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Research Article

TURNING SAWDUST INTO COOKING FUEL: AN OPERATIONAL FRAMEWORK FOR A BRIQUETTE PLANT AT SOKOBAN WOOD VILLAGE, KUMASI

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ABSTRACT

Energy is a key requirement for socio-economic development. However, the utilization of energy must not be at the expense of the environment and the future. One way of reducing dependence on biomassas a source of energy is to promote the use of briquettes by homes and industries. This study examined the feasibility of establishing and managing a briquette manufacturing plant at the Sokoban Wood Village, a leading wood industrial estate in Kumasi, Ghana. Using qualitative approach, a total of fifteen woodworkers and one technical officer were interviewed on the feasibility of such a project, availability of sawdust, and the ideal management structure for the project. Data were analysed by capturing the key themes and modes in responses, highlighting issues of contrasts and similarities, and supported by direct quotes. The results indicate that the setting up of plants to overturn sawdust into briquettes is highly feasible and would receive support and cooperation from saw millers and woodworkers. However, for ease of access and to ensure a more integrated system, such a plant should be sited at or close to the saw mill or wood village. Thirdly, it is argued that for such a plant to run effectively, operators must be recruited from among the woodworkers and trained on operational dynamics and maintenance. The management of the facility to exercise oversight responsibility should be broad-based and inclusive and drawn from the local assembly (KMA), representatives of the wood workers, and the funding/implementing agency. The study concludes that the establishment of briquette producing plants using this model is feasible and should be encouraged by stakeholders, including Non-Governmental Organizations (NGOs).

INTRODUCTION

The Energy is a critical requirement for socio-economic growth and development (Mensah-Kutin, 2007; Akuffo, 2007; Environmental Protection Agency, 2007). Activities of production, consumption, transportation, manufacturing, infrastructure, security, etc, are all built and delivered upon one energy source or the other; be it biomass, electricity, fossil fuels, nuclear, wind, solar, or thermal. This close relationship between energy and development has led (Akuffo, 2007) to project that an economic growth of 1% would require energy consumption of about 2% and that for a much desired growth of 7% to 10% would be the need for much higher sustainable supply of energy.

If Ghana is to consolidate its position as a middle income country and even improve on it,then,the burning issue of energy as a key driver must be taken seriously. According to (Wereko-Brobby, 2003), countries of the world are classified by the degree of success achieved in the management of energy resources to transform society. The so-called "Developed" nations are those that have been most successful in using energy to achieve economic

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prosperity, while the least successful remain tagged as "Developing" or "Least developed". The need for judicious use of energy resources today to promote sustainable development has been mentioned by (Ofosu-Ahenkorah, 2007). This concept has been popularized as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987).

Geographically, the common sources of energy in developing countries have included biomass, electricity, and fossil fuels, with biomass being the most dominant. An estimated 89% of the population in sub-Saharan Africa depend on biomass for energy supply (Mensah-Kutin, 2007). Biomass also dominates the energy mix in Ghana, where about 60% of energy consumed comesfrom firewood and charcoal, with 30% from petroleum and 10% from electricity (Akuffo, 2007; Environmental Protection Agency, 2007). Paradoxically, this overreliance on wood fuels has the potential to undermine development by contributing to environmental degradation and climate change.

The use of biomass is so pervasive that about 80% of all households in Ghana are believed to rely on fuelwood and charcoal as their main fuel for cooking, with 56% and 32% of households using fuelwood and charcoal respectively. In Kumasi, Ghana's second largest city, it is estimated that 80% of households use charcoal as the primary cooking and heating fuel, with a daily per capita consumption of charcoal estimated at 0.5kg (The Energy Center (KNUST), 2008; KMA, 2006). The use of firewood on the other hand accounts for about 10% of household cooking fuel mix (KMA, 2006). Firewood is also the main fuel used in commercial and informal sector enterprises, encompassing the fields of bakeries, food preparation, soap manufacturing, groundnut paste manufacturing, fish smoking, cassava processing and palm oil manufacturing (ESMAP, 2011).

The Government of Ghana, in its resolve to reduce the overdependence on biomass, adopted a programme to encourage use of liquefied petroleum (LP) gas by homes and small scale enterprises (Adom-Asamoah and Afrifa, 2011). Liquefied petroleum gas comes with major health, safety and environmental benefits compared to the traditional solid fuels (Adom-Asamoah and Afrifa, 2011). By potentially contributing to less dependence on fuelwood it ensures conservation of the forest cover. However, the programme has not attracted the needed results to date mainly due to frequent shortages and increasing price associated with LP gas (Adom-Asamoah and Afrifa, 2011).

Developed countries are also taking steps to reduce their dependence on fossil fuels. The European Union has targeted to reduce use of fossil fuels by 30% by 2020 (The Energy Center (KNUST), 2008). Fossil fuels are associated with adverse environmental impacts including those relating to climate change and human health. The use of residual fuel oils and diesels increases emission of gases that contribute to climate change (Environmental Protection Agency, 2007). Emphasis is rather advisedly being shifted to the development and use of renewable energy sources such as biomass, solar and wind, which have the potential to ensure energy security, mitigate the negative impacts of climate change and contribute to improved sanitation (Ministry of Energy and Petroleum, 2014).

Over 90% of the biomass energy (woodfuels) used in the country are directly from natural forests, with only 10% coming from wood waste, (i.e. logging and sawmill waste) and woodlands or planted forests (The Energy Center (KNUST), 2008). This disproportionate overdependence, together with other unsustainable agricultural practices, have contributed enormously to environmental degradation and destruction of the forest cover. For example, more than 70% of Ghana's original 8.22 million hectares of closed forest has been destroyed, and only about 10.9 to 11.8 percent (representing 15,000 to 17,200 square kilometers of forest cover) remain as intact forests, the bulk of which are in protected areas (Ntiamoa-Baidu, 2003). Deforestation rate in the Ghana is estimated at 22,000 square kilometers per annum. At this rate it is feared there will be no intact forest left in the country within the next 100 years (Ntiamoa-Baidu, 2003). Themanifestation of this prophecy cannot be far-fetched if the current high level of reliance on woodfuels is allowed to continue: it takes up to six kilograms of wood to produce just one kilogram of charcoal (Environmental Protection Agency, 2007). Overall, the main causes of deforestation and land degradation in the country are clearance for agricultural ventures, bushfires, the practice of shifting cultivation, timber operations, and cutting for fuelwood (Ntiamoa-Baidu, 2003; World Bank, 2007).

In addition to harming the forest cover, use of fuel wood contributes to climate change. Biomass acts as natural sinks for carbon dioxide, and its consequent removal leads to the emission and buildup of carbon dioxide and other greenhouse gases in the

atmosphere (Environmental Protection Agency, 2007; Ghana Statistical Service, 2008).

One practical way of reducing dependence on firewood and charcoal (and saving the forests) is to use instead residue and waste from biomass, in the form of briquettes. Briquettes can be made from the large amount of sawdust that come out from the sawmill and wood industry, and be burnt to produce heat as a form of energy. This can be used for cooking in homes and in the informal sector by bakers, food sellers, soap manufactures, fish smokers, and cassava processors, all of whom otherwise rely heavily on biomass. The promotion of briquettes will also help to improve sanitation by finding use for sawdust, which is treated as waste and dumped on the ground and in nearby streams, further causing pollution of these places. For this to be done, there is the need to set up briquette manufacturing plants that will produce and supply the product to end-users. However, the ownership and management of such a facility would have to be determined in order to ensure sustainability and smoothness of operations. Since there is no such facility currently existing in the country, the need for research to identify a model briquette operational system that can be replicated across either in whole or in modified forms becomes imperative.

This study therefore examines the feasibility of establishing, managing and operating a briquette manufacturing plant in Ghana. The aim is to identify the ideal organizational and management system for such a facility that can serve as a model and a standard for actual implementation. The main argument of the paper is that it is possible to identify and build a briquette manufacturing plant using the large available sawdust produced from the wood industry in Ghana, and this would be a good way of recycling waste and promoting environmental health. It also seeks to establish a workable management system that can be developed for such a venture and guarantee regular supply of the product. The goal of the paper is to contribute to efforts at reducing overreliance on wood fuels (charcoal and firewood) as cooking energy sources and hence save the forests and the environment. Moreover, this paper would contribute to efforts advanced to ensure access to affordable, reliable, sustainable and modern energy for all, as stipulated in the seventh goal of the Sustainable Development Goals.

Briquette Technology

(Filho and Butorina, 2002) assert that the development of the briquette technology has the potential to overcome depletion of natural resources by transforming organic solid waste into raw materials for heat production. According to Koufodimos and Samaras (Koufodimos and Samaras, 2002), briquetting is used in solid waste management as a form of recycling, and incorporates both raw material recovery and environmentally sound handling of organic solid waste. The production of briquettes from sawdust thus exemplifies the potential of appropriate technology for wood waste utilization. The 1990 United Nations Food and Agriculture Organisation (FAO) Report explains that briquetting of sawdust and other waste materials became widespread in many countries in Europe and America during World War II under the impact of fuel shortages. Countries such as Germany and Netherlands have realised the contribution of briquetting organic solid waste for heat production (Bautista and Pereira, 2006) (Fig. 1).

According to (Plistil, *et al*., 2005), different organic solid waste including cardboard, sawdust, shavings, waste papers, yard trims, and other assorted municipal solid waste can be turned into pellets or briquettes for heat production. Fulford and Wheldon[19],however, maintain that the best materials for high pressure briquetting are sawdust and other woody residues, because these contain a high proportion of lignin.

Globally, briquettes are promoted and preferred over traditional biomass forms of charcoal and firewood because of their comparative advantages. This includes reduction of deforestation and carbon dioxide emissions (Fulford and Wheldon, 2014). Further, they help to solve the residual disposal problem; minimise indoor air pollution; have a consistent quality and high burning efficiency; and are clean to handle and pack in bags for easy handling, transport and storage (Bikash, *et al*., 2013). (Emerhi, 2011) also asserts that briquette production saves trees that can prevent soil erosion and desertification by serving as an alternative to burning wood for domestic and industrial heating and cooking. Further, it impacts positively on public health by providing a cleaner burning fuel and also provides a better alternative to firewood (40% more efficient, longer burning and better) as well as helping to protect the environment by reducing the number of trees cut for firewood (Emerhi, 2011).

Briquette Processes and Production

Briquette production plants are fully automated plants that use processing steps to dry and harden sawdust and wood residues to be burnt for heat

Fig. 1 Samples of briquettes.

production (Seeger Engineering [SGE], 2015). (The Energy and Environment Partnership, 2013) distinguishes between two main types of briquettes, namely; carbonised and uncarbonised – produced by the application of two different processing techniques. Carbonised briquettes are made from biomass sources that have been processed through partial pyrolysis (which drives off volatile compounds and moisture leaving a higher concentration of carbon per unit). Hereafter, they are mixed with a binder, cast into appropriate shapes through pressing and finally dried. Uncarbonised briquettes are processed directly from biomass sources through various casting and pressing processes, which is also known as solidification. To operate an ideal production plant, (Grover and Mishra, 1996) highlight that the following equipment shown in (Fig. 2) is required.

Description of Briquette Plant Components

(Grover and Mishra, 1996) describe the components of the briquette plant as indicated in the flowchart as follows:

1. **Raw material supply**: The residues for briquetting should be kept in storage bins or in bays under shelters and protected from rain and run-off. The shelters should be well ventilated to allow any moisture in the raw material to evaporate. The residues can either be delivered to the start of the briquetting process manually or by automatic feeders typically used in the grain and cereal industry.

2. **Inclined screw or elevator**: The residues can either be lifted automatically or manually into the hammer mill.

3. **Vibrating Screen**: A screen or simple mesh should be fitted over the hammer mill to trap any foreign matter such as oversized residues, stones or metals.

4. **Hammer mill**: Used to reduce the particle size to 6 to 8 mm.

5. **Dryer Set-up**: Used to assist the control of the moisture content of the raw material.

6. **Intermediate Storage Bin**: The residue can be held in a storage bin after leaving the dryer. At least 4 hours of production capacity should be held in storage in case of a short break down.

7. **Main feed screw**: This screw distributes the material in the storage bin to the machines. The supply should be at least 15% greater than production to ensure that none of the machines are starved of material.

8. **Return feed**: The excess material not required by the machines returns to the intermediate storage bin.

9. **Pre-heater and Furnace**: The residues are dropped

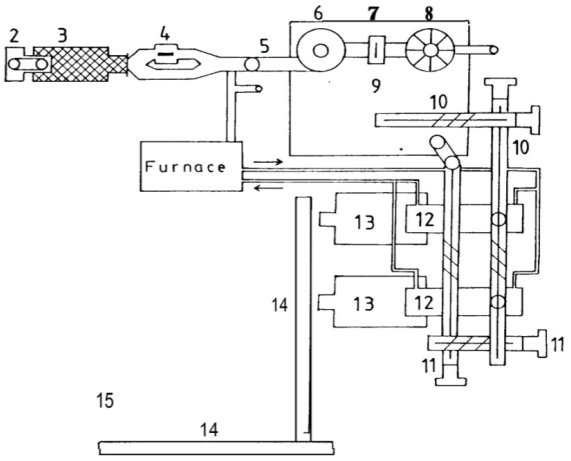

Fig. 2 Process flow sheet of briquette production.

into a chamber that pre-heats the material. The temperature should be adjustable from 90 to 200^{c} depending upon the type and moisture content of the material.

10. Briquetting Machines: The auxiliary equipment can be sized and matched to supply any number of machines. Although more than four machines may mean that the feed screws become unnecessarily complicated.

11. Cooling racks: The briquettes are hot after they leave the presses. A system of conveyors needs to be arranged so that the briquettes get time to cool down prior to storage and packing.

12. Ventilation Hoods: The smoke and fumes coming off the hot briquettes should be extracted to the outside of the plant buildings via ducts and hoods closely fitted over the cooling racks.

Procedure for Setting up a Briquetting Plant

Grover and Mishra [25] outline five critical steps that should be followed in setting up a briquette plant. These are:

1. **Initial Steps**

Grover and Mishra [25] recommend the following prerequisites prior to the establishment of briquette plants: Market need for briquettes; availability of biomass/raw materials; potential manufacturers; and availability of infrastructure.

2. Feasibility Studies

Once the preliminary market survey establishes the potentials for sales and procurement of raw materials, Grover and Mishra [25] strongly propose the conduct of feasibility studies to assess the technical and economic feasibility of the project.

3. Implementation of Project

After the feasibility studies, preparations should be made to construct the production unit. Grover and Mishra [25] suggest that a project management team should implement the project on the basis of turnkey.

4. Start-up Operation and Training

Grover and Mishra [25] again recommend start-up operation and training for effective running of briquette plants. This period according to the authors should be utilised to train the operators, welders and other technicians specifically recruited for the briquetting plant.

5. Manpower Requirements

The management of a briquette plant requires both managerial and operations staff. This however, depends on the capacity of the unit and number of operating hours by the briquette plant per day. Grover and Mishra [25] propose that the supply of raw materials and the sale of briquettes should be sub contracted as far as possible so that the management team can give adequate attention to running the production unit.

MATERIAL AND METHODS

The study context and setting

The study was carried out at the Sokoban Wood Village, an industrial estate for woodworkers located at Sokoban, about 20 km south of Kumasi, Ghana's second largest city and capital of the Ashanti Region. Kumasi is bounded to the north by Afigya Kwabre and Kwabre East districts, to the east by EjisuJuabeng and Bosomtwe-AtwimaKwanwoma districts, to the west by AtwimaNwabiagya and to the south by AtwimaKwanwomadistrict (Attuquayefio and Abdul-Rahim, 2013). The Wood village was established in 2008 as a resettlement place for woodworkers and sellers who were moved from their former base at the Anloga Junction, also in Kumasi. It is Ghana's largest wood products manufacturing district according to Effah et al., (Effah, 2013). The Sokoban community where the Wood Village is located, has a population of about 1,275 and a household size of five persons on average (Ghana Statistical Service, 2012). The wood district has an estimated 8000 workers, made up of saw millers, lumber sellers, carpenters and other woodworkers. Also, contributing to the local economic hub are other ancillary service providers including banks, food sellers, petty traders and artisans (Attuquayefio and Abdul-Rahim, 2013). The enclave produces about 100 to 150 metric tons of sawdust per day (Maddens, *et al*., 2013). The place has facilities such

as access roads and internal roads, sheds and stores, an administrative block and a modern car park. It was financed with funding secured by the Ghana Government from the Government of France through the AgenceFrancaise de Development (AFD). To ensure effective management of the wood village, the Kumasi Metropolitan that owns the facility and manages it on behalf of the government has appointed a 11-Member Management Committee with representatives from KMA, woodworkers, the Member of Parliament for the area, Regional Forestry Manager, and the management company of the village, Goldstreet Real Estate Consult (Ghana News Agency [GNA], 2011).

The study formed part of a larger research that investigated the feasibility of establishing a briquette manufacturing plant at the Sokoban Wood village to produce briquettes, and the prospects of patronizing the product by targeted end-users (food vendors) in the Kumasi metropolis (Fig. 3).

The study had two parts. One part examined the probability of food vendors switching from use of charcoal and firewood to briquettes, focusing on the conditions that would make them do so. The second part dealt into the plausible management system for the setup, with a focus on the critical issue of whether the facility should be manned and operated by the saw millers or by outsiders. This paper presents the findings of the ideal set up and management system.

The case study design was adopted for the study. The approach was basically descriptive and qualitative, focusing on the views and perceptions of woodworkers on the ideal management setup for a briquette factory at Sokoban (Fig. 4).

Target population and sampling

The target population for this study comprised woodworkers of the Sokoban Wood Village and the management members. In line with the qualitative nature of the study, purposive sampling was used to recruit 15 of the woodworkers and one member of the Management Committee.

These category of woodworkers were selected because they constitute the main groups of workers at the wood village. Purposive sampling technique enabled a quick scan of the population to select particular respondents who had in-depth knowledge of the local dynamics including the social organization and mood in the study area.

Data Collection

Primary data were collected through face-to-face interviews using an interview guide. The questions asked were mainly qualitative, seeking

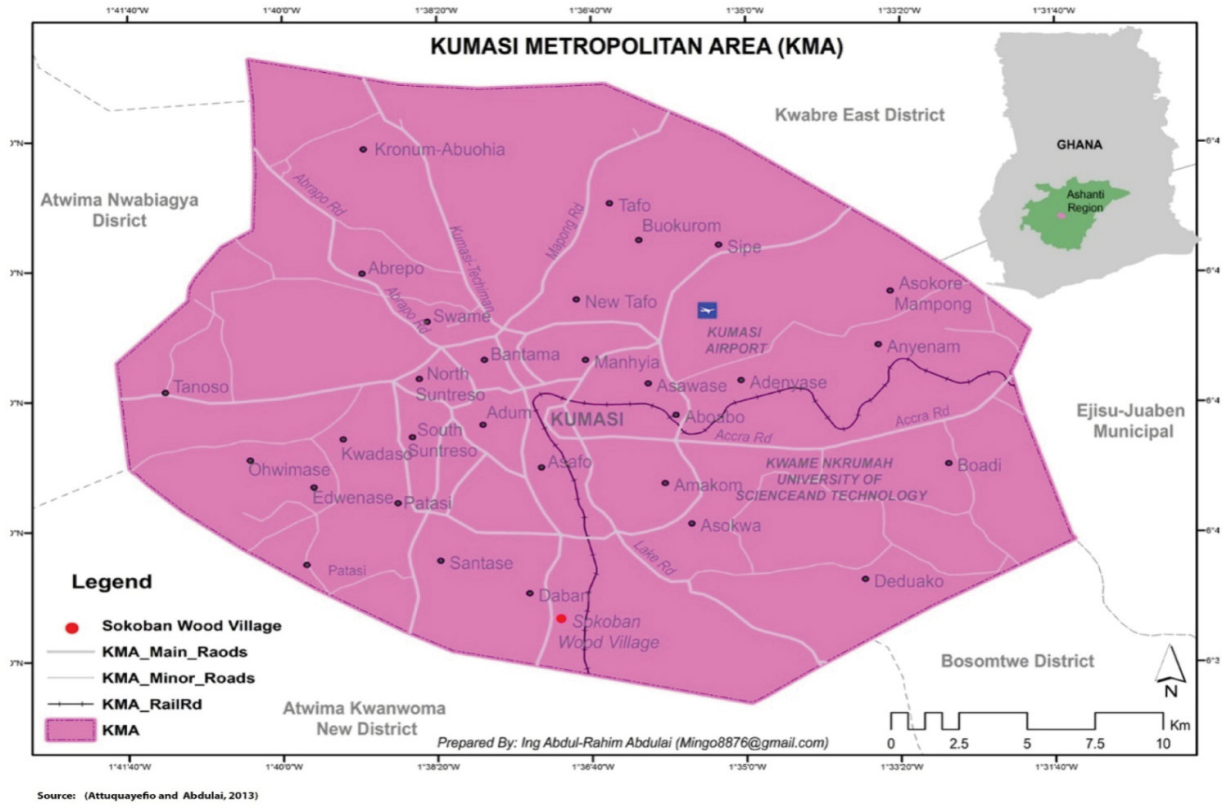

Fig. 3 Map of Kumasi Metropolitan area showing sokoban wood village.

Fig. 4 A picture of the Sokoban Wood Village in Kumasi.

for the opinions of respondents on the viability and management system for the briquette plant. According to Bryman (Bryman, 2008), interviews are the most widely used method in qualitative research. All the interviews took place at the Wood Village during working hours and lasted for about thirty-five minutes each. This provided the much-needed natural background setting needed and helped to elicit responses that reflected the nuances on the ground. To ensure uniformity and ease of procedure, all interviews were conducted in the local Twi language, but translated into English during recording.

Data Analysis

The study used the thematic analytical approach to analyse the primary data. By this process, the field data weretranscribed, described and narrated. Data were then grouped according to the specific themes at hand, from which issues of similarities and contrasts were derived and analysed. Direct quotations were used to give credence to the interpretive write-ups.

Ethical Considerations

(Creswell, 2007), groups ethical issues into informed consent procedures; deception or covert activities; confidentiality toward participants, sponsors, and colleagues; benefits of research to participants over risks; and participant requests that go beyond social norms. According to the ethical guidelines of the Social Research Association (SRA), researchers have obligations towards the subjects of study and therefore, must "strive to protect subjects from undue harm arising as a consequence of their participation in research" (Social Research Association [SRA], 2003).

In the conduct of this research, the researchers strictly adhered to these ethical standards. In order to build trust and gain support from participants, the identity of the researchers were disclosed and the purpose of the study explained to them. The purely academic nature of the study was also declared. Again, to protect the anonymity of participants, the researcher assured them of the confidentiality of their responses. They were further assured that participation in the study was strictly voluntary and they could withdraw at any time in the course of the interactions. They also had the right to refuse to answer any question they did not wish to.

RESULTS AND DISCUSSION

Characteristics of the sample

The respondents were people who were familiar with the conditions at the wood village. These comprised 15 woodworkers and one technical member of the management committee. The 15 woodworkers consisted of 5 carpenters, 5 saw millers, and 5 lumber sellers. All of the carpenters and saw millers were males while four of the lumber sellers were females. Carpentry and sawmilling are male-dominated activities while selling of lumber and other building wood products for the building industry has a strong women presence. Some of these women had been hired by the male shop owners while others were managing their husbands' shops. Six (6) of the respondents were aged 31-40 years, and another six (6) aged 41-50 years. The remaining three (3)were older and fell within the age bracket of 51-60. The majority had worked at the wood village for a period not less than six years; only one person had worked there for up to three years. This portends good knowledge of the study area and its conditions.

Existing management and associations at the wood village

In line with its aim, the study sought to find out how the various categories of woodworkers are organized and how this affects their work. A question was asked, "Do you belong to any association here, and if so, how does that affect your operations? All the 15 respondents indicated that they belonged to one association or the other. These unions sought out the welfare and smooth operation of members' businesses. They advocated on behalf of their respective members and came to their aid when they had any issue at the workplace. They also assisted members in times of bereavement.

"I belong to the Anloga Carpenters Workers' Union here (Sokoban Wood Village). So we have leaders who oversee our interests and affairs", (Carpenter, September 11, 2015).

"We have a union called the Anloga Carpenters Workers' Union, and we have leaders who manage our operations at the wood village", (Saw miller, September 11, 2015).

"I am a member of Israel Lumber Sellers' Association. Our leaders manage our activities", (Lumber seller, September 11, 2015).

However, in addition to the various woodwork-specific associations, there is an umbrella committee that hasoversight responsibility for the wood village. It is known as the Sokoban Wood Village Management Committee and is made up of representatives of the various woodworkers associations as well as representatives from the Kumasi Metropolitan Assembly (KMA), the Member of Parliament for the area, the Regional Forestry Manager, and the management company of the village, Goldstreet Real Estate Consult. Among the functions of the committee are granting of permits and regulating the establishment and operation of businesses and organisations at the wood village. Goldstreet Real Estate Consult has been contracted to undertake day-to-day consultancy services in security, sanitation and general maintenance. Both the Committee and GoldstreetCompany are answerable to the Kumasi Metropolitan Assembly, who owns and runs the facility on behalf of the Government of Ghana.

The main thrust of this study is to assess the feasibility of establishing a briquette manufacturing plant by evaluating the ideal management structure of the plant. According to (Amanor-Boadu, 2003), feasibility assessment is the disciplined and documented process of thinking through an idea from its logical beginning to its logical end to determine its practical viability potential, given the realities of the environment in which it is going to be implemented. Feasibility study or assessment focuses on four major areas, including market feasibility, technical feasibility, financial/economic feasibility and organisational/managerial feasibility (Davis, 2016). Organizational/managerial feasibility is the focus of this paper.

Expected benefits and availability of sawdust for briquette

The news about the proposed establishment of the briquette plant at the Wood Village was met with excitement and endorsement by the woodworkers, and they expressed their willingness to fully support and corporate with it. They further promised to offer their sawdust free of charge to the briquette plant when established. Among other things, woodworkers unanimously expected the briquette plant when established to address the sawdust waste disposal challenge the wood village faces, generate income to develop the wood village, as well as create employment.

"One major challenge facing the wood village here is improper disposal of sawdust waste. Now neighbours are even complaining about the site where we burn the sawdust. They say it generates too much smoke and is affecting them. When the plant is constructed therefore, it will help us to solve this problem. Also, I expect the plant to generate income to improve security and sanitation at the wood village", (Lumber seller, September 11, 2015).

To respondents, therefore, the establishment of the plant will help clear the high heaps of sawdust that had piled up the site. It will also address the health effect of burning of sawdust, which is currently the only other means of disposing of sawdust, other than throwing into streams and gutters.

Another interviewee commented

"The plant will eliminate the sawdust waste disposal challenge that we face here. It will also help me to even save some money since I pay for people to collect my sawdust. The plant will also generate income that can be used to rehabilitate some of our roads, and build schools", (Saw miller, September 11, 2015).

"My shed is always occupied with sawdust, and I find it difficult to even move around. I believe when the plant is established, the sawdust waste will be cleared regularly. I also believe the plant will provide income to develop the wood village and even create employment for people", (Carpenter respondent, September 11, 2015).

These high expectations are in tandem with the situation in other jurisdictions. For example, UNDP Nigeria (n.d) reports that a briquette producing

factory in that country was able to create about 200 jobs among the local communities, with an additional 8,000 to be created within five years of the operation of the project. The project was also projected to achieve 92% reduction in the amount of sawdust incinerated – leading to a significant reduction in environmental pollution and improvement in the health of the people. (Young and Khennas, 2003) also report that the expansion in briquette production in Kigali, Rwanda led to the production and sale of 15,000 tonnes of briquettes per year, created 450 jobs and supported indirectly a further 1550 jobs.

However, while almost all respondents agreed to offer their sawdust free of charge for the plant, one person gave indication that he would rather sellhis sawdust.

"I sell my sawdust to some poultry farmers and food vendors. I will therefore, sell it to the plant when it is established, so that I can continue to generate income from the sawdust waste", (Carpenter, September 11, 2015).

The technical member of the Sokoban Wood village management committee who was interviewed indicated that sawdust would always be available in required quantities to supply to the briquette plant when constructed. To him, if there was going to be any problem, it was not going to come from the availability of sawdust.

"I am not sure about the volume and type of sawdust that would be needed; but you can be assured that the availability of sawdust is guaranteed for the operation of the briquette plant and there is no question about that at all" (Technical committee member, September 7, 2015).

If the experiment works in Ghana, the country would be among the League of Nations using this technology to save the environment and forests. Countries such as Bangladesh, Thailand and China are reported to be using briquette technology to enhance their national economies, reduce carbon dioxide emissions and enhance environmental conservation by promoting efficient waste management (United State Agency International Development [USAID], 2010). Since 2000, (Fulford and Wheldon, 2014) report that there has been a rapid increase in the production and use of wood pellets in Sweden, Germany and Austria. In Kenya, Chardust Ltd, reckoned as the perhaps the best-known company in the briquetting industry in the country, is able to sell 220 tonnes of fuel briquettes per month to domestic users, restaurants and poultry farmers for brooder heaters (Chardust, 2008).

Siting and management of the proposed briquette plant

All respondents agreed that the briquette plant should be established on-site at the Wood Village. The main reasons for this choice were proximity, proper management and a sense of ownership. Woodworkers claimed that since they were the ones whose sawdust was going to be used to feed the plant, it would be unfair to locate the factory anywhere else.

On the management of the briquette plant, majority of the respondents preferred the Management Committee of the Sokoban Wood Village to be in charge. This committee is the overarching body with oversight responsibility for the wood village. Respondents held that the committee had the capacity to manage the plant, as it was broad-based and represented the broad spectrum of the various interest groups and stakeholders in the enclave. The committee was held to be trustworthy and also commanded the respect of the various workers. Ten (10) woodworkers out of the 15 supported this position.

"I prefer the Management Committee of the Sokoban Wood Village to manage this plant. I think the committee is representative and has the expertise and capacity to handle the plant when established", (Carpenter respondent, September 11, 2015).

Another offered

"Oh! The Management Committee of the Sokoban Wood Village can manage it. That committee has all the association members on it, so I think they can effectively manage it", (Saw miller, September 11, 2015).

Finally,

"I don't think the associations can manage this plant. In my view, the Management Committee of the Sokoban Wood Village has the capacity to manage it. The committee will also be more accountable and transparent", (Lumber seller, September 11, 2015).

However, three (3) woodworkers were of the conviction that the respective unions and associations should be the ones to be mandated to manage the briquette plant.

A carpenter indicated

"It is we carpenters who generate the bulk of the waste and so it is only fair that our union be allowed to manage the plant", (Carpenter, September 11, 2015).

This position was corroborated by another respondent

"I have trust in the Anloga Carpenters Workers' Union and I believe they can effectively manage the plant, (Carpenter, September 11, 2015).

A lumber seller also added his voice to this call thus

"The Anloga South Lumber Sellers Association can effectively manage the plant. We are one of the largest associations on site, and I believe we can manage it", (Lumber seller, September 11, 2015).

Taking a completely different view were two (2) woodworkers who indicated their preference for an outside and independent management team to be in charge of the plant. They cited their dissatisfaction with the work of the union leaders and the busy schedules of the Management Committee of the Sokoban Wood Village as their reasons.

"I am not satisfied with the work of union leaders and I don't trust them. I think an outside management team can effectively manage the plant. The outside team will also promote transparency and accountability", (Carpenter, September 11, 2015).

His other corroborator indicated

"I prefer an outside management team to handle the plant. I don't think the associations have the capacity to manage the plant. I also think the Management Committee of the Sokoban Wood Village is too occupied to add this to their work", (Saw miller, September 11, 2015).

However, to the Technical member of the Committee, the management of the facility should be a joint venture between KMA who owns both the land and the wood village, and GIZ who are the project promoters. To him, any management arrangement without the involvement of GIZ especially would be a non-starter since they are the principal stakeholders in the scheme.

"The management of the plant should be collaboration between KMA and then GIZ. This is because KMA owns the land and investment at the wood village.

The involvement of the private sector in such environmental efforts is not new. For example, Cambodia's briquette project, Sustainable Green Fuel Enterprise (SGFE) was initiated in 2008 by the NGOs GERES Cambodia and Pour unSourired'Enfant (PSE) through a joint project (SGFE, 2014). Private enterprises and NGOs have also been at the forefront of efforts at environmental conservation through setting up of briquette plants in Kenya. Chardust Ltd, a private entity, is perhaps the best-known company in the briquetting industry in Kenya (Energy and Environment Partnership (EEP), 2013). The company itself is managed by its three founders and directors, including two foreign nationals and one Kenyan citizen (SGFE, 2014). To sum up, according to (Njenga, *et al*., 2009), the conversion of organic wastes into fuel briquettes is being undertaken by non-governmental as well as Community-Based Organisations (CBOs) in various countries which have seen the positive side of waste.

CONCLUSION

The main objective of this study was to assess the feasibility of establishing a proposed briquette plant at the Sokoban Wood Village in Kumasi, with specific interest in the type of management system that should be put in place to manage the plant when set up. From the results, it is inferred that the setting up of briquette factories to overturn sawdust which has become a menace to the environment is highly feasible and should be encouraged. There are many sawmill and woodworking enclaves dotted all over the country, particularly in the forest region, that produce sawdust in large quantities, hence supply of the principal raw material would not be a problem at all. Secondly, for ease of access and to ensure a more integrated system, such a plant should be sited on or close to the saw mill or wood village. Thirdly, it is suggested that for such a plant to run effectively, operators who will operate the facility should be recruited from among the woodworkers and given sufficient training on its work processes and maintenance. They should be engaged with their clearly stated conditions of service. However, when it comes to management of the setup, the management team should be drawn from the woodworkers, the local authority and the project implementers. Such a composition would pass as inclusive as it is drawn from its principal stakeholders. A noted weakness of the study is that it is qualitative and relies on non-probability sampling, which limits the findings in terms of applicability. Future studies that rely on quantitative and probability sampling approaches would be needed to corroborate the results of these findings.

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