Value-Addition in Biomass for enhanced Household Energy Security in Navakholo Sub-County, Kenya

Stacey Waudo[1] and Fuchaka Waswa[2]

[1]*Department Environmental Science and Education, Kenyatta University, Kenya*

(waudostacey@yahoo.com)

[2]*Department of Agricultural Science and Technology, Kenyatta University, Kenya*

https://doi.org/10.62049/jkncu.v4i1.52

Abstract

Although firewood is still the dominant source of energy in the majority of rural households in Navakholo, its sustainable availability is threatened by a steady decline in tree cover as much land gets converted to agricultural use. Opportunities for expanding energy security in such places reside in previously untapped potential for value addition on biomass energy sources. The broad objective of this research was to enhance availability and access to biomass energy while at the same time conserving tree cover for posterity. The specific objective was to assess opportunities for energy security through value-addition on available biomass energy sources. Data was collected using a questionnaire survey and focus group discussions in each of the five Wards of the Sub-County. Descriptive statistics and content analysis of responses were used to analyse the data and generate knowledge to inform future decision-making. Although Navakholo sub-county is a maize and sugarcane zone, results showed that value-addition practices on these two biomass energy sources such as through briquetting are non-existent. Much of the maize cobs are directly used as low energy fuel or simply left to rot away. Cow dung, which has a potential for energy provision through conversion into energy balls is usually used as manure in the farm. In addition, investment in biogas production is untapped because of the high initial costs. Only rudimentary approaches such as use of saw dust in cook stoves, and extinguishing firewood and charcoal after the day's cooking are used to ease the pressure on available firewood. Although charcoal is a value-added product on wood fuel, respondents did not see it from that perspective. It was instead viewed as an energy alternative for those who could afford it. Opportunities for other value-added products like briquettes from charcoal, dust, saw dust and sugarcane cutting singly or in blended form remains unexploited. With appropriate exposure and capacity building on binder material and supply of press equipment, availability of biomass energy can be increased through the conversion of readily available maize cobs into briquettes. Secondary feedstock like cow dung, charcoal dust and saw dust may also be converted or used as binder material.

Keywords: Biomass, Value-Addition, Briquetting, Household Energy Security

Introduction

Current debate on energy supply and demand shows that renewable energy can supply two-thirds of the total global energy demand and contribute to the bulk of the reduction in greenhouse gas emissions (Gielen et al., 2019). As a key renewable energy source, biomass fuels are the largest source of primary energy in Kenya with firewood and charcoal accounting for about 69% of the total primary energy consumption. About 55% of this energy is obtained from woody perennials, crop residues and animal waste (Republic of Kenya, 2018). Reliance on firewood for cooking is also still popular in most developing countries, largely due to their inability to afford cleaner energy sources like electricity and Liquefied Petroleum Gas (Belward *et al*., 2011). The commensurate pressure on tree cover will exacerbate the impacts of climate change through persistent decline in this carbon sink (Waudo et al., 2023). Leveraging the potential in biomass, calls for innovations in value-additions towards energy use efficiency and higher environmental performance. This in part explains the growing shift in global energy sources from conventional to non-conventional, from high to low carbon, from simple production to technological production, and from one-time utilization to multiple use, where-in value-addition technologies exist (Lu and Dudensing, 2015).

As an aspect of value-addition energy use efficiency has been improved in various parts of Kenya through the introduction of improved cook stoves (ICS) (World Vision, 2020). A study on the use of ICS in the Peruvian Andes showed that improved stove usage appeared to reduce firewood consumption by 46% (Andrianzen, 2013). Despite such benefits adoption of ICS in Kakamega County is still low, with households still preferring the traditional 3-stone gasifier (County Government of Kakamega, 2016). Value-addition that involves conversion of agricultural feedstock is largely untapped and appears not to be a priority despite its potential to enhance domestic energy security in rural areas. Whereas Kenya's energy policy mentions the importance of biomass as the main energy source, the nearest it comes to value-addition is its acknowledgement of lack of efficient technologies for its conversion. Inherent in conversion is briquetting, which is hampered by lack of awareness of available technology and general apathy among farmers (Republic of Kenya, 2018). Similarly, the Energy Act (2019) only mentions value-addition with respect to coal (Republic of Kenya, 2019).

Value addition using agricultural feedstock appears not to be a priority, despite its potential for rural energy security and environmental performance through reduced pressure on wood fuel and hence tree cover. For instance, briquettes produced from bagasse, coffee, maize and saw dust provide a more sustainable alternative to firewood and charcoal (Kenya Briquette Industry Study of 2010; UNEP, 2019). Given the wide range of biomass energy sources available in rural areas including Navakholo, (e.g. charcoal dust, saw dust, stover, stubble, cow dung, maize cobs, crop husks) briquetting provides the opportunity to increase availability and access to domestic energy while reducing pressure on the already declining tree cover (Farm Energy, 2019; Asonia et al., 2017; Mitchual et al.,2013). This technology can be used widely in Kenya based on the kind of feed stock available. For instance, the maize zone can focus on cobs, the coffee zone on coffee husks, the rice zone on rice husks, and coast on coconut husks (Heuze et al., 2016; USAID, 2015). This potential in rural areas is however limited by lack of funds to acquire modern hydraulic presses and lack of briquette making skills (Mokaya, 2020; Ngusale et al., 2014).

Given the proven benefits inherent in energy use efficiency, this study sought to assess the status of value-addition on biomass energy sources in order to increase opportunities for energy security, while reducing pressure on tree cover using Navakholo Sub-County as a case study.

Methodology

This study was carried out in Navakholo Sub-County in Kakamega County (Figure 1), which lies within the western Kenya maize and sugarcane belt. Maize is grown mainly for subsistence. Surplus yield now forms a big part of small-scale agribusinesses. Sugarcane is the main cash crop The five Wards that constituted the research sites were: Bunyala West, East, and Central, Ingotse-Matiha and Shinoyi-Shikomari-Esumeiya. Firewood and charcoal are the main sources of household energy, used for cooking, heating and lighting. A total of thirty key stakeholders (vendors) in the biomass energy value chain were selected to provide information on value addition practices done in the sub-county (Table 1). These vendors were visited and interviewed on the official market day of the Wards, usually one day in a week.

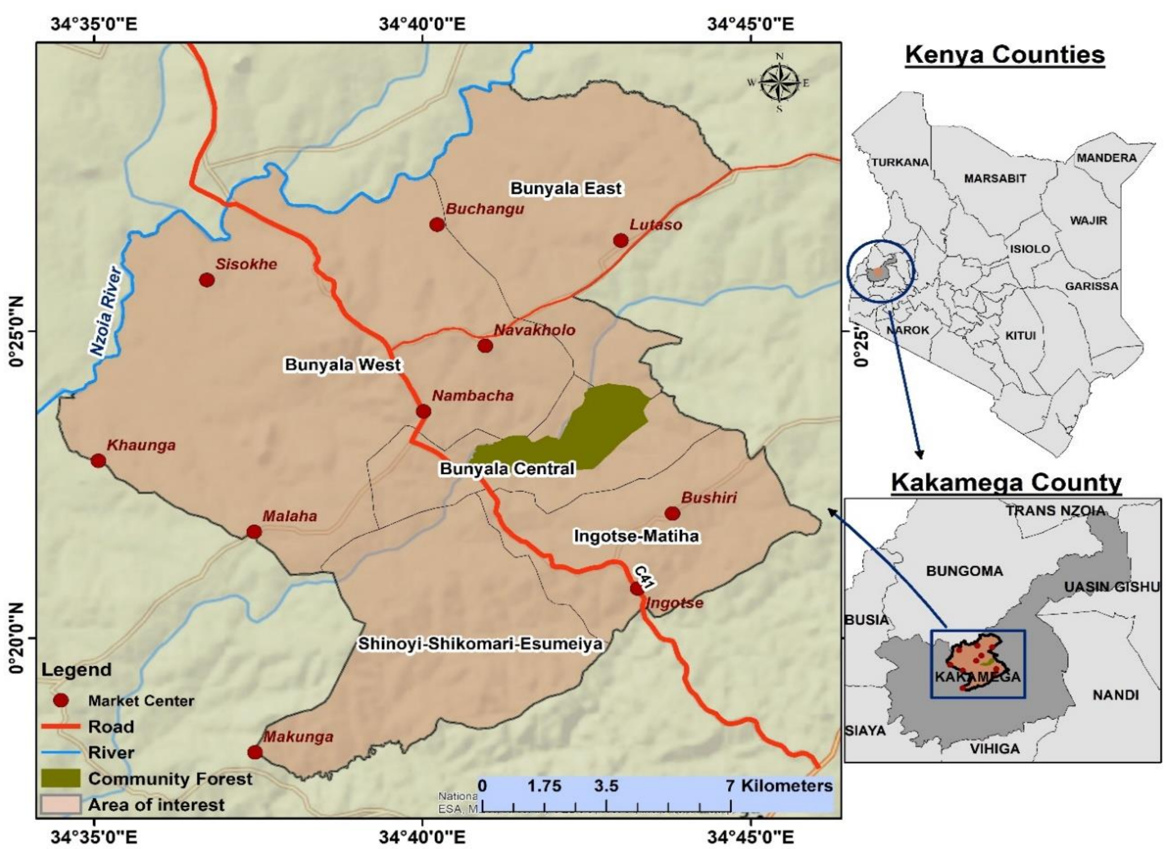

Figure 1: Location of study area (Source: Esri Eastern Africa, Garmin, National Geographic)

Table 1: Distribution of Market Vendors in Navakholo sub- County

Marketing Day	Market	Market Co-Ordinates	Number of Biomass Vendors
Monday	Nambacha	0.3949˚N,34.6675˚E	6
Tuesday	Makunga	0.3014˚N, 34.6238˚E	6
Thursday	Malaha	0.3619˚N, 34.6232˚E	6
Friday	Bushiri	0.3669˚N, 34.7297˚E	6
Saturday	Kakamega	0.2333˚N,34.5167˚E	6

Focus Group Discussions comprised 10-16 members purposively selected for each ward. Though not currently in Navakholo Sub-County, Kakamega market was chosen due to its strategic and unique position of having the biggest market day in the county. A total of 59 key respondents representing 37% males and 63% female participated. For being within the expected sample size range of 8-15 for a standard FDG (CCSU, nd), distributions per Ward were considered sufficient for meaningful discussion and generalization of results. The researcher led the discussion while her assistant took notes. Since majority of the participants (48%) had primary education, and only 12% had attained tertiary education, in-depth engagement on value-addition and energy alternatives aspects was severely restricted by an apparent knowledge gap (Table 2).

Table 2: Composition and Distribution of the Focus Group Discussion

Ward	N	Gender		Occupation					
		F	M	Salaried Employee	FMR	Business Person	Student	CHV	Clergy
Bunyala Central	10	5	5	2	1	--	4	3	--
Bunyala West	13	9	4	2	4	3	--	4	--
Bunyala East	16	8	8	6	6	--	3	1	--
Ingotse-Matiha	10	7	3	3	3	--	2		2
Shinoyi-Shikomari-Esumeiya	10	8	2	--	8	2	--	--	--
Total	59	37	22	13	22	5	9	8	2

Where: FMR = Farmer; CHV- Community Health Volunteer

Results and Discussion

Status of Biomass Energy and Value-addition Opportunities

Firewood is still the most popular biomass option for cooking and heating in Navakholo. Charcoal comes in second as a standby option for special cooking and when the cold weather makes use of firewood a challenge. Use of biogas is rare because most households do not have zero-grazing units, which makes accumulation of cow dung difficult. In addition, the cost implication is a key disincentive even to the few farmers who have semi-intensive grazing systems. Yet with only 2 dairy cows under zero-grazing system, a household can harness biogas for all its cooking needs (Wachera, 2017). Use of saw dust balls as a binder material was not observed. All respondents indicated not having seen any household using design briquettes obtained from agricultural by-products (Tables 3).

Table 3: Popularity of Biomass energy options households in Navakholo

Administrative Ward	Firewood	Charcoal	Biogas	Dung-Soil Balls	Saw Dust Balls	Design Briquettes
Bunyala Central	4	3	2	1	2	1
Bunyala West	4	3	2	1	2	1
Bunyala East	4	2	1	1	2	1
Ingotse-Matiha	4	2	1	1	1	1
Shinoyi-Shikomari-Esumeiya	4	3	1	1	2	1

Likert Scale Key: 4=Very high; 3=High; 2=low; 1= Not observed

With regards to sources of biomass energy, firewood was mainly obtained from own farm wood lots and purchased from vendors. Charcoal was mainly purchased by those able to (Table 4). Saw dust is often seen as a free good to be taken from timber production sites. However, as an alternative source of energy in cook stoves, some vending on it is starting to emerge. Cow dung remains largely non-existent as a possible source of energy or even as a binder in making energy balls from other materials like charcoal dust. Maize cobs and stubble are seasonally available after every harvest. Farmers often use them when dry to supplement firewood. The lost opportunity is however how to turn them into design briquettes for enhanced energy supply and efficient use. Investment in briquetting needs to begin from formalized bulking and delivery of cobs to designated processing centres within the county. Such small-scale processing can be funded through county budgetary allocations or incentives given to private investors and civil society organisations.

Table 4: Sources of Biomass Energy Options Within Households

	Firewood		Charcoal		Saw Dust		Cow Dung		Maize Cobs and Stubble)	
	F	% F	F	% F	F	% F	F	% F	F	% F
Forest reserve	7	23.3	3	10.0	2	6.7	--	--	--	--
Own farm	15	50.0	7	23.3	4	13.3	--	--	7	23.3
Distributors	14	46.7	11	36.7	5	16.7	--	--	--	--
Off-farm sources	--	-	6	20.0	3	10.0	1	3.3	--	--
Local purchase	24	80.0	11	36.7	6	20.0	--	--	--	--

In terms of continual supply of energy emphasis was put on firewood, saw dust and charcoal, including conventional management practices such as routine re-planting, dry storage and extinguishing remaining amounts after each days cooking (Table 5). Extinguishing charcoal and firewood, and saw dust after the days cooking is an indication of the severe scarcity of wood fuel. Through FGDs, it was noted that dry saw dust compacted in a clay cook stove can cook for 8 hours - generally enough for a day's three meals. Despite its demonstrated potential elsewhere in Kenya as demonstrated by Ngusale *et al.* (2014), there was no mention of briquetting as a value-addition option. Saw dust is often abandoned to its own fate in situ and sometimes burnt.

Table 5: Responses on the Management of Biomass Energy Options

	Firewood		Saw dust		Charcoal	
	F	% F	F	% F	F	% F
Extinguishing after cooking	5	16.7	3	10.0	8	26.7
Selling specific weights or sizes	18	60.0	2	6.7	8	26.7
Regular re-planting	21	70.0	--	--	6	20.0
Chopping to fit cooking facility	17	56.7	--	--	1	3.3
Dry storage	19	63.3	6	20.0	5	16.7

Cow dung was used by few for composting and making organic manure. No respondent indicated using cow dung feedstock in biogas production. Maize cobs were mainly used on the farm to supplement firewood for cooking. Some of it was simply disposed-off by burning (Table 6). These management practices particularly burning of feedstock or just abandoning it in situ reveal a huge gap in knowledge on value-addition options. The potential of charcoal dust as raw material in briquetting was also untapped.

Overall, correlation analysis between biomass types and management practices, which respondents thought (though erroneously) as aspects of value-addition practices showed significant relations especially for charcoal in terms of adding value through extinguishing after cooking (R=0.543), dry storage (R= 0.466), and selling specific weight sizes (R = 0.505). For firewood significant correlations existed in dry storage

(R= 0.471) and chopping to fit the cooking facility in use (R= 0.554) (Table 7). These management practices are rudimentary. Much more benefits lie in replacing them with investments in briquetting technology.

Table 6: Opinions on the Disposal of Surplus Biomass

	Firewood		Charcoal		Saw Dust		Cow Dung		Maize Cobs and Stubble	
	F	% F	F	% F	F	% F	F	% F	F	% F
Own Farm Use	19	63.3	12	40.0	8	26.7	--	--	8	26.7
Sell To Neighbors	19	63.3	12	40.0	9	30.0	--	--	1	3.3
Sell at Local Markets	24	80.0	12	40.0	9	30.0	--	--	--	-
Abandon on Site	--	--	--	--	3	10.0	1	3.3	--	--
Collect and Dispose	--	--	--	--	1	3.3	--	--	2	6.7
Composting and Manuring	--	-	--	--	--	--	20	66.7	3	10
Burn on Site	--	--	--	--	2	6.7	-	-	2	6.7

Table 7: Correlating Biomass value-addition Practices and Biomass Type (N =30)

		Firewood	Charcoal	Saw dust	Cow dung
Extinguishing after cooking	Pearson Correlation	0.338	0.543**	0.579**	0.541**
	Sig. (2-tailed)	0.068	0.002	0.001	0.002
Dry storage	Pearson Correlation	0.471**	0.466**	0.746**	0.000
	Sig. (2-tailed)	0.009	0.009	0.000	1.000
Selling specific weights or sizes	Pearson Correlation	0.333	0.505**	0.563**	-0.213
	Sig. (2-tailed)	0.072	0.004	0.001	0.258
Chopping to fit cooking facility	Pearson Correlation	0.554**	0.235	0.391*	0.152
	Sig. (2-tailed)	0.001	0.211	0.033	0.424

* Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

Challenges Faced in Biomass Value-Addition

Majority of the respondents (83.5%) indicated finding it difficult to invest in value addition of biomass energy sources. This was narrowed to the perceived high expenses involved especially with regard to biogas digesters and briquetting infrastructure. According to Njagi (2016), the cost of a basic home biogas digester is approximately Ksh 50,000 – 80,000 (ie. USD 500-800). Without access to friendly and affordable loans, this cost is prohibitive to most rural households. Similarly the costs of briquetting presses vary according to feed stock type and are also prohibitive to most farmer. With the current rates of poverty estimated at 33.3% of the population living below the poverty line (Ambalu et al., 2023) the struggle to meet basic needs will delay investment in value-addition technologies for a long time. The mention of available land being needed for other uses was indicative of the general lack of knowledge on what biomass value-addition entails (Table 8). To these respondents, more land for planting more trees was viewed, though falsely, as a form of value-addition.

Table 8: Key Challenges Limiting Investment in Biomass Value-Addition

Challenge	% of Respondents	Weighted % respondents
High expensive involved	49.7	39.66
Lack knowledge on what else to do with available biomass	39.3	31.36
Available land is needed for other uses	25.1	20.03
Other reasons	11.2	8.94

Conclusions and Recommendations

Investment in value-addition on biomass feedstock is generally non-existent in rural households in Navakholo. Charcoal, though a value-added product on wood fuel is not perceived as such by the local land users, but rather as a normal energy alternative. Immense opportunities for energy security in the Sub-County and the entire maize belt exist in biomass value-addition especially through briquetting of maize cobs as the primary feedstock. Secondary feedstock includes charcoal dust, saw dust, stubble, and sugarcane cuttings. The potential of cow dung as a binder material also merits investigation. Currently briquetting of biomass is non-existent due to the communities' lack of understanding of the technology and the prohibitive initial cost of hand presses. Similarly, investment in the generation of biogas is constrained by the high initial costs of digesters. Going forward, policy on rural energy security needs to equally focus on financing the establishment of briquetting industries and home-based digesters through strategic partnerships between the farmers, county governments, private sector, civil society, and international agencies.

References

Ambalu, R., Rashid, S., Atwa, S., et al. (2023). Factors related to women's use of health insurance cover in Navakholo, Kakamega County, Kenya: sub-county level results based on community household register. *BMC Public Health*, *23*(1), 576. https://doi.org/10.1186/s12889-023-15270-1

Belward, A., Bisselink , K., Bodis , A., Brink, J. F., & Dalmond, d. A. (2011). Renewable energies in Africa: Current Knowledge. *Luxembourg: European Union.* DOI: 10.2788/1881.

CCSU (nd). Helpful Hints for Conducting a Focus Group. https://www.ccsu.edu/sites/default/files/document/FocusGroupsHints.pdf

County Government of Kakamega. (2016). The First County Integrated Development Plan 2013-2017. *Kakamega: Department of Finance, Economic Planning and Investments.*

Farm Energy (2019). Corn Cobs for Biofuel Production. https://farm-energy.extension.org/corn-cobs-for-biofuelproduction/#:~:text=As%20a%20direct%20heat%20source,or%20approximately%208%2C000%20Btu%2Flb

Gielen, D., Boshell, F., Saygin, D., Bazilian , M. D., Wagner, N., & Gorini, R. (2019). The Role of Renewable Energy in the Global Energy Transition. *Energy Strategies Reviews*, *24*, 38-50. https://doi.org/10.1016/j.esr.2019.01.006

Heuzé V., Tran G., Lebas F. (2016). Maize cobs. *Feedipedia, a program by INRAE, CIRAD, AFZ and FAO.* https://www.feedipedia.org/node/718

Indian Council of Agricultural Research (2012). Final Report National Agricultural Innovation Project Value Chain on Commercialization of Maize Products. https://naip.icar.gov.in/download/c2-206701.pdf

Lu R and Dudensing R (2015). What Do We Mean by Value-added Agriculture? *Choices.* https://www.choicesmagazine.org/UserFiles/file/cmsarticle_479.pdf

Mitchual et al (2013). Briquettes from maize cobs and Ceiba pentandra at room temperature and low compacting pressure without a binder. *International Journal of Energy and Environmental Engineering*, *4*(1), 38. http://www.journal-ijeee.com/content/4/1/38

Mokaya D C (2020). Adoption of Biomass Briquettes as Alternative Source of Energy in Maasai-Mau Region, Narok County, Kenya. *MSc Thesis, Kenyatta University.* https://irlibrary.ku.ac.ke/bitstream/handle/123456789/21453/AdoptionofBiomassBriquettesasalternative....pdf?sequence=1

Ngusale, G K, Luo, Y, and Kiplagat, J K. (2014). Briquette making in Kenya: Nairobi and peri-urban areas. *Renewable and Sustainable Energy Reviews, 40,* 749-759. https://doi.org/10.1016/j.rser.2014.07.206

Njagi, K (2016). Biogas heats up in Kenya as fuel of choice for the poor. *Thomson Reuters Foundation.* https://news.trust.org/item/20160324121157-epqyi/

Republic of Kenya (2018). National Energy Policy. https://kplc.co.ke/img/full/BL4PdOqKtxFT_National%20Energy%20Policy%20October%20%202018.pf

Republic of Kenya (2019). The Energy Act 2019. *Kenya Gazette Supplement.* http://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/2019/EnergyAct__No.1of2019.PDF

UNEP (2019). Sugarcane Bagasse Briquettes and Charcoal Value Chains in Kenya: Results and recommendations from the implementation of the Global Bioenergy Partnership Indicators. *Technical Report.*https://wedocs.unep.org/bitstream/handle/20.500.11822/30924/GBEPKenya.pdf?sequence=1&isAllowed=y

UNESCO. (2022). UNESCO Environmental Sustainability Report. *Paris: UNESCO.*

USAID (2015). Kenya Agricultural Value Chain Enterprises. *USAID-KAVES.* Maize Value Chain Analysis. https://pdf.usaid.gov/pdf_docs/PA00M2T3.pdf

Wachera R W and Waswa F. (2017). Enhancing Energy Access and Soil Fertility Management through Biogas Technology in Smallholder Dairy Production Systems in Nyeri County, Kenya. *International Journal of Agriculture and Environmental Research, 3*(5), 3691-3708. ISSN: 2455-6939.

Waswa F, Mwamburi M and Mworia M (2020). Declining Wood Fuel and Implications for Household Cooking and Diets in Tigania Sub-County Kenya. *Scientific Africa.* https://doi.org/10.1016/j.sciaf.2020.e00417. Elsevier B.V

Waudo, S., Koske, J. and Waswa, F. (2023). More Trees and More Biomass Energy Options for Increased Energy Security within Households in Navakholo Sub-County, Kenya. *East African Journal of Environment and Natural Resources, 6*(1), 178-197. https://doi.org/10.37284/eajenr.6.1.1278

World Vision (2020). Improved Cook Stoves Boost Health and Economic Status of Families. https://www.wvi.org/stories/kenya/improved-cookstoves-boost-health-and-economic-status-families