was undertaken in Kitui County which is located between Longitudes 37º45’ and 39º0’...
east and Latitudes 0°3.7’ and 3°0’ south at altitude of between 400m and 1800m above sea level. The county covers an area of approximately 20,402 km² including 6,302.7 km² occupied by the Tsavo National Park. The central part of the county is characterized by hilly ridges separated by wide low-lying areas and has slightly lower elevation of between 600m and 900m above sea level to the eastern side of the county. The sub-counties are Kitui Central, Kitui West, Kitui East, Kitui South, Kitui Rural, Mwingi North, Mwingi Central and Mwingi West (County Government of Kitui, 2014). The climate of the county is arid and semi-arid characterized by erratic and unreliable rainfall. Most of the areas are generally hot and dry leading to high rates of evaporation. The annual rainfall ranges between 500-1050mm with 40% reliability. The county experiences a bimodal pattern of rainfall with long rains coming in April/May and short rains in November/December. The County experiences high temperatures throughout the year, ranging from 14°C to 34°C. The hot months are between September and October to January and February. The maximum mean annual temperature ranges between 26°C and 34°C whereas the minimum mean annual temperature ranges between 14°C and 22°C. July is the coldest month with temperatures falling to a low of 14°C while the month of September is normally the hottest with temperature rising to a high of 34°C (County Government of Kitui, 2014).

A socio-economic survey involving 95 charcoal producers comprising 62% male respondents were randomly selected targeting 12 Charcoal Producer Associations (CPA) in Kitui South (Mutomo, Ndetani, Muthaa and Katene), Kitui East (Miamiwani, Kyamatu, Kavango and Endau) and Kitui North (Uuneko, Mwingi East, Kyuso and Mwingi Central). The CPAs are registered with the Attorney General with membership ranging from 100 to 2000. Charcoal production within the county is on individual farms with production being higher during the dry season due to increased levels of poverty and available cheap labour. The respondents were interviewed using a pre-tested questionnaire which covered socio-economic characteristics of the charcoal producers, species and production technologies, pricing, challenges and policy and legal issues.

The key informants comprising of CPA chairmen, resource managers and national government administrators were interviewed using a pre-tested checklist. Secondary data was sought in addition to passive observations to compliment the primary data. The data was analyzed using MS Excel and SPSS computer packages. The findings of the survey were validated in three community feedback workshops held in Ngomeni, Mwitika and Mutomo.

RESULT AND DISCUSSION

Socio-economic characteristics of charcoal producers

The socio-economic characteristics considered were age, sex, family size, income, land holding, education and economic activities. The average age of the respondent was 46 years with an average family size of seven people comprising of four males and three females. Ninety six percent of the respondents were married with varied levels of education i.e. no formal education (5%), primary (63%), secondary (31%) and tertiary (1%). The average land holding was 26 acres with 77% of the land was lying fallow mainly as either woodland or grazing land whereas the rest of the land was reserved for farming and settlement. The main economic activities were charcoal production (49%) and farming (46%). The other economic activities include business and bee keeping. A small proportion of the respondents owned 19 bee hives on the average. Farmers in Kitui north owned an average of 30 bee hives while Kitui south registered an average of 11 bee hives. Alternatively, some groups were involved in tree nursery operations. The average monthly income (Figure 1) was estimated at KSh. 21,746. The main sources of income were: charcoal (47%), business (30%), subsistence farming (5%) and cash crops (17%). The contribution to the income by the tree nursery (1%) was very small.

Farming was practiced regardless of the harsh climatic conditions such as erratic rainfall patterns in the study area. The common crops grown were maize (24%), cowpeas (19%), pigeon peas (4%), beans (3%), and cassava (1%). The average annual yield based on a 90 kg bag was maize (4 bags), beans (0.4 bags), green
grams (3 bags), sorghum (7 bags), cow peas (4 bags), pigeon peas (1 bag), millet (5 bags) and black-eyed beans (2 bags). Cassava production was limited to very few farmers for domestic use. The other crops grown for subsistence purposes include pumpkins, sweet potato, water melon and a variety of fruits such as mangoes, pawpaw and citrus fruits. The types of livestock kept were cattle (16%), goats (28%), sheep (2%), donkey (25%) and poultry (29%).

Crop production at subsistence level has been a major source of food and incomes for the community. However, with changing weather patterns and increasing populations, the yields have been declining over the years due to a number of factors which include: mixed crop farming, rain failure/frequent droughts, poor spacing regimes, increased infestation by pests and diseases, use of uncertified seed sources, poor soil and soil management techniques, and poor timing of planting. As result, more community members are turning to charcoal production as a fall back strategy especially during drought when the crops harvests are very poor.

Preferred charcoal production tree species
A total of 26 tree species were identified for charcoal production. Top on the list of charcoal producing species were *Acacia tortilis*, *Terminalia prunoides*, *Cassia abbreviata*, *Balanites aegyptica*, *Acacia nilotica*, *Termaliabrownii* and *Acacia gerradii* in the order of priority. There were a large number of respondents using branches (70%) as compared to 28% who were cutting down the whole tree for charcoal production. Those respondents using branches (88%) in charcoal production used the rest of the tree for other important purposes such as construction poles and fencing posts other than in charcoal production. The various criteria used in selecting the trees to fell for charcoal production includes the size of the tree (38%), the species (28%), poor stem form (16%) and personal preference in the order of importance (13%). The other factors include the health status of the tree (3%), clear-felling for expanding agricultural farms (2.5%), the age of the tree (1%) and the rest of the respondents did not respond. Some of the on-farm trees being promoted to replace those that are harvested for charcoal were *Cassia abbreviata*, *Melia volkensi*, *Acacia tortilis*, *Azandrachta indica*, *Acacia mellifera*, *Bermamia discolor*, *Acaia polycanthera*, *Tarmarindus indica*, *Senna siemea* and *Terminalia brownii* in the order of preference.

Charcoal Production Techniques
There are few forests (7.08% of the land cover) in Kitui County which act as a source of forest products such as poles, timber, fuel wood, wood posts, charcoal, herbal products, wood for carvings, animal fodder and bee forage. However, the exploitation of some of these products such charcoal production has adverse impacts on the environment and the County government has committed itself to regulate their use through good governance to avoid destruction of vegetation and the ensuing drought (Wesangula, 2013; County Government of Kitui, 2014). Good governance involves making appropriate decisions over matters of public concern e.g. fair legal framework that are impartially enforced, transparency (where decision are made in accordance with agreed rules), equity; where communities feel they have a stake and are not excluded from society and efficiency where citizen and institutions produce results that meet the needs of society while making the best use of resources at their disposal (Sophie et al., 2005). Due to the proximity of Kitui to Nairobi, charcoal produced in Kitui was in high demand by the transporters. However, the production of charcoal in the county has remained unsustainable as characterized by minimal replanting of the cut trees or proper management to ensure regeneration. The charcoal production using the earth kiln was wasteful and/or inefficient. This is...
the reason that informed the Government to adopt the strategy of Charcoal Producer Association (CPA) as guided by the Charcoal Rules, 2009. The charcoal rules (LN No. 186 of 24th December 2009) require that the stakeholders establish charcoal producer/marketing associations before they can be licensed by KFS/County government to produce, transport and sell charcoal. Charcoal is a big industry in the dryland counties such as Kitui where it acts as a major lifeline for many household farmers who are vulnerable to food security especially in the dry season. Currently, there is a government ban on charcoal production and marketing in Kitui County which has lasted for the past three years. This ban on charcoal movement was as a result of a lot of pressure to enforce the ban on charcoal movement in Ukambani (Kitui, Makueni, Machakos, Mwingi) and Mbeere to save the environment from further degradation.

The CPA is an umbrella body comprised of individual charcoal producer groups who control and produce charcoal in a sustainable way. CPA formation is based on the following process as per the Charcoal Rules, 2009;

1. The constitution of a steering committee at sub county level with membership drawn from; County government, National Environment Management Authority, Kenya Forestry Service, National Administration, Social Development Office, Non-Governmental Organizations, opinion leaders and any other organizations with a stake in the charcoal industry.

2. The committee’s mandates include;

- Zoning the charcoal production zones based on tree species dynamics within specific areas,
- Awareness creation,
- Identifying persons involved in charcoal production,
- Sensitizing identified/potential charcoal producers on legal requirements,
- Facilitating the current and potential charcoal producers to form charcoal producer groups
- Facilitating the charcoal producers’ groups to form an umbrella producer’s association,
- Facilitating the CPA to develop a constitution and by-laws following the laid down procedures,

- The CPA apply for registration with the Attorney General under the Societies Act, CAP 108
- CPA applies for license from the Director, KFS.
- Initiate operations upon issuance of a valid license by the Director, KFS.

Among the conditions the CPA members have to fulfill include: meeting the minimum membership threshold of 25 members, establishing an office/charcoal collection centers and opening a bank account. The other conditions include land ownership, identifying an area of operation of not less than 100 hectares and developing a harvesting and rehabilitation plan, establishing at least a 25,000 seedlings capacity nursery, adoption of improved charcoal production technologies preferably the improved earth kiln/Casamance kiln and finally signing MoAs with transporters.

Members of the CPA in all the study areas reported that they had been members of charcoal producer association for the atleast seven years. Kitui North was introduced to CPA concept eleven years ago, Kitui East eight years ago and Kitui South three years ago. All other factors remaining constant, the respondents in all study areas reported that 89% of the charcoal produced was for income generation while 11% was for domestic consumption. Charcoal was produced from wood through a complex process called carbonization. Carbonization occurs at temperatures between 450 to 600 °C in absence of oxygen (Seidel, 2008). The respondents reported that they had acquired the skills on charcoal production through KEFRI (31%), personal initiatives (30%), neighbors (25%) and family members (14%). Charcoal was produced inefficiently using traditional earth kilns whose efficiencies range between 10–13% yet higher recoveries of between 30-40% have been achieved using brick and metal kilns. In Kenya, wood-to-charcoal conversion efficiency rates range between 10-15 % for the traditional earth kiln, 24-30% for the improved earth kiln, 28-30% for the brick kiln and 19-30% for the metal kiln (Danida and Relma, 2003; Bailis, 2009). In the study area, the respondents employ various technologies (Figure 2) in charcoal production:
the traditional earth kiln (76.5%), brick (12.5%), casamance (9%) and metal kiln (2%). All the technologies were used in Kitui South and East except Kitui North where the earth kiln was the main technology. In Kitui South and East the charcoal producers had an experience of two years with the modern charcoal production technologies. The wood was prepared by chopping to the right size and left to season to 20% moisture content. The wood was properly arranged in the kiln in readiness for covering with grass/leaves and soil in readiness for firing.

Figure 2: Type of kilns used in charcoal productions

The number of trees used per batch varied from kiln to kiln and the size of trees harvested. Most of the big trees have been harvested for charcoal production. The charcoal yield of the kilns is as follows: The traditional earth kiln has a recovery rate of 8-10%; The Casamance averages from 32-38%; the brick kiln 25-35%; the drum kiln 32-38% and the portable metal kiln 25-30%. Figure 3 gives the average recovery rate for each of the kiln types.

Figure 3: Average recovery rate by kiln type

The charcoal conversion period varied from kiln to kiln: the earth kiln was estimated to take five days, Casamance kiln takes six days; brick kiln takes five days while the drum kiln takes one day. The factors that influence the batch time was the moisture content of the wood, the size of the kiln and the types of kiln. The ready charcoal was harvested from the kiln in readiness for marketing. Charcoal production was reported to be labour intensive where two family members and two hired labourers were required. The monthly cost of hired labour averaged KSh. 1,100 (USD 10) in all the study sites. In Kitui South labour costs KSh. 650 (USD 6), Kitui East KSh. 1,554 (USD 14) and Kitui North KSh. 844 (USD 8). Few members were producing charcoal in groups of an average of eleven persons.

Impact of charcoal to livelihood improvement
Charcoal was marketed either individually (76%), group (17%) and family (7%). There is more profit gain when charcoal is marketed through groups for, they can negotiate for higher prices. The factors influencing the producer’s engagement in charcoal production include profitability of the business (50%), unemployment (21%) availability of raw materials (19%) and enhancement of family business (10%). The charcoal was packaged in either 90 kg (99%) or 50kg sacks. The 50 kg sacks were gaining popularity following the increase in prices. Charcoal was selling at an average price of KSh. 400 per 90kg bag for a monthly average production of 28 bags. The price ranged between KSh. 230 and 600. Producers in Kitui North received better prices than the other areas due to proximity to the Garissa - Thika highway. The mean monthly income of charcoal producers was estimated at KSh. 11,200 (USD 100). Producers in Kitui East received the highest income of KSh. 14,400 (USD 144) while producers of Kitui South got the least of KSh 5,400 (USD 50). The CPAs were expected to promote a well-coordinated transport system to charcoal collection points so as to negotiate for better prices than those provided by middlemen/transporters. The pricing of charcoal was meant to be inter and intra consultative process between CPAs, however the non-members involved in illegal charcoal production were able to dispose their charcoal at lower price. The prices of charcoal were mainly influenced by season (44%), buyers (40%), market forces (8%) and food security (5%). The least factors (3%) that influence prices of charcoal in equal proportions include ability of...
producer to negotiate, political influence and cost of transport.

The charcoal market segments consisted of charcoal vendors (49%), wholesalers (39%), households (6%) and hotels (6%). The charcoal vendors were many though the quantity of charcoal handled was small as compared to whole-sellers who are few in number but handle large quantities of charcoal at a time. Most of the charcoal produced was transported to other markets such as Nairobi (71%) and Thika (29%). Some of the wholesalers selling their charcoal in both markets. The local towns and market centres included Kitui (8%), Mwingi (6%) and Mutomo (6%). The transporters/wholesalers (91%) were the main beneficiaries of the charcoal trade since they purchased cheaply from the producers, transported in trucks to Nairobi and Thika to sell at very high prices. Very few numbers of respondents thought the producers (5%), retailers/vendors (2%) and government (2%) were also beneficiaries of the charcoal business.

Policy and Regulations
Charcoal production is multi-sectoral activity which involves Agriculture, Livestock and Fisheries Development, Energy and Petroleum, Environment and Forestry and County governments, resulting in an unclear framework for stakeholders (Iiyama et al., 2014). Most of the respondents were aware of the government regulations on charcoal production such as the Forest Act, 2005 and the Charcoal Regulations, 2009. They were also aware that it was the Kenya Forestry Service (KFS) (75%) who was mandated by the laws to regulate the trade in charcoal. The KFS was working closely with other stakeholders at the County and Sub-County level in the issuance of authority to harvest trees (92%) for charcoal production and at the same time issue the charcoal movement permits (98%). These functions are now being devolved to the County government. It was further reported that the organizations well placed to enforce the legislations on charcoal were: KFS (54%), Public administration (20%), other stakeholders (19%), Village elders (5%) and police (3%). All the stakeholders are important in the regulations of sustainable charcoal production systems. In Kenya, the bioenergy issues are addressed through the Forest Conservation & Management Act 2016; The Agriculture (Farm Forestry) Rules 2009; The Energy Act, 2019; The National Environment Management & Conservation Act 1919 and the National Environment Policy 2013.

RECOMMENDATION
The following recommendations are proposed:
- Sensitize the stakeholders in Kitui County on Charcoal Production Act 2014 for effective and efficient implementation: ensure zonation of charcoal production areas, undertake Environment Impact Assessment (EIA), recruit new association members, monitor and report all activities of non CPA members, renew of association membership, negotiate for better prices, ensure of registration with the AG’s office, operationalize the charcoal collection centers, ensure proper record capture, minimize charcoal wastage through briquetting, establish alternative source of income such as community nurseries and participate in tree planting programmes.
- Create more awareness and sensitization of stakeholders especially the CPA members on efficient charcoal production technologies to avoid environmental degradation and conserve tree resources for future generation through good woodland husbandry such as use of enclosures to encourage tree regeneration. In the short run, promote the use of improved earth/casamance kiln in all charcoal producing areas, support the construction of brick/ half orange kilns. The drum kiln should be promoted for family use.
- Link CPAs to credit providers so as to invest in provision of reliable water supply, EIA and establish tree nurseries to boost reforestation programmes. It will be prudent for CPA members to join the savings and loan schemes to enhance the charcoal business by providing credit facilities to members at a reasonable profit.
- Diversify income through alternative and sustainable tree based products such as
carbon trade through establishment of woodlots, selective harvesting of branches for charcoal production, value addition on indigenous fruits, honey production, crop production through irrigation and commercialization of pods (e.g. *Acacia tortilis* used as fodder) as a better option compared the destructive tree harvesting for charcoal.

- Ensure that other cottage industries such as sand harvesting, mining and brick making with adverse impacts on the environment are regulated through enactment of appropriate regulations where EIAs should be made mandatory.
- There is need for the country government to improve through budgetary allocation towards environment conservation activities to ensure continued sustainability of the charcoal sector and fund EIA activities on behalf of the CPAs.

**CONCLUSION**

Charcoal was mainly produced using the traditional earth kiln which is characterized by low recoveries. The other technologies such as the improved earth kiln, Casamance kiln, Brick kiln and metal kiln had been introduced in Kitui South and East with low adoption rates as a result of low awareness levels on improved technologies and the existing ban on charcoal trade. The current ban on charcoal movement has been in force since 2001 forcing the CPA members to remain inactive. The slow pace of devolution of Forestry function to counties through signing of the Transition Implementation Plans (TIPs) and current moratorium on commercial caused increase in illegal trade of charcoal also involving non-CPA members. Trees preferred for charcoal production are the indigenous species with dense heavy wood which produce quality charcoal hence being over exploited as the demand increases. Charcoal production activity was mainly undertaken as an alternative source of income especially during droughts but is currently becoming a day to day activity as effects of climate change continue to affect agricultural production yields. The requirement that the charcoal producers’ plant more trees than they harvest was difficult to enforce making the 10% tree cover target unachievable in the short run. Environmental Impact Assessment (EAI) had only been undertaken in Kitui North.

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