SHORT NON_REFEREED PAPER

UTILISING A BIOMASS-TO-ENERGY SOLUTION TO IMPROVE SMALL SCALE GROWER RETURNS IN THE NKOMAZI DISTRICT OF MPUMALANGA

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Abstract

The small scale grower sector in Mpumalanga is declining rapidly. Yields continue to fall, resulting in 34% of small scale growers being reliant on industry grants to generate a remuneration surplus. As there is little return to management effort, growers are exiting the sector. This has a detrimental impact on rural livelihoods, and declining cane supply places additional pressure on a very capital intensive milling sector.

The sector faces these challenges despite South African sugarcane farmers being the custodians of one of the largest reservoirs of short cycle renewable biomass. An opportunity exists to arrest the decline in this critical rural development catalyst by developing markets for biomass.

This study succeeded in matching the existing reservoir of biomass in the Nkomazi District of Mpumalanga Province with appropriate thermochemical technology to create a new market for growers. Detailed feedstock studies indicate a sustainable source of biomass, while logistics studies optimise the efficiencies associated with biomass. The technological and market studies suggest that slow pyrolysis offers the simplest technology and that charcoal offers the most direct route to market.

The establishment of one pyrolysis plant in the Nkomazi District is likely to create 29 direct employment opportunities. By offering small scale growers a cash payment for their biomass collected infield, the proposed enterprise generates an internal rate of return which exceeds the estimated weighted average cost of capital.

This study indicates that the pyrolysis process makes it possible to improve grower revenue by creating a market for biomass. This market may also offer growers an opportunity to mitigate their monopsonistic position in the sugar and molasses markets by owning the value addition as well as the raw material.

Keywords: biomass, pyrolysis, employment, Nkomazi

An opportunity presents itself

Biomass to energy: an opportunity for the South African sugar industry

The growing sector of the sugar industry is the custodian of a fantastic source of unutilised biomass. One-third of the industry's energy availability is typically burnt away in the field in order to improve harvesting efficiencies (Olivero *et al.*, 2010).

There are two reasons for this waste in a South African context. Firstly, no simple scalable technology was available in the past which was able to turn the energy in sugarcane leaves and tops into a valuable product. There was, therefore, no opportunity cost associated with sugarcane leaves.

Secondly, the current industry structure and market forces ensure that the growers remain weak suppliers to powerful buyers (the sugar milling companies). The milling sector adds value to the sugarcane by producing sugar and molasses, and traps that value for themselves without it flowing through the value chain.

This project aims to harness the rapid developments in the thermo-chemical processing of biomass to create a market for this biomass which benefits the producers and ensures the flow of value through to the rural communities producing sugarcane. In essence, the project will collect the biomass from a grower's field and use slow pyrolysis to create charcoal briquettes for sale on the leisure charcoal market. The growers benefit firstly through the establishment of a market for biomass, and secondly through their majority ownership of the business which emerges out of these investigations.

The opportunity presented here is not only to use sugarcane leaves and tops to produce charcoal briquettes. It is an opportunity to shape the development of an entirely new industry. In this industry, producers own the value added to their own product. The untapped potential energy of sugarcane residue is utilised to compete with the environmentally damaging traditional charcoal industry. This opportunity will create sustainable jobs in desperately poor rural environments and creates 'shared value' (Porter and Kramer, 2011) where, rather than being successful at the cost of the surrounding communities, the project's success is deeply rooted in the surrounding communities.

This opportunity will not create the 'gales of creative destruction' (Schumpeter, 1942) which will immediately reshape the sugarcane growing industry. Rather this opportunity will be an example of supply driven innovation (Geroski, 2003), pushing a technological innovation and collecting the organisational capabilities to explore the opportunities available in the market for charcoal briquettes.

Description of the industry

The South African sugar industry produces sugar and molasses from sugarcane. The industry is regulated by the Sugar Act (1978) and the Sugar Industry Agreement (2000) which is essentially an agreement between the industrial partners to 'provide for and deal with, such matters relating to the sugar industry' that are in the interests of the industry. [1]

[1] ACT OF PARLIAMENT. 1979. The Sugar Act. (Act 9 of 1978) *Government Gazette* 6419.

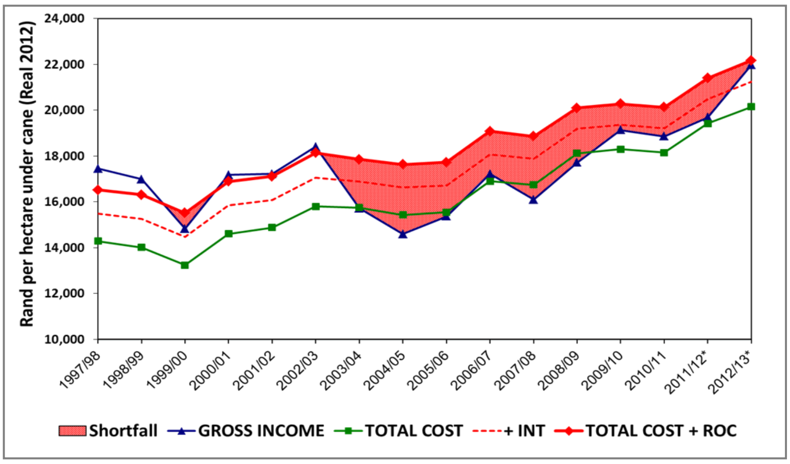
This legislation regulates the sugar and molasses markets effectively but provides no oversight for a possible biofuel industry. Each grower throughout the industry has signed a Cane Delivery Agreement (CDA) with their respective millers. Each CDA binds the grower to supply their sugarcane (juice and stalk material) to the mill for a period of between 5-15 years. None of these CDAs bind any grower's leaf material, which is therefore wholly owned by the grower and available for supply to alternative processors.

Industry analysis

The 'five competitive forces' of Porter (2008) propose that 'industry structure drives competition and profitability' in the medium to long term. The five forces combine to form a 'dam wall' which prevents the industry profits from flowing from one sector or industry to another.

In the sugar industry the growing sector's dam wall is weak, and industry profits flow through to the powerful buyers, the milling sector. The result of the weak monopsonistic position of growers is a sector under severe financial pressure.

Empirical evidence supports this analysis and is displayed in Figure 1, which shows a cost trend analysis of large scale growers (LSGs) of sugarcane in South Africa over the 1997/98 to 2011/12 seasons. The shortfall area indicates that since the 2002/03 season gross income has been exceeded by total costs plus an assumed[2] return on capital, interest and management.



Source: SA Cane Growers Association, Mill Average Expenditure Reports 1997/98–2010/11.

Figure 1. Growers' cost trend analysis for the 1997/98 to 2011/12 seasons.

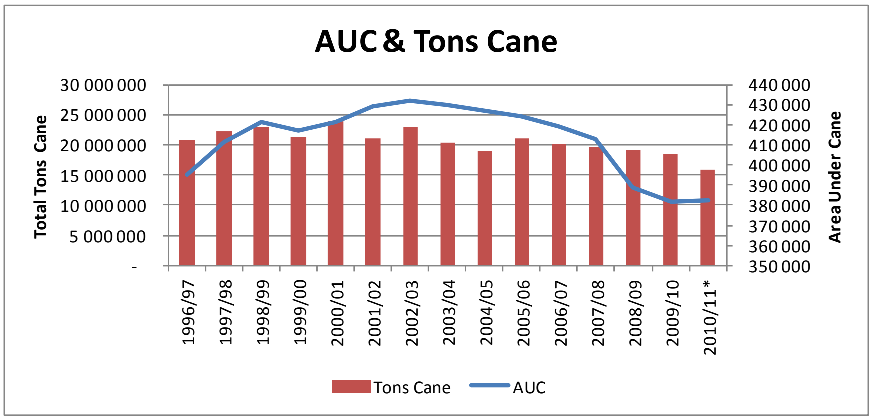
Figure 2 displays a time series of the Area Under Cane (AUC) and total production in the South African sugar industry for the 1996/97 to 2011/12 seasons. It is evident that the loss in profitability of cane farming has resulted in a decline in both the AUC and total production. The growing sector of the South African sugar industry is in crisis. Economic profits[3] have not been realised for a decade and production is declining.

The financial performance of the small scale growers (SSGs) is even more desperate. SSGs do not have the scale economies, the technical competence nor the available credit required to

[2]All assumptions are consistently applied and are implemented as per agreement with the Department of Trade and Industry.

[3]Economic profit is similar to accounting profit, but includes the implicit and explicit opportunity costs of a venture to an investor.

ride out periods of decline. SSGs in the Nkomazi district required industry grants in order to generate a remuneration surplus between the 2004/05 and 2008/09 seasons (Murray, 2010).



Source: SA Cane Growers' Association, Statistical Data 1996/97–2010/11.

Figure 2. Area under cane and tons cane produced by the South African sugar industry in the seasons 1996/97 to 2010/11.

The biomass opportunity

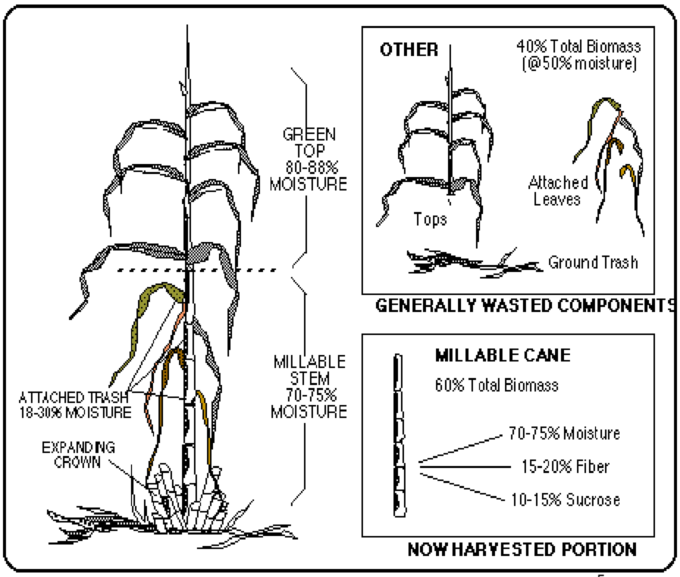
Throughout this period of financial pressure the sector has had a valuable asset: a major source of short cycle renewable biomass.[4] This biomass, along with the rapid advancements in thermo-chemical processing of biomass, presents an opportunity to own the feedstock and the beneficiation to claim added value.

The sugarcane plant is made up of three separate elements, the millable stalk, the green top and the brown leaves. The first and currently the most important element is the millable stalk, which accounts for 60% of the total biomass and includes both the juice and the fibrous material called bagasse. This is the focus of the existing industry and is controlled within growers' existing CDAs. The balance of the biomass is made up of the green and dry leaves, as illustrated in Figure 3.

From an energy perspective these three biological elements have roughly equivalent energy potential. Olivero *et al*. (2010) found that sugarcane tops and leaves accounted for 30% of the energy available in a sugarcane plant.

This business creates value out of that 30% energy availability through the establishment of a slow pyrolysis plant in the Nkomazi District of Mpumalanga Province. Slow pyrolysis adds value to the surplus sugarcane biomass by producing charcoal briquettes for the local leisure charcoal market.

[4]Once sugarcane is planted it can be harvested between 8-10 times before it needs to be replanted again. The period between harvests varies between 12 months in irrigated regions and 24 months in colder rainfed regions as contrasted with timber's 10 – 12 year inter-harvest period.



Source: Chris Norris: Personal Correspondence[5]

Figure 3. Sugarcane as biomass.

Technology[6] and Operations

Slow pyrolysis, in its traditional form, is a technology which is used for the production of charcoal by controlling the amount of oxygen available to the combustion process. Starving combustion of oxygen ensures a very slow burn and a high ratio of carbon remaining once the process is complete. Traditional charcoal ovens are environmentally hazardous, with heavy smoke billowing out of the chimneys for the few days its takes to convert the wooden feedstock into charcoal.

Thermodynamic efficiency
Modern technology and materials ensure that a greater proportion of the energy available in sugarcane biomass is available in the final product (char) at the conclusion of the process. In particular the scalability of fluidised bed technology is the key which is unlocking the greater efficiencies available in modern slow pyrolysis technology.

Emission control
Traditional charcoal manufacturing technology results in large volumes of heavy smoke being emitted from the oven chimneys. Modern slow pyrolysis technology allows for proper emission control through the use of scrubbers in the vent gas. The result is an environmentally sustainable charcoal briquette produced through an environmentally friendly technology.

Processing speed
Fluidised bed technology ensures that heat transfer takes place between the biomass particles far faster than the traditional process. The improved rate of heat transfer ensures a faster turnaround and equates to smaller plant equipment.

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[6]The technology developed during this project was showcased at the 'From Biomass to Bio-energy via Thermochemical Processing' workshop hosted by Stellenbosch University, in association with Cranfield University and Aston University.

Inbound logistics

Operations are structured around those of the project's shareholders and cause minimal disruption to existing operations. Once the sugarcane has been burnt, harvested and transported to the nearest sugar mill, the processing operation will begin.

Immediately following the harvesting operation the collection of biomass will commence and biomass will be baled in field. These bales will be transported a maximum of 25 km on tractor-drawn flatbed trailers to the pyrolysis plant. Figure 4 shows the field in which trials were conducted after having secured the use of a tractor and baler[7].

Figure 4. Baling of sugarcane residue.

The plant has been optimally located to minimise the lead distance for as many fields as possible. The biomass supply area is displayed in Figure 5. After evaluating the SSG production figures over the previous three seasons on a field-by-field basis, it is estimated that an average of 18 000 t of 'wet' feedstock (which equates to 7233 t of oven dried feedstock) can be obtained.

Processing

The initial processing step is to remove the moisture from the biomass in a rotary dryer before processing through the slow pyrolysis plant. The biomass is heated to 400-500°C for a period of 5-30 minutes. The char produced by this process is then compressed into a briquette and is available for distribution. The 7233 t of oven dry feedstock will produce 2228 t of briquettes per annum.

Outbound logistics

In order to establish a sustainable business out of this opportunity, significant consideration needs to be given to the marketing and distribution of the charcoal briquettes. This is a competitive market with established incumbents and it is expected that entering this market will not be a simple process. The costs of marketing and distribution have been taken into consideration in the financial modelling.

[7]Acknowledgement and thanks to Trans African Concessions (TRAC) for the loan of their equipment for field trials.

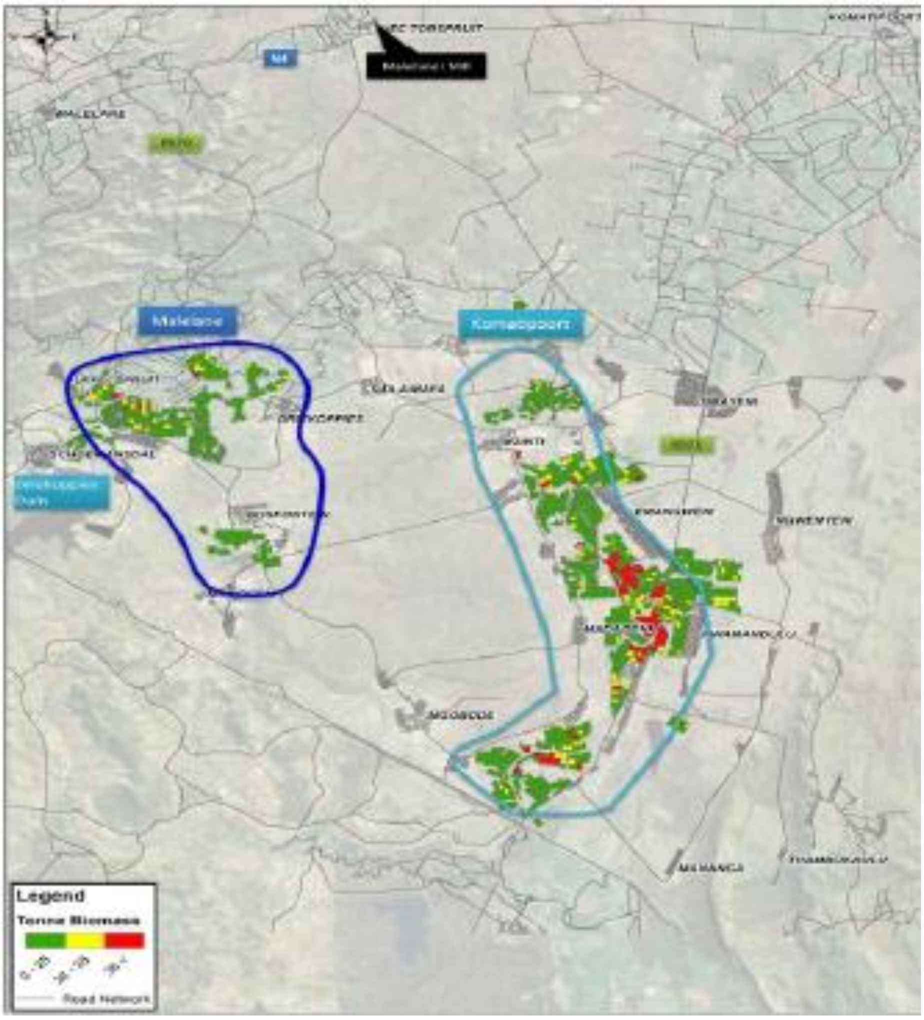

Figure 5: Malelane and Komati small scale grower biomass supply areas[8].

The market environment[9]

National market
In 2004, South Africa produced an estimated 205 000 t of charcoal for both the consumer and industrial markets[10]. The consumer market accounted for 120 000 t, with 70 000 t sold domestically and the balance exported. At a ratio of 3 kg wood to 1 kg charcoal, South Africa's charcoal consumer market requires the harvesting of 210 000 t of trees annually.

Local market survey
A market review was conducted by means of personal visits to retail establishments and semi-structured interviews with shop managers. These visits were conducted in towns or

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[8]Sourced from Nicolene Wattel: Inbound Logistics and Transport Model
[9]Details from the market report have been omitted from this paper as they form elements of a competitive advantage for any possible business which may emerge from this opportunity.
[10]Department of Water Affairs and Forestry: Round wood Supply and Demand to 2030. Available from http://www2.dwaf.gov.za/webapp/files/Roundwoodscr.pdf [accessed: 10/03/13].

cities within 100 km of the planned site of the pyrolysis plant. Some important towns and cities which fall outside the 100 km radius were also visited.

Quantities

The sampled stores accounted for approximately 30.88 t of briquettes per month and indicated that briquettes were selling at a ratio of 2.5:1 to charcoal. It is expected that this sample accounts for less than a quarter of the total sales in each of the towns visited, indicating a market of roughly 120 t of briquettes per month.

Consumers

A consumer survey conducted during the personal visits concluded that consumers have a preference for charcoal (64%) over wood for braai purposes; 37% of consumers bought at least two bags of charcoal per month, and 21% bought four or more bags per month.

Consumers did not seem to be brand conscious at all and reported that they 'grab a bag' predominantly based on price, but do value long-burning characteristics and the ease with which the briquettes light. Availability was considered very important and indicated that intensive distribution is critical in gaining market share. No preference for the species of wood used to manufacture charcoal was reported by consumers, who indicated that as long as the perceived quality was maintained the feedstock was irrelevant.

Socio-economic impact

The production of charcoal briquettes from sugarcane residue will create a specialised sector of the regional sugar industry, and uniquely adds value along the entire production chain. It is estimated that the impact of the capital spent will add 17 formal employment opportunities during the period of the capital expenditure. The impact of the operation of the planned pilot plant will create and sustain 16 formal employment opportunities.

It is envisioned that the resulting business will be a community owned organisation that sources labour from the community. Where community members do not have the necessary skills at start-up, a skills training programme will be introduced to build capacity through apprenticeships and mentorships. There is a dynamic interdependence between this opportunity and the communities in the Nkomazi district.

Environmental sustainability

Environmental sustainability is not simply a catchphrase or marketing ploy, it is a fundamental principle of the way this opportunity is able to create value at farm level with feedstock and at a manufacturing level. This prospect creates an opportunity cost for sugarcane biomass. At a farm level every grower will have to consider the value forgone by burning away biomass rather than allowing the newly created charcoal business to come and collect it and then leave a cheque with them.

Utilising sugarcane biomass replaces wood as a feedstock. Sugarcane has a far shorter life cycle time, produces significantly higher yields over the equivalent period and displaces three tons of wood for every ton of charcoal.

At a manufacturing level, rather than producing charcoal using the old ovens currently being used in conventional wood-based charcoal production, which spew tons of heavy black smoke into the atmosphere, this report proposes the use of modern technology, with vent scrubbers to meet the highest emission standards.

Financials

Overview

The creation of a sustainable charcoal business provides an opportunity to build a business with environmental sustainability and social upliftment as its key pillars, and the authors believe that these objectives are perfectly aligned with the pursuit of shareholder returns. The financials demonstrate that a community focussed business with an environmentally appropriate technology and product, can deliver meaningful returns to shareholders.

Assumptions

The assumptions used in the financial forecasts are the product of detailed research and wide consultation with industry experts and are thus an accurate reflection of the business. The financial forecasts make the following assumptions:

- One slow pyrolysis plant built at a logistically optimal position in the Nkomazi district.
- Average SSG farm yields at start-up and increasing at 8%/annum to reach long term potential.
- Inflation is set at 8% per annum.
- Price of biomass is set at the farm gate and growers face no costs associated with biomass collection.
- Straight line depreciation of vehicles and implements (tractors, bailers, forklifts and trucks) over five years and of the plant over ten years.

Revenue and income projections

This investigation started out as a technical curiosity, and a tangible business opportunity has emerged. The financial forecasts indicate a business which generates a positive net present value over a ten year period, and an internal rate of return which exceeds the estimated weighted average cost to company. The implication is that the creation of a business producing charcoal briquettes can both attract investors and remunerate growers for their biomass.

It is intended that growers would be both the suppliers of biomass and equity holders in the processing business. It is, however, unlikely that the growers would be the only equity holders. This form of entrepreneurial activity carries significant risks. While attracting non-dilutive funding would be the ultimate outcome, a more likely outcome would involve attracting equity investors to partner with growers. Ideally, these investors would contribute more than their equity. The identification of investors with agri-processing experience as well as extensive marketing, a distribution network would form a key strategy in developing a business out of an opportunity.

Scalability opportunities

This investigation has unearthed a simple scalable technology for SSGs to create and retain the value that their biomass offers. As the slow pyrolysis plant design enables production to scale up as SSG production increases, or LSGs make their biomass available, an opportunity exists to double the supply of available biomass to 38 000 t within five years.

The scalability opportunities within the South African sugar industry are significant. There are currently no CSAs which require the growers to supply their surplus biomass to their miller. As a result, the only constraint on expansion into other sugar producing regions is the topography of the coastal regions which makes infield baling of biomass difficult. At a minimum, it is estimated that an additional 180 000t of available biomass exists in regions with similar yields and topography as the Nkomazi district.

Conclusion

Small scale growers in the Nkomazi district have not made an economic return for over a decade and, as a result, the growing sector of the sugar industry is contracting. SSGs who do not have the benefit of scale economies nor access to capital, face an even more desperate financial position. Yet, this sector is the owner of one of the best sources of short cycle renewable biomass.

This projects set out to investigate whether recent advancements in thermochemical processing of biomass offered an opportunity to create value out of the currently unutilised biomass left in field at the conclusion of the harvesting process.

The first task was to minimise the costs associated with the collection and transport of the biomass, and identify the most efficient method of transporting the material from the field to the process facility. With this achieved, the next hurdle was the appropriate choice of technology to match processing efficiency to market. The final step was to establish whether a market existed which would generate sufficient revenue to remunerate growers for the biomass, cover all capital and operational costs and finally reward all investors.

This has been achieved and the result is an opportunity which can make a contribution to growers' revenue, thereby improving grower sustainability. This opportunity creates sustainable jobs, offsets deforestation and opens the door to the creation of an entirely new industry, a biomass to biofuel industry to operate parallel with the existing sugar industry.

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REFERENCES

Geroski P (2003). *The Evolution of New Markets*. Oxford University Press, Oxford, UK.

Olivero JL, Carmo VB and Gurgel MA (2010). The DSM-Dedini sustainable mill: A new concept in designing complete sugarcane mills. *Proc Int Soc Sug Cane Technol* 27: 1-33.

Porter M (2008). The five competitive forces that shape strategy. *Harvard Business Review* 86(1): 78-97.

Porter ME and Kramer MR (2011). Creating shared value. *Harvard Business Review* 89(1/2): 62-77.

Murray JJ (2010). Analysis of small scale grower returns in Mpumalanga: Tenant farmers or sustainable producers? *Proc S Afr Sug Technol Ass* 83: 136-142.

Schumpeter JA (1942). *Capitalism, Socialism and Democracy*. Routledge, London, UK.