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SOCIO-ECONOMIC AND ENVIRONMENTAL IMPACTS OF CHARCOAL PRODUCTION IN SOUTH GEM SUB-COUNTY, SIAYA COUNTY, KENYA

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Abstract:-
Charcoal production is a source of income to many rural dwellers in Kenya. There are, however, several social, economic and environmental cost associated with its production. This study was conducted to assess the impact of charcoal production and the level of adoption of sustainable forest management practices in the South Gem Sub-County, Siaya County, Kenya. Data were collected through questionnaire administration on 377 respondents in 6 village, key informant interviews with officials of four Government Departments, and field observations. Land use maps for years 1998, 2008 and 2018 were used to determine changes in land use in the Sub-County. Findings indicated that charcoal production was being carried out with traditional earth kilns largely by relatively young adults, 70.3% of whom were in the 20 – 39 years age, 60.6% of whom had no more than primary education, and 59% of whom were male. Some of the tree species commonly used for charcoal production had been depleted. Majority (55 %) of the respondent charcoal producers had a relatively low monthly income of Ksh. 1000-3000. Coughing was mentioned by 38% of the respondent producers as a common health challenge. Notable environmental impacts included soil erosion, loss of forest cover and biodiversity, and change in micro-climate. However, the adoption of sustainable forest practices and modern charcoal production methods had started. This trend may eventually help in ameliorating the noted negative impacts. To facilitate the adoption of modern technology, it was recommended that the charcoal producers be encouraged to form co-operative associations.

Key words:- *Charcoal, environmental degradation, climate change, agroforestry, impact*

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INTRODUCTION

The growth of towns and cities in most African countries has contributed to the need for more charcoal for cooking and cottage level industries. According to Bailis et al. (2013), charcoal is predominantly an urban fuel while firewood is the primary energy source in the rural areas. The estimation is that for each 1% increase in urbanization, there is a 14% increase in charcoal consumption (Balirwa, 2007). Charcoal is also a primary energy source for cooking as well as major source of income generation. In Africa, utilization of charcoal is expected to increase to 46.1 million tons by the year 2030 (Bailis et al., 2013). Its unsustainable methods of production has however led to environmental degradation in rural areas of most African countries including Kenya (Gabaldón-Estevan et.al, 2014).

Charcoal use in Kenya is predicted to double by 2030, since it is durable, preferred, and cheap source of energy. With a forecasted increase in consumption, there is a great need to identify real versus perceived energy futures with respect to charcoal. In the last few years, economic hardship, poverty, unemployment and increase in the price of oil have necessitated the need for people to find alternative means of making a living in respect of domestic cooking energy in Kenya. At present, millions of households in Kenya use charcoal as domestic and outdoor recreational cooking energy as a result of epileptic power supply, scarcity and increase in the price of oil and gas

Also, according to Di Donato (2015), an estimate of 2.5 billion people across the globe lack access to modern energy services. This has constrained their opportunities for economic development and improved living standards. They rely on traditional biomass sources such as wood fuel, agricultural residues, and animal dung to meet their basic energy needs (World Health Organization, 2015).

Large-scale charcoal production in South Gem Sub-County, Kenya, has been a growing concern due to its threat of deforestation, land degradation and climate change impacts. It is cited as the most environmentally devastating phase of this traditional energy supply chain (Hou et.al, 2014). Despite increasing per capita income, higher electrification rates, and significant renewable energy potential, charcoal still remains the dominant source of cooking and heating energy for eighty percent of households in South Gem (O'Rourke et.al, 2003).

As a traditional fuel that has been used for hundreds of years, charcoal serves as a lifeline for the rapidly increasing populations in the urban centers of the region, in addition to potentially significant portions of the rural population. Due to its low cost compared to other fuels like kerosene and liquefied petroleum gas (LPG), as well as other factors such as availability and its reliability the demand for charcoal is expected to continue rising dramatically in the coming decades despite efforts by modern energy advocates (Cerutti et.al., 2015).

Objectives of the study

i. To determine the socioeconomic status and health challenges of charcoal producers in the South Gem Sub-County.
ii. To determine the degree of contribution of charcoal production to deforestation in the sub county.
iii. To assess the management measures put in place to reduce negative impacts of charcoal production in the study area.

Methodology Description of the Study Area

The study area was South Gem Sub County which lies in Siaya County, Kenya. The Sub County is located in Eastern part of Siaya County as shown in Figure 3.1. The vegetation of the study area can be classified as woodland Savannah with scattered trees and grasses. The area is situated on a gentle undulating slope on the platform that is plain. These soils are weakly developed and nonleached ferruginous tropical soil of alluvial origin (Okoyo et. al., 2017).

The climate at Siaya County (2016) weather report revealed is that the highest temperature in South Gem occurs in the dry season between January and April (SID, 2012). During this period, maximum temperature within the area ranges between 24^0 -27^0 C. The temperature drops during the rainy season to its lowest level in June that is about 18^0C. The rainfall is moderate with annual total ranging approximately between 1,100 to 1,650 millimeters with about 60% of the annual rainfall during the months of February to June.

South Gem is composed of one ethnic group and has a population of approximately 16,653 people (Okoyo, et al., 2017)

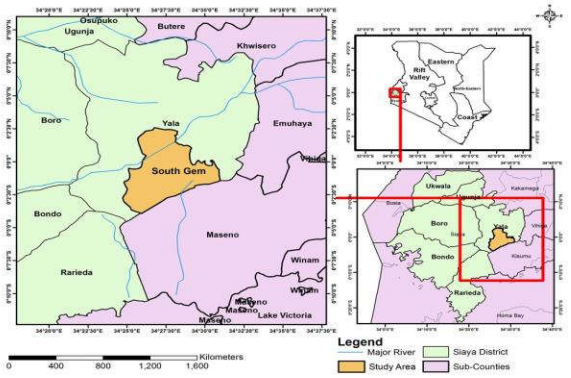


Figure 3.1: study area, South Gem Sub-County

Data Collection

Close- and open- ended questionnaire were administered on 377 respondents in six villages under the Sub-County to help in collecting information on people's opinion, attitude and perception on charcoal production among households and from sampled residents of the Sub-County. Key Informant Interviews were conducted to elicit information from the local Sub County government officials. Observation checklist was also used to check the accuracy of respondents' feedback, thereby providing a means of assessing charcoal production methods, types of tress used, its impacts and management practices. Published documents related to forestry and charcoal production were collected from government, non-governmental and other respective institutions. The trends of vegetation cover for 20 years (1998-2018) were generated using GIS software to help in assessing the decrease in forest cover in the area. Qualitative and quantitative data were classified into themes and coded for analysis using Statistical Package for Social Sciences (SPSS).

Results and Discussion Demographics of the respondents

Out of the sampled respondents 59% were male and 41% female (Figure 4.1). It was noted that women were more involved in domestic chores while men were more involved in charcoal production. The educational levels attained varied with 10.2 % of the respondents having tertiary education, 22.4% secondary education, 56% primary education and 10.6% of them having informal education as shown in Figure 4.2. Charcoal production in the area cut across all age groups as shown in Table 4.1. However, about 70 % of the respondent producers were in the 2039 years age bracket. As shown in Figure 4.3, most of the respondents had been in the business for more than two years. About 41% of had been engaged in the charcoal production for a period of between 2-5 years

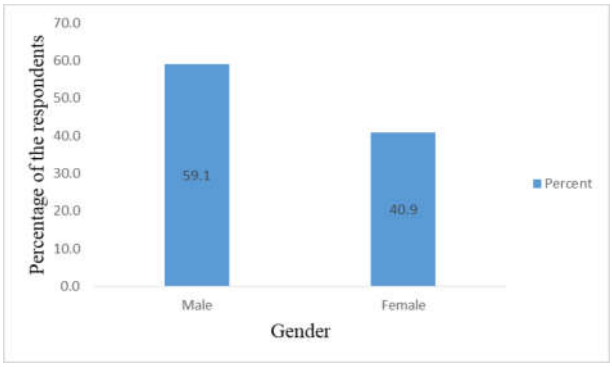


Figure 4.1: Gender of the respondents

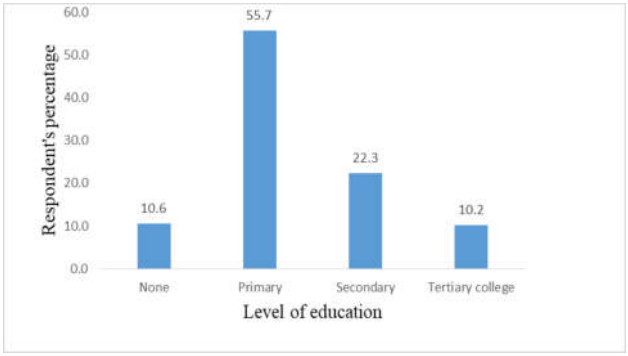


Figure 4.2: Level of education

Table 4.1: Age of the respondents involved in charcoal production

	Age group	Percent
	20-29	34.0
	30-39	36.3
	40-49	18.3
	Over 50	11.4
	Total	100.0

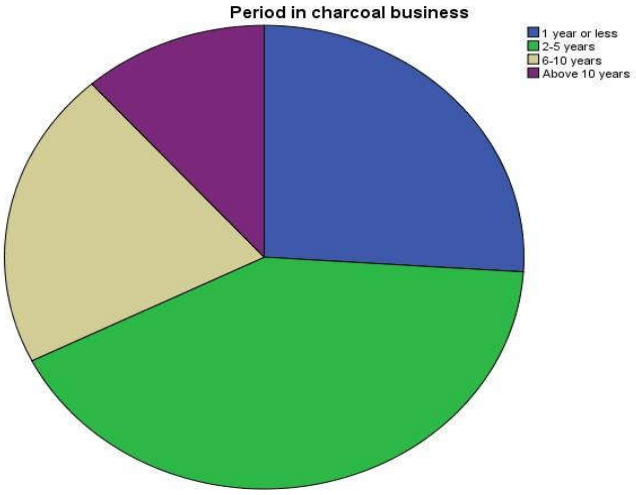


Figure 4.3: Period respondents involved in charcoal production

Methods of charcoal production Types of trees felled for charcoal production

As shown in Table 4.2 the most common tree preferred by the respondents for charcoal production was *Swietenia mahagoni* with 31.4% of the respondents giving it preference. Most of respondents reported that it was readily available and has high colorific value. *Olea africana* was also readily available and being used by 25.7% of respondents. *Rubus fruticosus* had been of high demand in the past leading to its depletion in the area. *Euclea divinorum* was not common among the respondents since it was depleted in the region though it had suitable quality for charcoal for production. *Vachellia xanthophloea* was not commonly used since it has low colorific value hence most respondents avoided and only used it when there was no alternative. Generally, the choice of types of trees used for charcoal production was based on the following three major factors: ease of cutting and burning, availability and quality of charcoal produced.

Table 4.2: Type of trees felled for charcoal production

Trade Name		Scientific Name	Percent	Cumulative Percent
	Indian mahogany	*Swietenia mahagoni*	31.4	74.6
	Brown olive	*Olea africana*	25.7	43.1
	Fever tree	*Vachellia xanthophloea*	17.4	17.4
	Diamond-leaved euclea	*Euclea divinorum*	16.3	90.9
	Black berry	*Rubus fruticosus*	9.1	100.0
	Total		100.0	

Tools used in charcoal production.

The major tools employed for charcoal production are shown in Figure 4.4. Most of the respondents (45%) used axe as the main tool for charcoal production. The axes were more commonly used for felling big trees. The other tools used included machete (40.3%) and power saw (14.3%). Power saw was not commonly used because it was expensive to buy and maintain for most of the respondents.

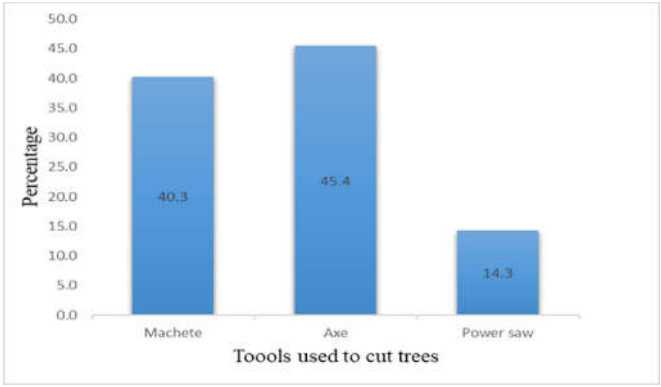


Figure 4.2: Tools used in cutting trees

Type of kiln used in Charcoal production.

During the field visits, it was observed that most of the producers in the area used traditional earth kiln in charcoal production, involving cutting logs into smaller pieces and arranging them in the kiln. The logs are covered with soil to

reduce aeration which in turn control oxygen allowed for the combustion. Due to limited oxygen allowed in to the kiln, there was incomplete combustion leading to formation of charcoal as shown in Figure 4.5.

Figure 4.5: Traditional kiln used to make charcoal

Income generated from charcoal production

Majority of the charcoal producers in South Gem Sub County produced for household use and for commercial purposes. Since they are in rural set-ups, their cost of living is not high therefore most people produce charcoal in small quantities. The frequent and persistent production of charcoal has caused massive environmental degradation in this area. Monthly income of the producers are shown in Figure 4.6 in Kenyan shillings. Majority of the respondents had a monthly income of Ksh. 1001-2000. The relatively poor monthly income may be as a result of low market prices paid by brokers who bought from the producers. Government regulations and restriction like putting a ban on charcoal production has also hindered the income from charcoal production. Hence even though it is a major source of livelihood to most of the respondents, it was illegal.

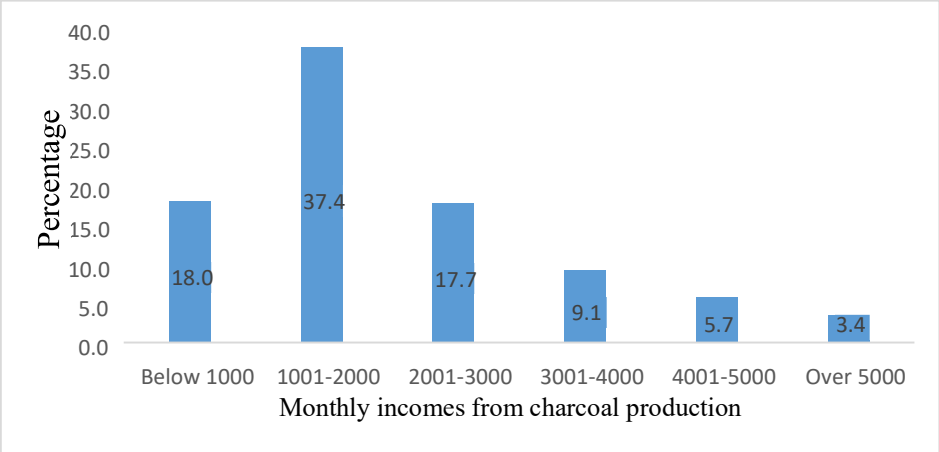


Figure 4.6: Monthly income

Common ailments associated with charcoal handling

It was very apparent that charcoal handling had negative health impacts on both producers and users. Coughing was mentioned by 38% of the respondents as shown in Figure 4.7. Coughing was caused by the irritating smoke that irritates the lungs and windpipe leading to persistent coughing among producers and many consumers. Charcoal which is not completely combusted or burnt produces a lot of smoke and affects users a lot. The charcoal making process also produced carbon smoke that tend to choke and irritate producers. About 21% of the respondent suffer eye irritation which might be due to the smoke from charcoal production. After a long period of exposure this might lead to eye problems. Breathing difficulty was also identified as another major side effect of charcoal use. About 16% of respondents reported breathing difficulties. Eyes filled with tear caused by the irritation from gases and smoke was reported by 15.1 % of the respondents. Body ache due to the hard labour involved in the charcoal production was also reported by 29% of the respondents.

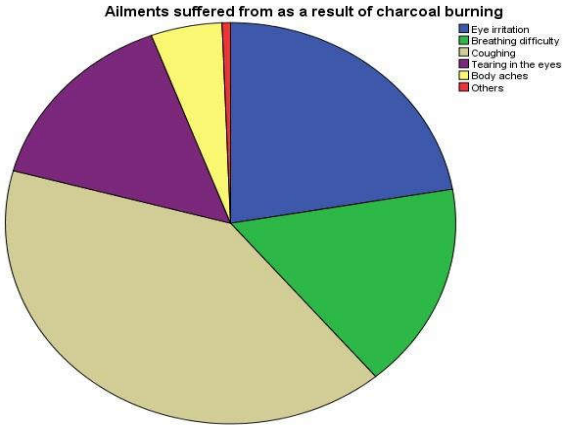


Figure 4.7: Ailments suffered by the respondents

Number of times respondents visited hospitals

Majority (insert the percentage) of respondents did not go to the hospital for treatments as shown in Figure 4.8 even though there were ailments related to charcoal production and use. This was attributed to the fact that the charcoal produced in this area fetches little money since the middlemen had lowered the prices to help them gain more profit. The study area was also in the rural set up where the level of education has been very low. The percentage of respondents that had never visited the hospital was relatively high at 34% and this poses more danger to the community. The number that had visited hospital frequently i.e. at least five times in the past two years was very low (4.9%) translating to 17 respondents out of 350 respondents.

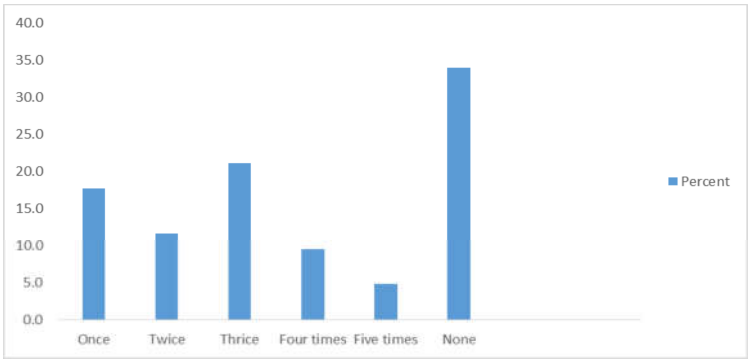


Figure 4.8: Number of times respondents visited the hospitals

Most of the respondents did not seek medical attention or services as they opted to go to work even when they were sick. The number of respondents who missed charcoal production due to identified ailments was low (9.2 %). The percentage that had never missed work in the past two years was 57.5% of the respondents as shown in Figure 4.9.

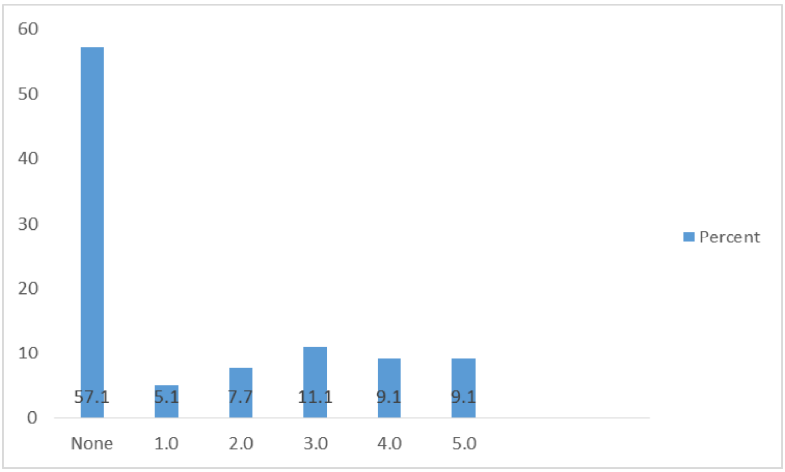


Figure 4.9: People absent from charcoal production work

Environmental Impacts of charcoal utilization

Environmental impact of charcoal burning is a major concern in this area. The respondents clearly indicated that since they started charcoal production there had been tremendous change in the environmental status of the area. The environmental changes which were observed and highlighted by the respondents are indicated in Figure 4.10. Reduction of forest and vegetation cover at large had been witnessed due to the fact that the charcoal production in this area in the past years was dependent fully on the indigenous trees in the forested area within the sub county. The forest cover has changed, and the area covered by the forest has since reduced. This assertion was supported by 29.7 % of the respondents. About 29% of the respondents also reported that many rivers that used to serve them had tried up. This is because of the encroachments of the water towers which were basically the forests in these area. An example of a river that had completely dried in the area is river Gombe which used to be a permanent river is no longer following throughout the year. It has turned to be a seasonal river, yet it used to be a permanent river.

20% of the respondents had witnessed soil erosion in the area. This was attributed to clearance of the vegetation to make charcoal. This has left the ground bear hence the soil becomes loose. Loose soil is prone to erosion. The erosion agents in this study area range from water to wind. This has in turn affected crop yield in the area. The respondents reported that they used to cultivate crops without applying fertilizer but this was no longer the case. By the time the research was carried, the farmers were depending on high fertilizer application on their farms to realize high yields in their farms.

About 16% of the respondents noted that the weather had become drier in the area. Forest creates a micro climate in an area. When a vegetation is cleared, the climate changes. Transpiration from the vegetation makes air humid hence high humidity leads to more rainfall. With the intensive production of charcoal in the area, the trees were cut and vegetation cleared leading to low humidity. This in turn has made the area to be drier hence unreliable and low rainfall is experienced. Being that this area was forested in the past, there were wild animals which were hosted by the forested environment. 15.1% of the respondents said that there has been a reduction in the number of wild animals that were once common in the area. For example, it was noted that it was very common to come across monkeys in the area in the past. However, since heavy charcoal production started the many of the monkeys had disappeared. Other wild animals like the gazelles and antelopes that were once hunted for meat and their habitats had also disappeared.

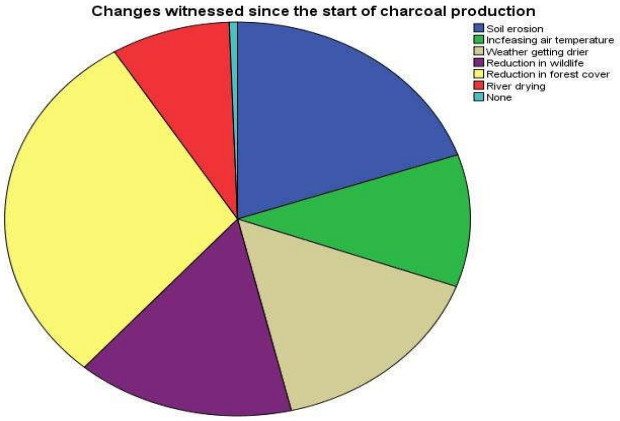


Figure 4.10: Environmental changes witnessed

A steady increase of temperature in the area was reported by the respondents, who noted that temperatures were getting hotter day by day and this has led to changes in the crops planted in the study area. This finding concurs with a study carried out by Hughes (2016) in Siaya County which stated that there had been annual temperature increase of $+0.05^{0}C$ between the year 2000 ad 2016.

Forest Cover and Land Use 1998 – 2008

There was a noticeable forest cover change between 1998 and 2018 (-31.76 %) as shown in Table 4.3 Figure 4.11 and 4.12 respectively. This is a clear indication that human activities were encroaching the forest vegetation. As the forest vegetation cover reduced, the built up environment increased. Between 1998 and 2018, it had increased with a positive percentage of 23%. Water body cover on the area has increased due to construction of pond in the study area. The land use land cover maps were also developed to show the change in forest cover.

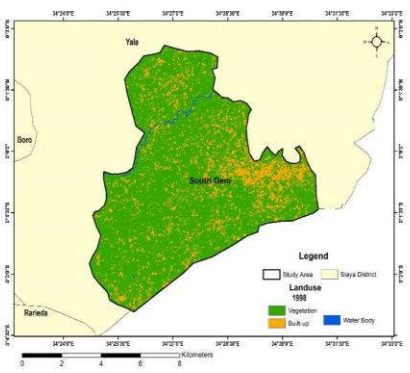


Figure 4.11

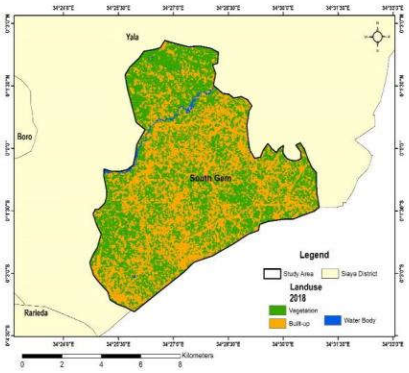


Figure 4:12

Table 4.3 showing percentage change in land use from 1998 to 2018

Land Covered	Hectares in 1998	% cover in 1998	Hectares in 1998	% covered in 2018	% change from 1998-2018
Forest Vegetation	6774.8	82.27	3743.19	50.51	-31.76%
Built-up	1271.79	17.16	3590.01	48.44	31.28%
Water Body	42.39	0.57	78.3	1.06	0.49%
Total	**7411.5**	**100**	**7411.5**	**100**	

Institutions controlling charcoal production

There were several institutions involved in controlling charcoal production in South Gem Sub County (Figure 4.13). Siaya County Government was largely in control of charcoal production as noted by 60% of the respondents. It was also reported that the County Government always organised tree planting days and trainings through Community Based Organisations (CBOs) to enlighten people on the significance of trees and good environment. The Government had also trained people on the negative impacts associated with indiscriminate tree cutting especially for charcoal production. It was reported that traditional leaders also played a significant role in the control of charcoal production, largely by regulating the age of people allowed to engage in charcoal production, insisting that it is an abomination for children to engage in charcoal production. . They also had control of the location of charcoal production as some parts of the forests were considered sacred and hence, no activity was allowed in such places. The government was partnering with the traditional leaders to help in the forest conservation. Other organizations involved in controlling charcoal production included, National Environmental Management Authority (NEMA), Kenya Forest Service (KFS) and Kenya Forest Research Institute (KEFRI).

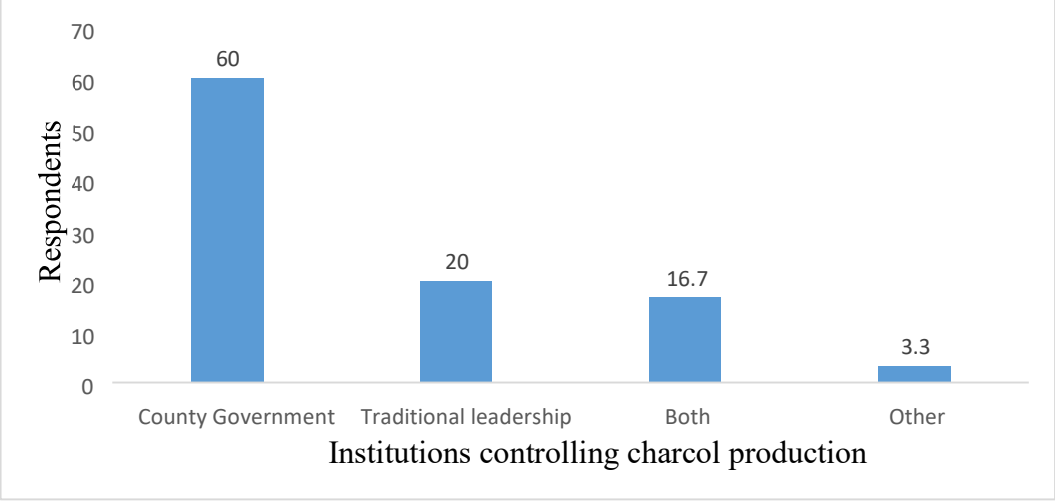


Figure 4.13: Institution controlling charcoal production

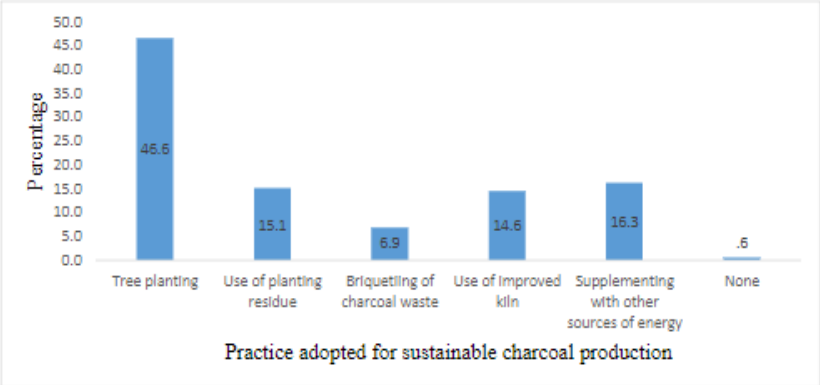
Sustainable Forest Management Practices Adopted

Several management practices had been put in place in the study area to help in sustainable charcoal production. The most common management practice used was tree planting. About 46% of the respondents said that they had been practising tree planting in line with the government policy of ''cut one and plant two'' (Figure 4.14). The tree seedlings were occasionally provided by county government free of charge. Siaya county government had also trained people on the significance of the forest and benefits derived from a protected environment.

Figure 4.14: Tree nursery

Although traditional methods of charcoal production were still dominant in the area, about 14% percentage of the respondents had adopted the modern kiln methods. Charcoal residue previously regarded as a waste has now been considered as a residue for briquetting. This technology had been adopted by 6.9% of the respondents (Figure 4.15). Also, about 16% of the respondents reported that they had switched to other sources of energy such as kerosene, gas cylinder and hydro-electric power (HEP) to supplement charcoal. Plant residues were also being used by 15.1% of the respondents.

Figure 4.15: Sustainable charcoal production practices



Government regulation and policy awareness

There were specific government regulations in place, but the awareness of the local community was relatively low as shown in Figure 4.16. Only 42% of the respondents interviewed were aware of the County Government's regulations on charcoal production. The remaining 58.4% claimed complete ignorance. This finding is not too disturbing, even though it calls attention to the need for government to improve on its mechanisms for awareness creation, because a higher percentage of the respondents were already aware of and engaged in sustainable forest management practices including tree planting, agroforestry, briquetting of charcoal fines, and the use of improved charcoal stoves.

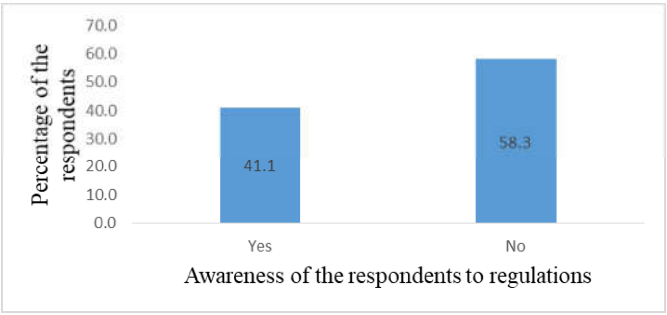


Figure 4.16: Awareness of the respondents on government regulation

These regulations that were put in place by national and county government were considered effective by 62% of the total respondents as shown in Figure 4.17. Though few were aware of the regulation and they had put them into practice hence effective. The 38% of the respondents who said that the regulation were not effective is majorly composed of the population that are not aware of the regulation.

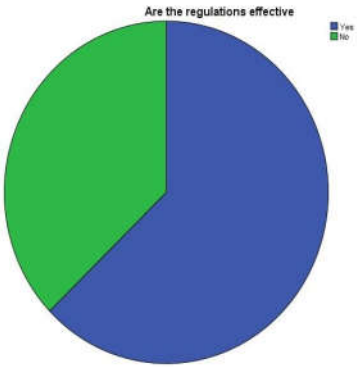


Figure 4.17: Effectiveness of the government regulations

Conclusions

The following are the conclusions of this study:

1. Charcoal production remains a major economic activity that provides jobs for producers and marketers in the south Gem Sub-County, Kenya re-affirming the general belief that charcoal production remains a veritable source of employment and income generation in sub-Saharan Africa. Lesser time is committed to farming than charcoal production in the sub-county in the belief that crop production is more time consuming. Kenyan Government and Siaya County Government had put a ban on charcoal for a long period but the ban has not been effective in this sub-county.
2. Charcoal production is carried out largely by relatively young (20 – 39 years old), less educated people. Unfortunately, children are also made to participate on a full time basis in charcoal production in the sub-county, despite interventions by traditional institutions to stop the practice. This un-acceptable practice has led to an increase school drop-out rates in the sub-county.
3. The methods of charcoal production in the Sub-County are still traditional, involving the use of earth kilns which are noted for poor charcoal conversion. The attendant extensive cutting of trees and other vegetation types for charcoal has resulted in deforestation and environmental degradation in the Sub-County. Climate change effects such as increase in temperature and unreliable rainfalls leading to low food production and incidences of repeated famine appear to have set in. However, adoption of modern method of charcoal production has started in the county, an indication of the willingness of the producers to embrace modern technology. This willingness coupled with the progressive adoption of sustainable forest management practices in the subcounty may go a long way in ameliorating the climate change effects on the long run.
4. Charcoal production creates health challenges for the charcoal producers and users in the subcounty. The common ailments include coughs, body aches, and eye irritation. Unfortunately, most of the people affected do not seek medical attention in hospitals partly due to financial reasons and also because hospitals and other social amenities are few in the Sub-County.
5. Both the County Government and traditional institutions are actively engaged in effective promotion of sustainable charcoal production activities, though the level of awareness of the County Government's regulations on charcoal production is apparently still relatively low. Nevertheless, the promotion activities are already yielding some positive dividends in terms of increasing adoption of sustainable forest management practices by charcoal producers in the subcounty, including tree planting (an acceptance of the extant government policy of "cut one plant two" to help control indiscriminate tree cutting), agroforestry, briquetting of charcoal fines, and the use of improved charcoal stoves.

Recommendations

Based on the findings and the conclusions of this study, the following recommendations are made:

1. Banning charcoal production in the South Gem sub-county, Kenya is not effective, being the major source of livelihood for many inhabitants as this study has indicated. Also, it will not be possible to conserve the forest vegetation when the poor rural people are not given alternative source of livelihood. Instead, promoting sustainable methods of charcoal production and distribution is recommended.
2. Sustained efforts should be made by the County/Sub-County governments and traditional institutions to discourage full –time participation of children in charcoal production.
3. The on-going awareness campaigns aimed at promoting sustainable forest management and charcoal production should be sustained. There is, however, a need for government to improve on its mechanisms for awareness creation.
4. Hospitals and other essential social amenities that are readily accessible and affordable to charcoal producers should be provided in South Gem sub-county.

5. To enable more charcoal producers to adopt sustainable forest management practices, and adopt modern production techniques, and also to facilitate government intervention, charcoal producers and mark

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