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Research Application Summary

An analysis of the profitability and factors driving farmers' decisions to produce bioethanol from cassava in Northern Uganda

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Abstract

The study examined profitability of producing bioethanol from cassava among smallholder farmers in northern Uganda. Although small scale production of bioethanol was found to be profitable, selling cassava dry chips was found to be more profitable. In addition, selling fresh cassava roots was also more profitable than small scale production of bioethanol. However, bioethanol producers who grow cassava and process bioethanol get more returns on investment compared to those who buy cassava chips and process bioethanol. Sensitivity analysis results revealed that 40% decrease or increase in price of dry chips and firewood contributed remarkable change on profitability of bioethanol. The study concludes that farmers should be supported to produce quality dry cassava. However, to promote bioethanol production (small and large scale), there is need to increase cassava production by increasing acreage and cultivating improved high yielding varieties. This should be coupled with expansion of market opportunities and reduction in cost of energy required for bioethanol production.

Key words: Cassava bioethanol, gross margins, Northern Uganda, profitability analysis, sensitivity analysis

Résumé

L'étude a examiné la rentabilité de la production de bioéthanol du manioc chez les petits exploitants agricoles du Nord de l'Ouganda. Bien qu'une production à petite échelle se soit avérée rentable, la vente de copeaux dérivés du manioc s'est avérée plus rentable. Par ailleurs, la commercialisation de racines de manioc frais est également plus rentable que la production à petite échelle de bioéthanol. Cependant, les producteurs qui cultivent du manioc et le transforment en bioéthanol obtiennent plus de profits que ceux qui achètent le manioc et le transforment en bioéthanol. Les résultats de l'analyse de sensibilité ont révélé qu'une baisse ou une augmentation de 40% du prix des copeaux secs et du bois de feu a contribué à un changement remarquable de la rentabilité du bioéthanol. L'étude conclut que les agriculteurs devraient être appuyés pour produire du manioc de qualité. Cependant, pour promouvoir la production de bioéthanol (à petite et grande échelle), il est nécessaire d'augmenter la production de manioc en augmentant la superficie et en cultivant des variétés améliorées et à rendement élevé. Cela devrait être associé à l'expansion des débouchés commerciaux et à une réduction du coût de l'énergie nécessaire à la production de bioéthanol.

Mots-clés: bioéthanol de manioc, marges brutes, Nord de l'Ouganda, analyse de rentabilité, analyse de sensibilité

Background

As the current global population continues to grow especially in developing countries like Uganda where the population growth rate (3.3%) is higher than the growth in agricultural sector (1.5%) (World Bank, 2016), the demand for food and fuel to enable people live a healthy and an improved life style continues to grow. Food demand is expected to increase by about 54% (Valina *et al.,* 2014), and fuel is expected to increase by 28% by 2040 (EIA, 2018). These increases in food and energy demand means extracting more fuel from the farms. Jean Ziegler, the UN Special Rapporteur on the Right to Food from 2000-2008 argued that, burning hundreds of millions of tonnes of staple foods to produce biofuels is a crime against humanity (Mathews, 2012). Similar sentiments have been echoed by Monbiot (2007) who castigated Swaziland's government for deciding to export biofuel made from cassava when 40% of its population was facing acute food shortages (Monbiot, 2007). The argument is that extracting fuel from the farm will drive prices for food high thus leading to reduced food availability and increased land prices which results into increased hunger, land grabbing, environmental damage and loss of life (Mitchell, 2008; Schmitz and Moleva, 2013). Monbiot (2007) argued that even when the price of food was low, 850 million people went hungry because they could not afford to buy it and if promoting biofuels is not reversed, humanitarian impact will be greater that the Iraq war. Ziegler *et al.* (2011) contends that, every five seconds, a child under the age of 10 dies directly or indirectly because of hunger somewhere in the world.

The advocates of biofuel production on the other side argue that rapid food price increases, hunger and malnutrition have been widespread even before the boom on biofuel occurred (Tenenbaum, 2008). They argue that biofuels can play a very significant role in revitalizing agricultural land use and livelihoods in rural areas. Increased prices could benefit smallholders farmers and could drive farmers to adopt improved technologies thus leading to significant increase in both yields and incomes which is key to poverty reduction (Cotula *et al.,* 2008). Mathews (2012) argues that farmers in developing countries lack income to purchase inputs on the open market, therefore governments need to promote biofuels to generate income, employment, and export earning to boost input use and agricultural productivity. Production and processing of bioethanol also helps in reducing post-harvest losses in crops like cassava. FAO (2011) report notes that 40% of post-harvest losses in cassava and other root crops are reported in sub Saharan Africa, 35% in Latin America and 31% in South and South-East Asia (FAO, 2011). Moreover, there is no guarantee that food production will increase if bioethanol production is avoided (Ejigu, 2008). Therefore others argue that bioethanol production has a potential to increase agricultural production which in turn will lead to increased food and fuel supplies by increasing input use (Kueneman *et al.,* 2012; Kristensen *et al.,* 2014; Thatoi *et al.,* 2016).

In Uganda, the demand for the bio-fuel is expected to grow from 187 million litres in 2012 to 220 million litres by 2022 (NEMA and NARO, 2010). While sorghum, maize, millet and sugarcane molasses feedstocks are used for bioethanol production in Uganda as one of the bio-fuels, cassava is a commonly used and preferred feedstock to produce bioethanol. This is attributed to: firstly, the high productivity, high starch content and the availability of cassava (Adiotomre, 2015). Secondly, unlike other crops, cassava can be harvested all year round and can tolerate harsh natural conditions, especially drought (Jakrawatana *et al.,* 2015). Moreover, it can be planted on marginal lands where other crops do not grow well (Dai *et al.,* 2006). Thirdly, it has ability to be stored dry in high quantities to be used during low harvest periods (Nguyen *et al.,* 2007; Bertrand *et al.,* 2016). Lastly, the processing of cassava into bioethanol is more efficient compared to crops like sugarcane, maize, wheat, and sweet potato (Liu *et al.*, 2013). For instance, cassava has a conversion rate of about 180 litres per tonne of cassava roots when compared to 70 and 80 litres per tonne of sugarcane and sorghum, respectively (Balat and Balat, 2008; Ohimain, 2015).

Although production of bioethanol production from cassava is preferred option for producing biofuel and presents significant opportunities for improving rural livelihoods, current cassava bioethanol production in Uganda is low. Only about 11% bioethanol is produced from cassava (Mutyaba *et al.,* 2016) and over 90% of bioethanol produced by smallholder farmers is mostly for local consumption and about 10% for industrial uses (Mutyaba *et al.,* 2016). This study examines the reasons for the low level of production of bioethanol from cassava. Specifically, the study examines whether smallholder farmers are making profits from the current cassava bioethanol production or not? The analysis of profitability is important because it influences investment decisions (Malinvaud, 1989). Such investment decisions include decisions to process cassava bioethanol or not. The study also examines the profitability of processing cassava into dry chips and of selling cassava in form of fresh tubers. The study also examines the profitability of processing cassava into dry chips. The study uses sensitivity analysis to incorporate uncertainty into economic evaluation to determine the best possible scenario of maximizing benefit from bioethanol production.

Methodology

Study area and data collection. The data used in this study were collected in June 2016 in Apac, Kole and Lira districts in Northern Uganda. The districts were selected because cassava is a staple in the three districts and is eaten and processed in different forms such as fresh tubers, dry chips and bioethanol. Production of bioethanol in the three districts is done by individual farmers using cassava chips bought from the market or from cassava grown in their own farms. Specifically, Apac and Kole district were the leading cassava producing district in the country allocating 42,836 ha and producing 239,932 Mt of Cassava (UBOS, 2010). On the other hand, Lira district is the end market for most of the cassava products such as fresh tubers and dry chips. Lira district also hosts the only bioethanol processing factory called Kamtech Technologies located in Northern Uganda (Oketch, 2016).

Data used in this paper were collected from 243 farmers. Farmers who were selected but could not be accessed at the time of interview were replaced by other farmers within the sampling frame used to eliminate bias. Precisely, the quantitative data collected included; all household activities (farm and non-farm), enterprise types, crop area and production levels, inputs and expenditures for the first and second season were captured during the survey. Socio-economic and institutional data such as household characteristics, land size and farm characteristics and investment in assets were also captured. Other questions in the questionnaire tool administered were related to the supply of on-farm family and hired labour and educational status and religion, costs and revenues incurred in production processing and marketing of cassava products including fresh tubers, bioethanol and dry chips.

Empirical methods. To examine whether smallholder farmers are making profits from the current cassava bioethanol production compared to selling cassava dry chips, gross margins analysis approach was employed. Although other methods such as cost benefit analysis, and enterprise budgeting can be used to assess profitability, the gross margins approached was used because it is reasonably straight forward, easy to understand and allows for easier comparison (Rushton, 2009). Additionally, the focus of the study was mainly on financial outputs without fixed costs. Rushton (2009) argues that gross margins are computed as the difference between total revenue (TR) and Total Variable Costs (TVC) which is expressed mathematically as in the equation below:

$$GM_i = TR - TVC \quad 1$$

Where GM= Gross margin

$$TR = \sum_{j=1}^{n} P_j Q_j \ ; for\ j = 1,2,3 \dots n$$

$$TVC = \sum_{i=1}^{n} P_i X_i \ ; for\ i = 1,2,3 \dots n$$

Where GM= Gross margin of ith cassava product category in Uganda shillings normalized at hectare level

P_j=Unit price of one litre or kilogram of output sold of cassava product by jth farmer

Q_j= Total output sold of cassava product by the jth normalized at hectare level.

P_i= Unit cost/price of a given input used by ith farmer to produce cassava product (Ushs/ha)

X_i= Quantity of input used in production of bioethanol (UShs/ha)

Total variable costs computed included all costs incurred in production of cassava such as costs of land clearing and land preparation, cost of purchase of inputs such as planting materials, planting costs, weeding, harvesting and transportation costs for both hired and family labour. For the category of farmers who bought chips for bioethanol production, the variable costs included cost of purchasing chips per kilogram which were computed and then normalized at hectare level. Transport costs to milling and processing facility were also computed. In addition, processing costs such as, peeling, drying and packaging costs, milling, fermentation, roasting and distillation costs were calculated for both farmers who bought chips and farmers who grew cassava for bioethanol production. Other costs computed included costs of yeast and cost of firewood used for distillation process, packaging, transportation and market dues for bioethanol. Revenues were then generated by multiplying the average price of one litre of bioethanol at market price at the time of data collection and the number of litres of bioethanol produced using quantity of chips purchased and normalized at hectare level.

Sensitivity analysis of the costs of cassava bioethanol production was conducted. Following Nuwanyama (2017) Unpublished report, the three most essential factors affecting bioethanol production are price of cassava chips, cost of roasting and cost of firewood. The influence of price of cassava chips, costs of roasting and costing of firewood on the gross profits were determined by creating four scenarios which included varying the costs by plus or minus 40% from the base figure taken as 0% which was the profit computed for each category from bioethanol category following (Hanif *et al.,*2016). The values obtained were presented in an excel tornado plot.

Results and Discussions

Profitability of cassava bioethanol production. Table 1 presents a summary of the production, processing and marketing costs as well as revenues for each of the three products including computations of gross margins and gross margin percentages. The results show that on average about 23 tonnes per hectare of fresh roots are produced by farmers in the three districts of northern Uganda. This is equivalent to about 8 tonnes of dry cassava chips per hectare indicating conversion ratio of 3 to 1 for fresh tubers and dry chips. The results further show that about 23 tonnes of fresh tubers per hectare produce about 3000 litres of bioethanol indicating an average production of 139 litres of bioethanol per one tonne of fresh cassava roots. At the time of data collection, on average farmers sold one kilogram of fresh tubers at 235 shillings, one kilogram of dry chips was 927 shillings and one litre of bioethanol was being sold at 4175 Uganda shillings. However, these prices vary greatly depending on season and availability of cassava.

The results indicated that households who bought chips for bioethanol production incurred much higher total variable costs than households who produced own cassava for sale as fresh tubers, dry chips or processed into bioethanol (Table 1). This is probably because most of the work is done by household labour and farmers have a tendency of undervaluing their cassava below the market price. Among the cassava farmers producing fresh tubers, dry chips and bioethanol from cassava grown by the farmers, the results showed that production costs were highest in fresh tubers followed by dry chips and bioethanol with the least production lost. This is probably because fresh tubers are perishable and considered of high value. It may also be because there are no additional costs such as processing costs incurred in production of fresh tubers.

Table 1. Gross margin analysis of fresh tubers, Dry chips and Bioethanol

Item Description	Fresh tubers	Dry Chips	Bioethanol from Cassava	Bioethanol from Cassava
			Grown	Bought
Revenues				
Quantity of fresh cassava (kg/ha)	22,862.51	22,862.51	22,862.51	N/A
Quantity of Dry chips (kg/ha)		7,942.05	7,942.05	7,942.05
Bioethanol yield (L/ha)			3,171.75	3,502.34
Average price per litre or kilogram (Ugx)	235.00	927.00	4,175.00	4,175.00
Total Revenues (TR)	5,372,689.85	7,362,280.35	13,242,056.25	14,622,269.50
Total Variable costs (TVC)				
Total Production Costs(Ugx)	1,260,828.07	1,225,084.34	1,207,729.02	7,362,280.35
Total Processing costs (Ugx)	0.00	478,054.81	2400559.07	1,641,347.59
Total marketing costs(Ugx)	290,208.25	269,351.90	709,370.06	814,646.81
Total Variable Costs (TVC) (Ugx)	1,551,036.32	1,972,491.05	4,317,658.15	9,818,274.74
Gross Margin (TR-TVC) (Ugx)	3,821,653.53	5,389,789.30	8,924,398.10	4,803,994.76
Gross Margin (%)	71.13	73.21	67.39	32.85

Source: Survey Data 2016; UGX- Uganda shillings, 1 USD = 3364.65 UGX

As indicated in Table 1, the results show that bioethanol generated the highest revenue followed by dry chips and fresh tubers. Farmers who produced bioethanol from cassava bought generated more revenues than farmers who grew cassava for bioethanol production. Bioethanol produced from cassava grown generated the highest gross margins followed by dry chips and bioethanol produced from cassava chips bought and fresh tubers generated the lowest gross contribution. Although bioethanol generated the highest revenues, bioethanol generally generated the least gross margin percentages of 67.39% while dry chips generated the highest gross margin of 73.21% and fresh tubers generated a gross margin of 71.13%. Bioethanol produced from cassava grown generated higher gross margin percentage of 67.39% than bioethanol produced by farmers who buy cassava chips and generated gross margin percentage of only 32.85%.

Figures 1 presents the results from the sensitivity analysis to investigate the changes in production costs on the profitability of cassava bioethanol produced using cassava chips bought. The investigated elements included price of buying dry chips, cost of firewood and cost of roasting. The results reveal that a 40 % decrease in the price of cassava dry chips increases the gross profit of bioethanol by 61% from 4.8 to 7.75 million Uganda shillings. On the contrary increasing the price of dry chips by 40% reduces the gross profits of bioethanol by 61%. Similarly, reducing cost of roasting of fermented broth by 40% increases the gross profit of bioethanol by only 2.50% from 4.80 million Uganda shillings to 4.92 million Uganda shillings. Likewise, reducing the cost of firewood by 40% increased the profitability of bioethanol by

2.30% from 4.80 to 4.91 million Uganda shillings. The above results demonstrate that price of buying cassava chips present significant effect on the gross profits of bioethanol and unlike the cost of firewood and costs incurred during roasting of the fermented broth.

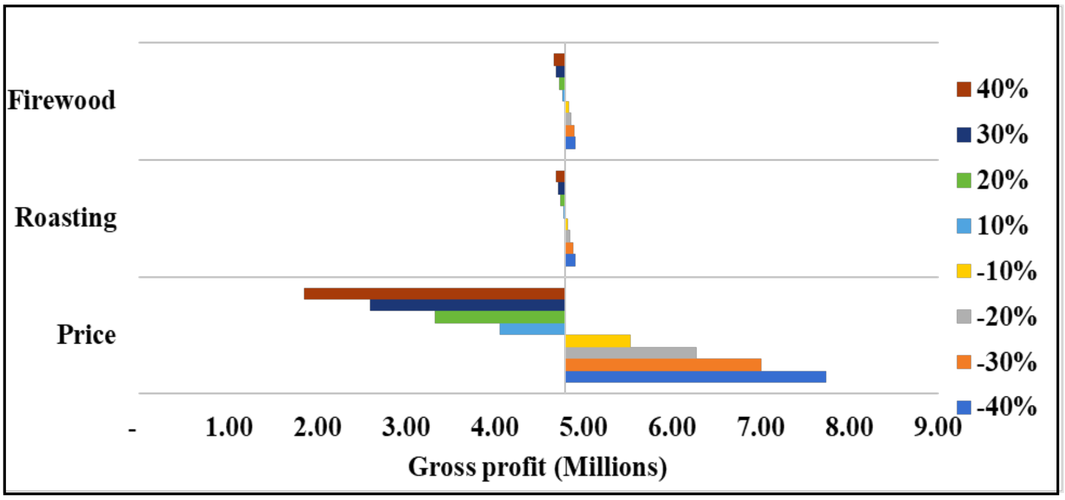

Figure 1. Sensitivity analysis of costs of cassava bioethanol production for farmers buying cassava chips

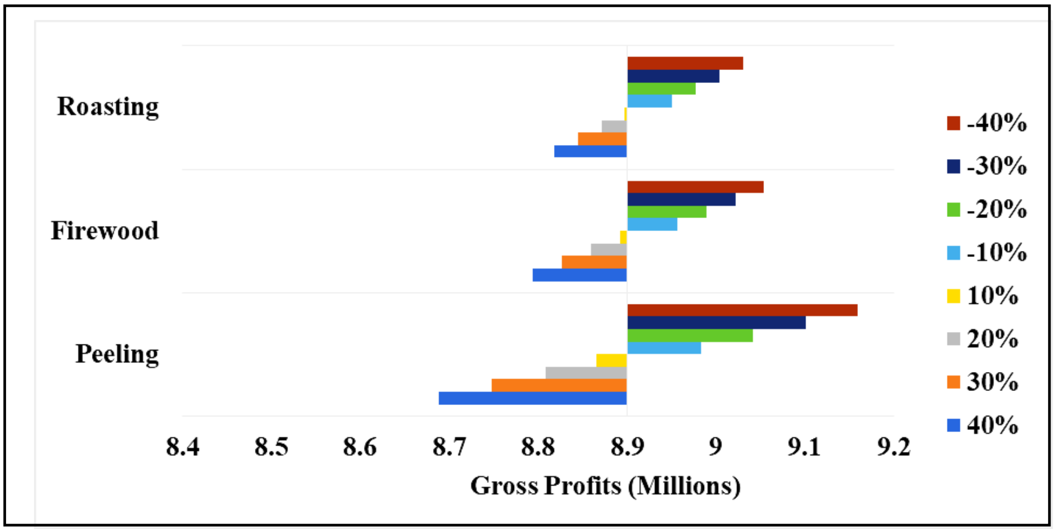

Figure 2. Sensitivity analysis of costs of cassava bioethanol production for farmers growing cassava

Figures 2 presents the outcomes of sensitivity analysis to investigate the effects of changes in production costs of some elements on the gross profits of bioethanol produced from cassava grown by farmers in their households. The elements investigated included cost of peeling cassava, cost of firewood and roasting of fermented broth. The results revealed that a 40% decrease in peeling cost increases gross profit of bioethanol by 2.80% from 8.9 to 9.15 million Uganda shillings. Relatedly, reducing the cost of firewood by 40% increases the gross profits by 1.46% from 8.90 to 9.03 million Uganda shillings. Similarly, a 40% reduction in cost of roasting of fermented broth increases the gross profit of bioethanol by 1.46% from 8.90 to 9.03 million Uganda shillings.

Discussion

Generally, the study reveals that all the three products, i.e., dry chips, bioethanol and fresh tubers are profitable. More specifically, bioethanol produced from cassava grown at home is more profitable that bioethanol produced from dry chips bought. Additionally, the results show that price of dry chips have significant effect on the gross profit of bioethanol for farmers producing bioethanol from cassava chips bought. Similarly, our findings show that cost of peeling of cassava has an effect on the profitability of bioethanol produced from farmers cassava grown in the households. These findings are similar to the results obtained by Ogbonna and Okoli (2013) which demonstrated that small scale bioethanol production is profitable. The results are also similar to findings by Hanif *et al.* (2016) who reported that the price of the raw material contributes the highest production cost of bioethanol. Certainly the difference is that our study relied on values from individual small scale producers.

Conclusions and policy implications

The study findings indicate that smallholder bioethanol production as an off-farm rural activity is a key strategy for helping smallholder farmers and the rural landless to raise their income, mitigate seasonal income swings and manage risks by absorbing excess labour in the farm workforce. However, bioethanol production and food security are interrelated. Therefore, increasing bioethanol production will be hinged on a number of critical factors that affect household food security.

The policy implication of the findings is that vertical integration of the bioethanol production process should be promoted. There is need to increase the area of land under cassava production so that it can meet the twin demand for food security and fuel inform of bioethanol production. Increasing production increases the supply of chips in the market thus reducing the price of chips and consequently reducing the cost of production of bioethanol from chips bought in the market. Therefore, policies which support or motivate farmers to increase area under production should be put in place and this include; favourable and inclusive policy on access and use of land, providing farmers with better inputs such as improved planting materials, providing subsidy on improved planting materials, encouraging mechanization and mechanized agriculture to open up more land. Improved varieties have specifically been found to have better qualities for bioethanol production such as high starch content. This underscores the need to sensitize the local communities to start using improved varieties which are high yielding, tolerant to diseases and have reasonably good bioethanol conversion rate owing to high starch content. Improved varieties are also associated with traits which auger well with the preferences of farmers such as taste and dry matter content. In the current state the improved planting materials are very expensive for an ordinary farmer to afford. In addition, current institutional arrangements on distribution and access to improved clean seed ought to be strengthened.

If bioethanol production is to increase, better markets should be created to make it more profitable. Better road infrastructure should be developed to ease access to markets for bioethanol and bring the industrial players closer to the rural people. There should be deliberate efforts to promote alternative uses of bioethanol and this would help expand the market and increase the value of bioethanol, hence raising the selling price and profits due to increased demand. Alternatively, policies to buy locally produced bioethanol from the farmers and further processing it to meet the various market niches could be explored to encourage more production.

In improving the production process of bioethanol, emphasis should also be put on promoting and reducing the cost of buying cassava and reducing the cost or use of fuel while being mindful of increasing production of quality bioethanol suitable for its diverse uses. Therefore, alternative innovative ways of eliminating roasting which increases cost of firewood like improving the fermentation process, introduction of external fungi or yeast which fastens fermentation process would reduce on use of firewood further be investigated. This would not only reduce local consumption which is dangerous to health and perpetuator of rural poverty but also encourage production which not only empowers rural communities but also strengthens the cassava industry.

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