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Potential of agro-waste briquetting for domestic heating and cooking as an environmental management strategy in Rushinga, Zimbabwe.

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***Abstract*— Deforestation and pollution are externalities produced by agriculture and natural resources exploitation economic activities. The rate of deforestation in Zimbabwe is very high relative to other SADC countries. This is due land clearance for agriculture, fuel-wood for processing of agriculture produce and fuel wood for domestic heating. With agriculture being the main source of rural livelihoods, substantial amounts of crop residue remain behind after harvesting and post-harvest processes. The practice of burning crop residue in the fields and homesteads is common and results in the dissipation of energy into the environment. To this end, this study seeks to ascertain the possibility of producing biomass briquettes from agro-residue for domestic heating and cooking as an environmental management strategy. The pre-survey established the baseline conditions and agro-residues available in the study area. Groundnut shells were selected as the briquetting feedstock while paper was used as a binder. A manual press was then used to mould briquette at the ratio of 3:1 (paper:biomass). Formed briquettes were distributed in the community after which a post-survey was conducted to evaluate the willingness to pay for and use of briquettes. Results showed that the communities were willing to pay $10 per month on briquettes, thus a binder costing less that USD$10 would be ideal for briquetting.**

Keywords*— *Briquettes, agro-residues, biomass, binder)

I. INTRODUCTION AND BACKGROUND

Agriculture is a paramount source of livelihoods in Sub-Saharan African [1]. Most of the developing countries' economies are hinged on agriculture as it is the major source of revenue [2]. Increased environmental and sustainability concerns put developing countries at a dilemma of choices in resource allocation and use especially in agriculture [3]. Deforestation and pollution are externalities produced by agriculture and natural resources exploitation economic activities [4]. In the third world, one of the major problems is the issue of the environmental degradation [5]. Forests and trees account for 23% of global carbon stored in forests, and deforestation and forest degradation account for 30% of Africa's GHG emissions [6] thus contributing to climate change. The extensive removal of tree cover for dry-land farming, overgrazing, and the disproportionate cutting of wood resources for fuel purposes are the main causes of deforestation in arid and semi-arid environments [7].

Currently, biomass provides only about 15-20% of global energy needs. In developing countries biomass provides 20-33% of total energy demand [8]. The main sources of energy used in Zimbabwe comprise coal, wood fuel, electricity and petroleum fuels. According to the Ministry of Energy and Power Development, Zimbabwe [9], wood fuel provides the bulk (61%) of the total energy supply, followed by liquid fuels (18%), electricity (13%), and coal (8%). Thirty-seven per cent of households in Zimbabwe have access to electricity that is connected via power lines. In urban areas 83 per cent of households have electricity, compared with 13 per cent in rural areas [9]. Rural communities meet 94 per cent of their cooking energy requirements from traditional fuels, mainly firewood, and 20 per cent of urban households use wood as the main cooking fuel [10].

Vision 2030 is the aspiration of Zimbabwe that they attain upper middle class economy status by the year 2030. This would translate to the re-industrialization and increased capacity utilization of industries. Regardless of the low capacity utilization of industries which affords the grid to supply domestic needs, electricity supply is erratic and demand for fuel wood is high. Thus, if Vision 2030 is realized, the industrial demand for electricity from the grid would mean that domestic supply would be more erratic than currently experienced culminating in the high demand of wood fuel, resulting in increased deforestation rates. A majority of urban households use electricity for cooking (73%); in contrast, only 6 per cent of rural households use electricity for this purpose [10]. With the current erratic electricity supply from the power utility and limited off-grid and distributed electricity supply, very high cost of LPG, low uptake of solar technologies, it is highly probable that the dependence on wood for domestic heating and cooking has increased in both rural and urban areas.

During the period 2000 – 2010, forest in Zimbabwe was declining at a rate of 1.78% against the average of 0.48% for the Southern Africa region [6]. During this period [11], the capacity utilisation of industries declined rapidly from 33.8% in 2006 to 10% in 2008. The UN Food and Agriculture Organization (FAO) [12] listed Zimbabwe as being among 10 countries that recorded the largest forest cover loss between 1990 and 2010 (losing 327,000 hectares of forest cover per year). Cutting down trees for wood fuel has been identified by Chipika and Gowero (2000) as one of the major drivers for deforestation in Zimbabwe [13]. As in most developing countries, Zimbabwe is lagging behind in terms of global trends of renewable energy, especially in biomass densification through briquetting.

Access to energy is not homogeneous with the energy matrix in urban areas comprising of a number of energy sources against that of rural folks who depend largely on wood fuel. Statistics from the Ministry of Energy, Zimbabwe [9], reveals that 94% of the people in the rural areas use fuel wood and most of the rural areas are facing wood fuel shortage as a result of inter alia, the clearing of land for agriculture and unsustainable firewood harvesting. Demand for wood fuel already exceeds supply in Manicaland, Mashonaland Central, Mashonaland East, the Midlands and Masvingo provinces [9]. Most of the people in the rural areas depend on crop farming for sustenance and produce agriculture waste which has the potential to be used as a fuel energy source. It is against this backdrop that this research seeks to assess the viability of agro-waste densification for use in domestic cooking. This paper investigates Potential of agro-waste briquetting for domestic heating and cooking as an environmental management strategy in Rushinga, Zimbabwe.".

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In Zimbabwe, biomass accounts for about 47% of the energy supply in Zimbabwe (Ministry of Energy and Power Development 2012). The structure of energy supply in Zimbabwe in relation to the African continent and the world is shown in Table 1. Like in most parts of the developing world, fuel is the most widespread used energy source in rural communities.

Energy supply sources in %	Energy supply source			
	Biomass	Electricity	Coal	Petroleum
Zimbabwe	47	13	19	21
Africa	59	8	4	25
World	14	16	7	44

Source: Shonhiwa C. (2013) [13]

Biomass briquettes from agro-waste can be a biofuel substitute to wood fuel and charcoal. They are a renewable source of energy and avoid adding fossils carbon and sulphur to the atmosphere. Carboniferous material can be briquetted either without a binder under high pressure or by the aid of a binder at lower pressure. This study is therefore aimed at investigating the agro-waste densification (briquetting) using binders for domestic cooking as a substitute or compliment for fuel wood.

The rate of deforestation in Zimbabwe is very high relative to other SADC countries. Forest loss contributes significantly to Zimbabwe's green-house gas emissions as industries capacity utilisation is very low. The practice of burning crop residue in the fields and homesteads is common among rural and urban areas. In doing this, crop residues combust inefficiently polluting the environment and dissipating heat/energy which if harnessed could help reduce the dependence of people on fuel wood. Thus, briquetting will go a long way in anthropogenic CO2, enhance energy security among the vulnerable (women and children as they are the ones who fetch fuel wood), reduce pollution and provide affordable renewable energy.

II. Methodology

This paper seeks to ascertain the techo-economic feasibility of briquetting agro-waste residues for domestic heating and cooking. Qualitative research tools were utilized in the collection of data. A pre-survey was conducted to ascertain the types of crop residue that is found in the area. During this period, Key Informant Interviews were used to assess the practices of crop residue handling, utilization and disposal. Informants were chosen from community and extension workers, community leaders, farmers and child councilors. Groundnut shells were selected to be the biomass based on abundance and calorific value while waste paper was chosen as

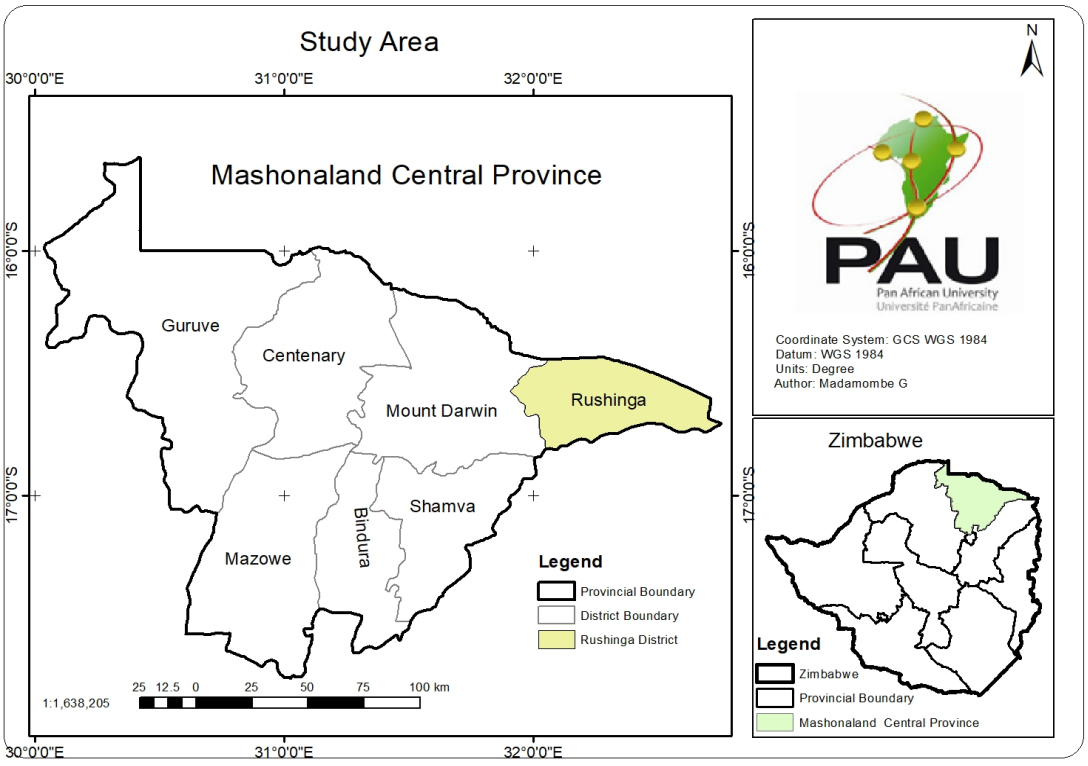

Figure 1: Location of Study Area

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binder based on convenience to the researcher.

Paper was mashed in water to make a paste which was used as the binder to the biomass. Excess water was drained during the molding of the briquettes by the use of a manual hand-press. The molded briquettes were sundried for a period between 3-7days. Participants in the study then used the dried briquettes intermittently for a period stretching three months. After three months, a structured questionnaire was administered among 30 households to assess a number of things among which willingness to pay was extrapolated, contemporary fuel source, cooking practices and amounts of other fuels used. All interviewed households had stayed for at least a decade in the district. Participants were chosen based on the consent from the participants and amount of groundnut shells within the vicinity of the homestead or willingness of the participants to carry briquettes from a homestead meeting the first two conditions.

The questionnaires were printed in English and the enumerator would translate to the local Shona dialect were the respondents needed clarifications. To ratify the results from the questionnaires, enumerators would do additional checks on the amount of wood collected together with the participants as enumerators were drawn from the study area. Fig 1 shows the location of Rushinga District in Zimbabwe.

III. Results and Discussion

This section of the paper presents and discusses the results of the study. Only one member of a household participated in the questionnaire survey. On average, a family comprised of five members. Fig. 2 and Fig. 3 show the characteristics of the sample respondents from the sampled households.

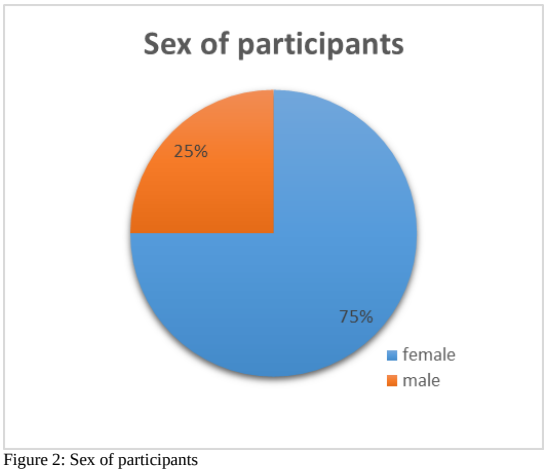

Figure 2: Sex of participants

Women are the ones mostly involved in cooking and most domestic chores. As such, 75% of the respondents were females while 25% were males. From this study alone, one cannot conclude that women are the ones mostly involved in the use of energy as the study did not cover the whole year.

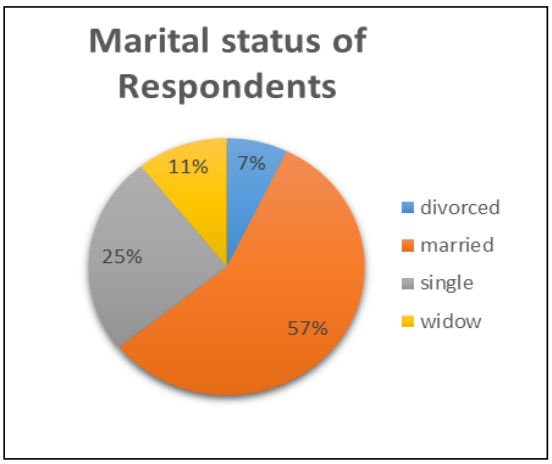

Figure 3: Marital Status of Respondents

During some seasons, in the study area, men would be engaged in beer brewing for rituals such that if the study was to be carried out during this period, the results would be different. Figure three shows the marital status of the participants. It is worth to note that participants who were single were out of school youths who were either staying with their parents or guardians.

Rushinga District lies in the arid north-east part of Zimbabwe (Fig. 1) which is sparsely vegetated. It has been noted from the participants that people in the area are aware of the consequences of the relying much on wood as the primary source of energy. 75% of the respondents considered using briquettes on the basis of curbing deforestation and increasing energy security. 30% highlighted health concerns as the motivation to using briquettes as they perceived wood as causing more pollution than briquettes. A fifth of the participants were reluctant to adopt briquettes are they did not perceive an energy crisis as was by the four fifths who were concerned about a perceived energy crisis due to shortage of wood.

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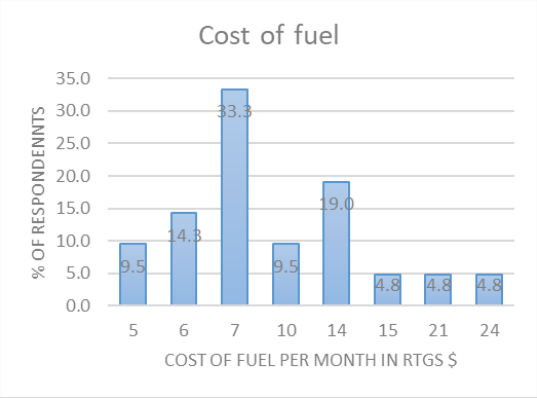

Figure 4: Cost of fuel

The results indicated that people use an average of RTGS$10 per month (at the time the study was conducted the parallel market exchange rate of USD$ to RTGS$ was at 1:2.5). From this, at the time of conducting of the research a person would be using RTGS$ 2 on wood fuel per month.

The cost of wood differed with location with a cart costing RTGS$6 and RTGS$7 while a wheelbarrow load costed between RTGS $3 and RTGS$5. The expenditure of the respondents on fuel is shown in Fig. 4. The quantities of wood used varied as with the cost as shown in Fig 5.

Figure 5: Quantity of fuelwood used per month

IV. Conclusion and Recommendations

The study results have shown that there is a proportion of people in Rushinga district who are willing to make, use and pay for briquettes made from agro-residues. With a considerable percentage viewing briquetting as means to curb deforestation thus also GHG emissions due to forest loss, policy makers may consider promulgating policies that promote briquetting. Rural communities are likely to embrace briquetting not only for harnessing energy from loose biomass, but also for managing solid waste. There is need for further research on the optimization of briquette making at community level and the developing of low cost briquetting equipment suitable for using feedstock available in the area.

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References

[1] Rukuni M and Eicher C. K. (1994). Zimbabwe's Agricultural Evolution, University of Zimbabwe, Harare, Zimbabwe

[2] Keyser J. C. (2002). The costs and profitability of tobacco compared to other crops in Zimbabwe. Health, Nutrition and Population (HNP) Discussion Paper 1, Economics of Tobacco Control, World Bank, Washington, DC, USA.

[3] Chivuraise, C., Chamboko, T., & Chagwiza, G. (2016). An Assessment of Factors Influencing Forest Harvesting in Smallholder Tobacco Production in Hurungwe District, Zimbabwe: An Application of Binary Logistic Regression Model. Advances in Agriculture, 2016.

[4] Pearce D and Brown K (1994). Saving the world tropical forests. The Economics and Statistical Analysis of Factors Giving Rise to the Loss of the Tropical Forest, pp. 2–26, UCL Press

[5] Benhin J. K. A. (2006). Agriculture and deforestation in the tropics: a critical theoretical and empirical review. Ambio, vol. 35, no. 1, pp. 9–16

[6] Bromhead, M. (2012). Forest, Trees, and Woodlands in Africa: An Action Plan for World Bank Engagement.

[7] Hassan R. M. and Hertzler G. (1988). Deforestation from the overexploitation of wood resources as a cooking fuel: a dynamic approach to pricing energy resources in Sudan. Energy Economics, vol. 10, no. 2, pp. 163–168, 1988.

[8] Ministry of Energy and Power Development, Zimbabwe (2009). Energy Balance.

[9] ZIMSTAT (2010), Demographic and Health Survey.

[10] Zimano, D., & Kaseke, N. (2014). Turnaround strategies choice and effectiveness: The case of the manufacturing sector in Zimbabwe.

[11] Zimano, D., & Kaseke, N. (2014). Turnaround strategies choice and effectiveness: The case of the manufacturing sector in Zimbabwe.

[12] Chipika, J. T., & Kowero, G. (2000). Deforestation of woodlands in communal areas of Zimbabwe: is it due to agricultural policies?. Agriculture, ecosystems & environment, 79(2-3), 175-185.

[13] Shonhiwa C. (2013) An assessment of biomass residue sustainably available for thermochemical conversion to energy in Zimbabwe. Biomass and Bioenergy;52:131-8.