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Master's Thesis

SUSTAINABILITY IN SUGAR CANE FARMING SYSTEMS: A CASE STUDY OF MAZABUKA IN ZAMBIA

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Abstract

Farming systems are designed to reduce the negative impacts of agriculture activities on the environment and ecosystem. This paper focuses on investigating the effects of farming systems in maintaining a sustainable agriculture environment in sugar cane farming. The farms were defined as either mixed (implies that they had both animal production as well as plant production) or. unmixed means they had just plant production farming systems.

The study was conducted among 100 sugar cane farmers surrounding Kaleya and Nega Nega of Mazabuka District in Southern Zambia. All statistical analysis was performed using a chi square, analysis of variance or t statistics in excel and a confidence level of 0.05 was used for all tests.

The yield/ha and income/ha was significantly different between the mixed and unmixed farms. It was found that the farmers who were aware of the possibility of energy production from animal waste and plant residues had a beteer treatment of the plant residues as well. There was also a seeming difference in the residue treatment between the two types of farming systems. Farmers renting equipment for cultivation of their fields experience a numerically lower yield compared to those who own their own cultivation equipment.

Therefore,the results suggest that farming system farming systems can be a considerable way to maintain agriculture sustainabilty.

Key words: Farming System, Sugar Cane, Sustainability

Sammendrag

Dyrkingssystemer er normalt utformet slik at de skal påvirke miljø og økosystem minst mulig I negativ retning. Denne masteroppgaven undersøker hvordan dyrkingssystemer påvirker bærekraftigheten innen sukkerproduksjon. De utvalgte gårdene ble definert enten som «blandet» (mixed) (innebærer at de hadde både dyr og planteproduksjon) eller «ublandet» (unmixed) som innebærer at de kun hadde planteproduksjon.

Studiet ble utført blant 100 sukkerprodusenter I området ved Kaleya og Nega Nega i Mazabuka Distriktet i det sydlige Zambia. All statistisk analyse ble utført ved hjelp av kji-kvadrat, variansanalyse eller T-test i Excel, og med et signifikansnivå på 0.05.

Produksjon per ha var signifikant forskjellig mellom blandet og ublandede produksjoner. Det ble også funnet at de bøndene som var klar over muligheten for å produsere energi basert på planterester og husdyrgjødsel, også hadde en bedre håndtering av planterestene. Det så også ut til at det var en forskjell I planterestbehandlingen mellom de to dyrkingssystemene. Bønder som leide utstyr for jordbearbeiding, opplevde også en tallmessig lavere produksjon sammenliknet med de som eide deres eget jordbearbeidingsutstyr.

Resultatene fra dette studiet antyder derfor at valg av dyrkingssystem kan ha vesentlig betydning for bærekraftigheten i et jordbruksproduksjonssystem.

Nøkkelord: Produksjonssystem, sukkerproduksjon, bærekraft

Introduction

As urbanization continues to take place, the management of agriculture lands is becoming a major environmental concern in most of the developing and agriculture dependent countries like Zambia. The Zambian ecosystem like many other ecosystems in the sub-region has been influenced by both natural and anthropogenic factors such as fire, cultivation practices and charcoal production. Like most developing countries, Zambia has been experiencing severe drought for the past years. This has not only affected the agriculture system but the energy production levels as well.

Generally, agroecosystems/farming systems in Tanzania, Zambia and Malawi is the maize mixed farming but however Tanzania and Zambia also have the forest based farming and root crop farming systems (Khalil et al., 2011). Some agroecosystems developed are designed to reduce the negative impacts of agricultural activities on the environment and the ecosystem. Agriculture is a dominant form of land management globally, and agricultural ecosystems cover nearly 40 per cent of the terrestrial surface of the Earth (Kabanda, 2015).

Some agroecosystems developed are designed to reduce the negative impacts of agricultural activities on the environment and the ecosystem. Poor agriculture or farming system networks will have negative impacts on the environment as uncontrolled agriculture systems with less services will contribute to climate change (Mbumwae, 1998). However positive impacts are also a possibility.

Agroecosystems can be used to refer to the communities of plants and animals which interact with their physical and chemical environments that have been modified by people to produce food, fiber, fuel and other products for human consumption and processing (Altieri, 2002). Agroecosystems may be regarded as true cybernetic systems whose goal is increased social value and this social value can be achieved through a variety of strategies that combine different levels of productivity, stability, sustainability and equitability (Conway, 1987). Therefore, the development of agriculture will involve trade-offs between these properties. Agroecology emphasizes on the inter-relatedness of all agroecosystem components and the complex dynamics of ecological processes instead of focusing on one particular component of the agroecosystem (Vandermeer & Perfecto, 1995)

Globalization of the energy supply chain and increasing demand in energy production are increasing the impact and benefits of energy production in the agriculture sector. Numerous sustainable energy options in agriculture including energy savings through use of more energy efficient technologies which replace the fossil fuels through renewable energy powered technologies (Bundschuh, Chen, Yusaf, Chen, & Yan, 2014) are being used to fulfill future needs of a modern sustainable agriculture. Zambia has significant renewable energy resources which include hydro, biomass, solar, wind and geothermal energy that can be exploited not only for grid use but also to for sustainability of the agriculture systems. Agriculture and energy production in this generation are two separate fields which cannot be separated. The agricultural sector globally has become more energy intensive for the supply of more food for increasing population and provide sufficient and adequate nutrition (Yousefi, Mahdavi Damghani, & Khoramivafa, 2016).

At the farm level, consumed energy consists of both direct and indirect uses (Sebri & Abid, 2012). The direct energy use in agricultural activities includes crop production (e.g., cereal grains, oilseeds, pulses, fruits, and vegetables), poultry production (e.g., chickens, turkeys, and hens), animal products production (e.g., milk, eggs, and meat), and transportation of farm productions. While energy is used indirect for the off farm for manufacturing and transportation of fertilizers and pesticides (Sebri & Abid, 2012). On-farm management practices can significantly enhance the ecosystem services provided by agriculture. Habitat management within the agroecosystem can provide the resources necessary for pollinators or natural enemies (Tscharntke, 2005) which are useful in a sustainable agroecosystem as these are useful for energy recycling.

However most of the renewable energy sources have not been fully utilized (Mbumwae, 1998), especially in terms of linking them to production of energy in the agriculture sector. The understanding of energy flow and greenhouse gas emission in agricultural production systems helps in the optimization of crop management practices and environmental crises for sustainable development (Yousefi et al., 2016). Figure 1 below illustrates the main sources of energy and how these interact with agriculture (Dodder et al., 2015). The Zambian government highlights energy as being a driving force for the socio-economic development of the nation (Mbumwae, 1998) However, even though Zambia has made great strides in energy supply, not much has been done in promoting efficient use of renewable energy sources (Mbumwae, 1998) and the demand still remains a great challenge.

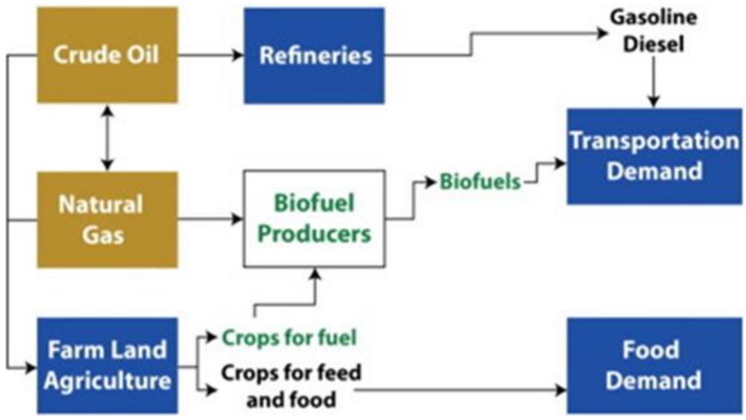

Figure1: Shows the interactions between Agriculture and energy with biofuel linkages highlighted in green (Dodder et al., 2015)

Development is understood as that development that is mindful of the future generations' needs While resources are used to meet the needs of the present generation (Brundtland, 1987) issues arise when we start talking about sustainable development (Lewandowski & Faaij) are made. In this, sustainable development presents an ideology upon which development-related activities are initiated and implemented. Adoption of sustainable farming practices that utilize and conserve biodiversity may ultimately improve environmental quality and limit agricultural expansion into natural forests as well as the negative impacts of agriculture on biodiversity (Khumalo, Chirwa, Moyo, & Syampungani, 2012).

Therefore, this paper investigates the effect of the farming system in maintaining a sustainable agriculture environment in sugar cane farming. The following indicators will be analyzed;

1) association of the farming system to yield levels, income, benefits and person (age, gender and education).

2) the role played by knowledge on the practice methods and treatment of residue.

3) The amount of plant residues in different farming systems, and the association between the amount and the treatment of plant residue.

4) Association between residue treatment and use of manure as fertilizer.

5) Effect of owning or renting equipment for soil preparation and irrigation on yield level

Materials and Method

Description of the Study Area

The study was conducted in Mazabuka District in the southern province of Zambia. Mazabuka is located on latitude 15.86 and longitude 27.75 at an elevation of 1050 meters above sea level. The climate in this region is warm and temperate with an annual temperature of 20.9 °C and a precipitation of about 780mm annually. The region is driest in the month of June with 0mm precipitation and a maximum precipitation of 215mm a in December and average temperature of 24.6 °C, October is the warmest month. At 15.5 °C on average, July is the coldest month of the year. The variation in annual temperature is therefore around 9.1 °C

Mazabuka has a population of approximately 261,268 with about 43,545 household numbers. It is a farming town with the main crops grown being Maize and Sugar Cane. Most of the sugar cane farmers are in an out-grower scheme with Zambia Sugar. Livestock such as cattle, chickens and goats are also a predominate feature for farms in this region. Cattle is however not just a measure of wealth but also a status symbol to the farmers in the southern region. In some areas, this the contract or out-grower scheme also involves land ownership and in most of such areas the keeping of animals such as cattle and goats is prohibited.

Data Collection and Sampling

The data used in this thesis was collected from 100 sugar cane farmers in Nega Nega and Kaleya Areas through a scheduled interview using a questionnaire. Kaleya small holders company limited (www.kaleyasmallholders.co.zm) was contacted, and from their member lists of 160, 50 farms larger than 5 hectares were selected through stratified random sampling methods and contacted. The other 50 were selected from Nega Nega and Manyonyo sugar cane farming areas within Mazabuka. This total of 100 volunteer farms were included in the study and interviewed using a structured questionnaire on a single farm visit. However, 5 farms were removed during the analysis process as they did not contain some critical components to be analysed. Furthermore, non-structured interviews were conducted with key informants from Zambia sugar, Kaleya small scale company and Manyonyo irrigation company to obtain information on the agriculture and energy nexus in the region of study. All the interviewed farms were involved in the sugar cane scheme, with 83.2% being only part of this scheme and 16.8% with other schemes. Out of the total 34.7% were females run while 65.3% were male run. Age was categorised into four categories with the following distribution: 0 to 20 years = 2; 21 to 34years = 8; 35 to 50years =32 and above 50years = 53. The farm variation mean was 11.6 ±11.9 ranging from 5 to 80 hectares in size. 81 were classified as small scale farmer and 14 were commercial farmers (having 20 hectares and above of farming land). The farms levels of education varied from having no formal education to the highest education acquired (None= 14.7%, Primary= 26.3%, Secondary= 37.9%, College= 14.7 and University= 6.3%). The farms were either a mixed 56.8% or unmixed 43.2% farming system. A mixed implies that they had both animal production as well as plant production rearing animals sure as chickens, goats and cattle, whereas unmixed means they had just plant production. The treatment of the plant residue were categorized either as renewable (n=1), incorporated in soil (c=33), burnt in field (b=56) or as a mix of these practices (m=5).

Statistical and Data Analysis

All statistical analysis was performed using a chi square, analysis of variance or t statistics in excel. The confidence level of 0.05 was used for all tests performed. The effect of the interaction between mean yield levels and income on the agroecosystem network and that of yield levels and the type of farming. The following classification were used to perform these analyses fully: The mean harvest was calculated from the harvest collection of 2014, 2015 and 2016 farming seasons (Equation1) was used to examine whether the effects differ depending on the farm type (mixed with animals and unmixed without animals). Comparison of the income between the mixed and unmixed and unmixed farmers was also done using the T-test assuming equal variances.

$$Yield = \frac{Harvest\ 2014 + Harvest\ 2015 + Harvest\ 2016}{3} \quad \text{…….. equation 1}$$

The role played by knowledge on the type of practice that the farmers uses and the residue treatment methods were analysed by examining and comparing these between the different types of farmers. The number of residues in 50kg bag that are left in the field after harvest were among the farmers were used to establish this analysis.

Further, the differences in energy potential between the two different farming types was analysed by comparing the amount of stalk feed or residues that are left in the field after harvest. Use of mechanisation was also used and examination of the types of machine owned and if it played any role in the amount of residue left.

The possibility of energy production was established from the effect of residue treat on the environment. The benefits of animal waste use were also used to examine the effect on the environment.

Results

Associations of the farming system to yield level, income, benefits and person

No difference in the yield levels (mean yield for the harvest in 2014, 2015 and 2016) between the mixed and unmixed farmers were found. The average yield in farms with mixed farming system was 130.9 ± 161.3 tonn/ha, whereas the yield on farms with unmixed farming system was 132.3 ± 52.0 tonn/ha ($P = 0.96$). The yield variations between years were investigated, however there was no significant variation found ($p=0.82$). The range was considerably high from 9.54tonn/ha smallest to largest 1062.83tonn/ha in the cane supplied in relation to farm size.

There was also a significant difference between the mixed and unmixed farmers ($P < 0.0001$) related to income/ha. Mean income/ha for mixed farmers were 1131.5 USD, whereas mean income for unmixed farmers were 635.2 USD. No difference between farming systems were found related to age of the farmer ($\chi^2 = 0.23$, df = 3, $P = 0.97$). No difference between farming systems related to gender were found ($\chi^2 = 0.29$, df = 1, $P = 0.59$), and finally, no differences associated to education level were found between the farming systems ($\chi^2 = 4.35$, df = 4, $P = 0.36$).

Based on the interview, benefits of practicing a mixed farming system are extra income (n=36), organic fertilizer (n = 27), work and transport (n=9), food source (n=3) and others (n=2).

Residue treatment vs knowledge and practice

Education level were not found to play a role on the type of treatment that is given to the residues after harvest (χ^2=, Df=12, $P=0.64$).

There is however a significant association between the knowledge of the possibility for using farm waste for energy production and the treatment of residues ($\chi^2= 9.68$; Df=3 and $P < 0.0001$). Less of the farmers without knowledge of energy production are incorporating the residues compared to the expected number, and even the farmers being aware of this possibility seem to incorporate less of the residues as well.

The amount and treatment of plant residues in different farming systems, and the association between the amount and the treatment of plant residue

The amount of plant residues does not differ between farms with mixed or unmixed farming systems ($\chi^2 = 2.21$, df = 3, P = 0.67). The percentage for Mixed farms were (< 50kg = 4.2%; 50 to 99kg = 12.6%; 100 to 150kg = 15.8% and > 150 = 24.2%) while the unmixed (< 50kg = 6.3%; 50 to 99kg = 7.4%; 100 to 150kg = 12.6% and > 150kg= 16.8%).

There seem, however, to be a difference in residue treatment between farms with mixed and unmixed practice (χ^2=7.25, Df=3, P=0.06). The main difference is that the unmixed farmers are incorporating plant residues into soil a higher number than expected.

In relation to the treatment of stalk feed; 59.0% practice burning, 34.7% incorporate; 5.3% practice mix (rotation between burning and incorporation) and only 1.1% treat the residue as a renewable resource.

No association between the amount of stalk feed that remains in the field and the treatment given to these residues in the field were found (χ^2=12.79, Df=9, P=0.17).

Residue Treatment, use of Manure and effects on yield

Since only mixed farms have animals, and manure, use of manure is discussed within the mixed farms. No effects were, however, found between those who used (n=42) and those who did not use manure (n=7) as fertiliser in relation to residue treatment (χ^2= 1.64; Df = 3 and p = 0.65).

Farms using both plant residues (burnt and incorporated) and manure from animals as fertilizer had a significantly higher yield/ ha (183,2 t/ha) compared to those who only used plant residues as fertilizer (82,4 t/ha) with P<0.0002.

Effect of owning or renting equipment for soil preparation and irrigation on yield level

Farmers renting equipment for cultivation of their fields experience a numerically lower yield (112.9 t/ha) compared to those who own their own cultivation equipment (149.5 t/ha), however, not significant with $P<0.18$. The same is the case for those who are renting irrigation systems. All farms had access to irrigation – their own or rented, however, farmers owning their own irrigation system had a numerically higher yield (148.5 t/ha) compared to those who are renting their systems (108.7 t/ha) with $P<0.15$.

Ownership of equipment were also found to influence on yield/ ha specified as indicated below (Table1). Those who own irrigation systems or cultivation and irrigation systems had significantly higher yields compared to those who did not own cultivation equipment or irrigation and cultivation equipment. From farmers incorporating plant residues, a significantly higher percentage ($P<0.0001$) are owning both cultivation and irrigation systems compared to those who are not incorporating these plant residues. There is also an interesting difference between mixed and unmixed farmers where more farmers are also owning both types of equipment, however not significant ($P=0.10$).

Table1: Influence of not owning or owning irrigation, cultivation or both equipment's on yield/ha.

	Yield/ha ± SD	% mixed farms	% incorporating plant residue
Not owning irrigation or cultivation equipment (n=40)	108.7 ± 37.7^{a}	45.0^{a}	10.0
Owning cultivation equipment (n=27)	89.5 ± 75.2^{a}	59.3^{a}	25.9
Owning irrigation system (n=6)	151.3 ± 90.8^{b}	50.0^{a}	83.3
Owning cultivation and irrigation equipment (n=22)	222.9 ± 237.7^{b}	77.3^{a}	72.3

Discussion

Yield/ ha was found to be higher when plant residues as well as manure from the animals were used as fertilizer in the sugar crops as compared to the farms that neither incorporated the residues nor used animal manure. This was in accordance with the study by (Laxminarayana, John, Ravindran, & Naskar, 2011; Tukaew, Datta, Shivakoti, & Jourdain, 2016), which found that low amounts of fertilizer are mostly associated with lower use of nutrients applied and non-adoption of improved technologies which leads to low crop productivity. It is also logically associated with common knowledge that application of fertilizer positively influences the yield. The large variation in yield/ha may be caused by several factors like amount of fertilizer and water being used, as well as quality of plant material, water and soil. These factors were, however, not investigated in this study. Since no difference were found between year, the differences may be less associated to weather. However, it in this study the variation in the yield/ha recorded on different farms can be associated to cultivation practices, irrigation systems and methods, residue management and fertilization use. This is similar to (Khamjan, Khamjan, & Pathumnakul, 2013) were the variation in cane production or cane yield during the periods of a crop year were seen to be dependent on the cultivar selection of the farm and the time at which the cane reached its optimum yield. Farm management factors are therefore important for determining variation in instance were weather is a less factor of consideration.

Also, the income/ha was higher on mixed farms compared to farms not keeping animals. This is in accordance with previous findings from (Makhanya, 1997) who highlights the role of extra income in sugar cane production. This may be due to the simple fact of having access to a cheap, and easy accessible fertilizer. Manure from the animals may also contain high levels of nutrients which may contribute to the nutrition of the kern, thus earning the farmer a higher income due to higher yield as well as improved crop quality compared to a farmer without animals. Crop quality was not recorded in this study; however, it was an impression that mixed farmers were more aware of this extra quality payment compared to unmixed farmers. This quality payment is associated to the sugar cane composition contents; extractable juice (sucrose, soluble non-sucrose and water) and fibre. Hence, it seems to be a good thing for farmers searching for a higher income in sugar production to also keep animals to have access to this valuable fertilizer.

The size of land on which cane is grown is one of the other key factors determining income/ha of a farm. The income/ha earned in mixed farming systems was higher because of the factors of both farm size and income being put into consideration from this measure. However, for the unmixed farming systems increasing the amount of land where cane is raised can be done for the farmer to be economically viable (Makhanya, 1997). However even though this the most economic viable way it is not as sustainable as it sounds to be as there are many other factors that also influence yield such as the soil content and lack of water.

The plant residue treatment was found to be different on mixed farms compared to unmixed farms. The mixed farms incorporating and burning residues had a higher yield similar to the findings of (Basanta et al., 2003), were burning of residues gave an increased yield. Use of agriculture waste for nutrient management is an important factor in yield maximization. Adequate use of crop residue is also important for healthy and production soils (Vallis, Parton, Keating, & Wood, 1996; Wood, 1991). There is a difference in the appearance of the farms given different residue treatment (Appendix II). However, being a grass crop if the incorporation is not properly done the crop will dry out and will not be able to regrow in the next planting season as cane is not replanted every year but is cultivated for several years before replanting. (Guan, Nakamura, Shikanai, & Okazaki, 2009) in their study show that cropping systems can contribute to loss mathematically. Another factor can be associated with the number of weeds in the farm. Incorporation residues can lead to an increase in the number of inversive species compared to burning which is an inexpensive and effective way of weed control, insects, diseases and excessive crop residue. Combining or rotating between incorporation and burning is seemingly a better option as both treatment methods have advantages for soil properties and will increase long-term yield.

The farms owning equipment of their own, either irrigation or irrigation and cultivation equipment, had relatively a higher yield/ ha, although all the farmers have accessibility to cultivation or irrigation equipment through leasing. This links to the timely availability of the equipment to these farmers compared to the not owning farmers who must wait for their turn to be able to use and access the equipment. Owning equipment therefore stands as an advantage for high yielding farms in sugar cane production. Furthermore, these farmers have a higher percentage of plant residue incorporation, yield/ha and income. Following the study by (Li et al., 2016) sugar cane production can improved by development of appropriate farming technologies for rain-fed upland production. The ability to sustainably manage the farm system is higher with farmers owning the equipment.

This is in accordance with findings from (Laxminarayana et al., 2011) where non-adoption of improved technologies led to low crop productivity. These technologies may include those caused by that irrigation which can be done as timely as needed and the management of inversive species is easier for farmers with own compared to the farmers who must wait for rented equipment.

Knowledge about the possibility for using farm waste for energy production was found to be associated with the way plant residue were treated. Although none of the interviewed farms was producing energy from the plant residues and animal waste. There were associations between the levels of education and the treatments of residues. The farmers with some levels of education are aware of the possibility of energy production, which indicates that that the knowledge has a role to play in sustainability and farm management. These farmers are likely to understand better the concepts introduced to them at out grower meeting. Agricultural contracts have positive impact on agricultural production (Tukaew et al., 2016), Farmers involved in such cooperation's have access to trainings, seminars and workshops related to their farming, this is similar to the sugar cane farmers found in the study (Guan et al., 2009). Sugar cane residues may be used for energy production, e.g. ethanol or biogas used for producing electricity. This is a better replacement for use of fossil fuels. Thus it is a good alternative for climate change mitigation (Nguyen, Gheewala, & Sagisaka, 2010).

Mixed farming systems seem to be favourable compared to unmixed systems in several aspects related to yield, income as well as for personal development. This is previously stated by (Laxminarayana et al., 2011) investigating effects of e.g. organic farming which is highly comparable. Disadvantages are, however, that access to larger areas as well as rented or owned farming equipment are more capital intensive. Having animals may sometimes lead to yield losses especially to farms owning cattle that is free range, the animals may graze in the sugar cane farm (Appendix III).

It could be more interesting if a further field study be done with more details of the use, cost and use of resources of machinery could be useful to be able to describe effects and efficiency of the machinery itself related to yield, income and sustainability. A follow-up performed in a way building the foundation for e.g. yield prognoses based on different residue treatment practices/ use of manure should also be touched in a future study. Lastly, also the way a sustainable sugar cane farmer manages weed, pests and diseases through internal regulating mechanisms on a farm with or without animals is of interest. However this information was not collected during the study due to time constraints.

In conclusion, a mixed farming system is positive for the income of sugar cane farmers, and brings several benefits, e.g. yield/ ha was found to be higher when plant residues as well as manure from the animals were used as fertilizer in the sugar crops. The income/ha was higher on mixed farms compared to farms not keeping animals. The size of land on which cane is grown is one of the other key factors determining of income/ha of a farm. The plant residue treatment were found to be different on mixed farms compared to unmixed farms. The farms owning equipment of their own, either irrigation or cultivation equipment, had relatively a higher yield/ ha and were also, to a higher degree, incorporating plant residue in soil. Knowledge about the possibility for using farm waste for energy production was also found to be associated with the way plant residue were treated. Mixed farming practice may also, beside higher yield and income, at the same contribute as a climate mitigation. Therefore, with farmers using both manure and incorporation methods it is easy to maximize use of nutrients and thus lessen inputs as much as possible, hence being more sustainable and hence sustaining the agriculture environment in the long run.

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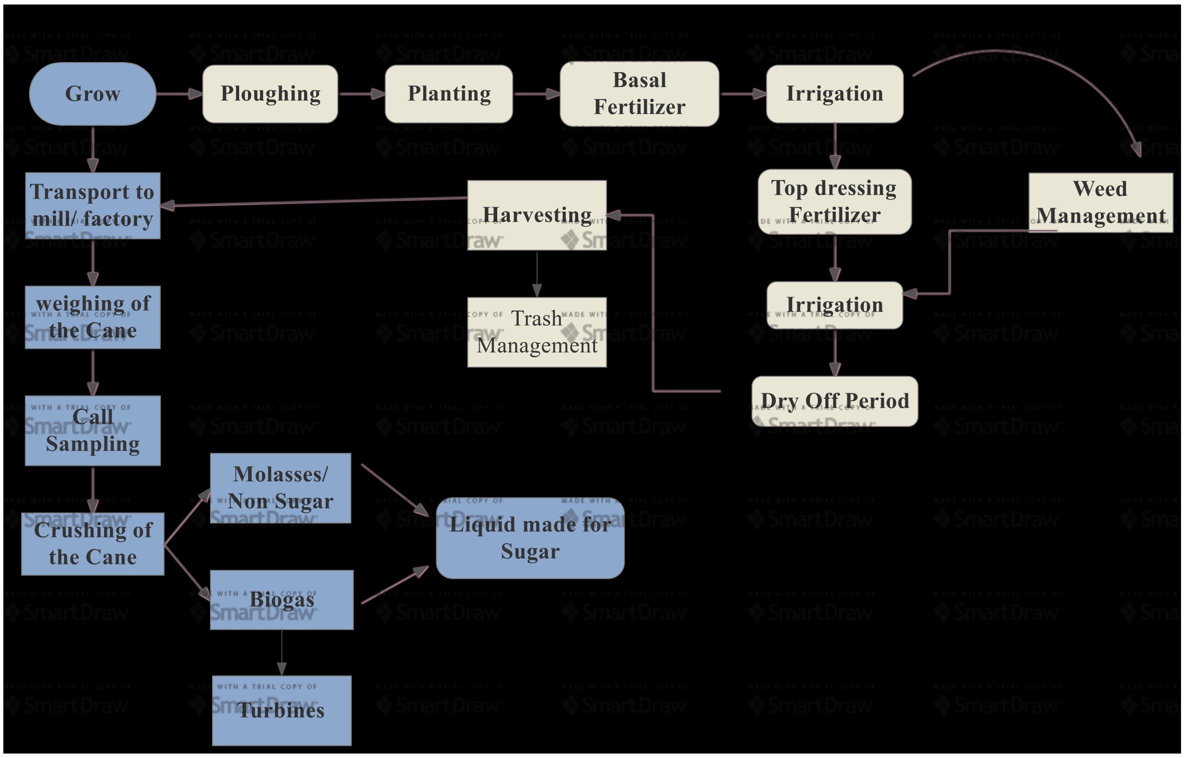
APPENDIX

APPENDIX I

Processes involved in sugar cane production and handling. The brown boxes indicate the process that the farm is directly responsible for and can be either maximised or improved to increase the yield/ha. While the blue boxes show some of the processes not directly linked to the farm but largely influence the income that the farm earns from the sugar cane.



APPENDIX II

The pictures below show two farms with differently treated residues the previous harvest two months after new cultivation: a) the residues in this farm were incorporated and b) mixture of burning and incorporating.

a)

b)

APPENDIX III

Picture showing free range cattle owned one of the sugar cane farmers.


a)


b)

APPENDIX IV: STAGES OF SUGER CANE GROWTH

The pictures below were taken from different visited farms each indicating a different stage of sugar cane handling in these ecosystems: a) a non-cultivated farm after harvesting cane; b) Newly growing cane a month after harvesting; c) Cane at three and half months being pipe irrigated; d) Three months cane and centre pivot irrigation system; e) Cane at nine months; f) Cane beginning to dry at eleven months and getting ready to be harvested; g) Cane cutting/ harvesting after burning; h) partially cut cane; i)cut and piled up cane ready to be collected; j) cane loading into pickup truck and k) Transporting of harvested cane to the factory or sugar company for further processing.

a) 

b) 

c) 

d) 

e) 

f) 

g) 

h) 

i) 

j) 

k)