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Biofuel Policy as a Key Driver for Sustainable Development in the Biofuel Sector: The Missing Ingredient in Zimbabwe's Biofuel Pursuit

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Abstract

As global warming continues to be a challenge, there is urgency to look into fossil fuel alternatives for sustainable energy supplies which have also been hastened by the volatility of crude oil prices and the fact that fossil fuel depletion is clearly in sight. Zimbabwe has not been spared of the negative effects of climate change which have affected both the food and energy sectors. This has proved to be a major challenge for the sustainable development of the country's economy. In an effort to be energy independent, the country has for over decades looked into the prospect of utilising its vast biomass resources to produce biofuels. These programmes have been met with a number of challenges which has seen most such projects not succeeding. The current paper gives a narration of the history of biofuel programmes in Zimbabwe looking at their driving factors and reasons that led to their collapses. Lack of a national biofuel policy is identified as the major factor that has been the missing link in the past and must be addressed. The paper goes further to call for the crafting of a National Biofuel Policy for Zimbabwe highlighting the major thematic issues it would need to cover. An implementation plan for the programme has been proposed.

Keywords: biofuel, Zimbabwe, policy, bioethanol, biodiesel, renewable energy, climate change

1. Introduction

While fossil fuels have and continue to play an essential role in keeping the pulse of the global economy beating, their use has had profound effects on the global environment. Undoubtedly, one of the most widely researched and documented detrimental impacts associated with fossil fuel use, in recent years, is the production of green house gasses (GHGs), primarily carbon dioxide. These have lead to global warming consequently resulting in the climate change phenomena. This change in the global climate patterns has caused a plethora of challenges currently confronting mankind. The agricultural sector which is a key component of the African and global food source is highly vulnerable and sensitive to climate changes. Other than being a source of livelihood for a significant population in sub-Saharan Africa (Tadesse, 2010), agriculture accounts for approximately 40% of the African gross domestic product (GDP) and nearly 70% of employment on the continent (Fields, 2005). Africa has been reported to be warming much faster than other parts of the world which has led to predictions that within the Southern region of the continent, temperatures will increase by over 4 ºC and precipitation will decrease by as much as 15% within the next century (Conway, 2009). Such temperature increases are believed will lead to a decrease in the agricultural output of crops such as wheat and maize. The decrease is estimated will be in the range of 30–40% for both cereals (Warrens et al., 2006, cited in Clements 2009), in Southern Africa and in addition an increase in water scarcity is also expected (Clements, 2009).

Within the Southern African Development Community (SADC) region, the impacts of climate change have been evident in the agricultural sector over the past few decades as observed by the stagnation in cereal crops

produced. According to the SADC Secretariat (2009), in 1990 cereal production was 22,062,000 metric tonnes while in 2006 it was 23,607,000 metric tonnes. Population over the same period rose from 152,000,000 to 249,000,000 indicating a decrease in per capita food consumption from 145 kg to 95 kg per annum. Zimbabwe has not been spared from the effects of climate change. The 1992 drought, which occurred as result of the *El Nino*, caused the country's GDP to significantly drop by 11% (Kandji, Verchot, & Mackensen, 2006). The country has seen a significant decrease in its agricultural productivity over many years for which climate change is one of the major factors. As the region continues to warm up, the current prevailing weather patterns may only get worse. The effects of global warming have a far more outreaching impact in Africa as they also affect biodiversity (Malcolm et al., 2006; Sala et al., 2000), health (IPCC, 2007; Thomas et al., 2007) and the economic state of the continent (Clements, 2009).

The urgent need to tackle climate change can never be overemphasised considering its wide spread calamitous impacts are likely to get even worse in the future. The extensive use of fossil fuels has led to the release of a high concentration of the GHGs, the major catalysts in the global warming effect. The transport sector has heavily relied on the use of fossil fuels for the provision of petroleum and diesel and hence has played a significant role in climate change accounting for close to 19% of carbon dioxide emissions (Goldemberg, 2008). Hansen (2004) states that the number of vehicles currently on use will increase significantly within the coming years implying that the demand for fuels will also subsequently rise and so will be the carbon dioxide emissions. Therefore, investing in an alternative environmentally friendly energy source for this sector could prove a sustainable option to this challenge and reduce global addiction to fossil fuels. Moreover, fossil fuels such as petroleum are a finite source of energy (Pires & Schechtman, 2009) which could soon run out. The current major oil supplying states are located within politically unstable regions of the world (Birur, Hertel, & Tyner, 2008) which makes oil prices highly unstable (Pires & Schechtman, 2009) and their constant supply uncertain. This further echoes the need to have an alternative energy source to fuel the transport sector to ensure its prolonged survival and at the same time not producing more GHGs. Biofuels are increasingly being seen as a viable environmentally friendly and sustainable option to fossil fuels (Demirbas, 2009).

Demirbas (2009:108) defines biofuels as "... a renewable energy source produced from natural (biobased) materials, which can be used as a substitute for petroleum fuels." Examples of biofuels are bioethanol which is produced from sugarcane, maize or wheat and biodiesel produced from oil seeds and oil rich plants (Demirbas, 2009; Moschini, Cui, & Lapan, 2012; M. Balat & H. Balat, 2009). They are classified into three different categories based on the feedstock used in their production. First generation biofuels are those produced from agricultural crops such as maize and sugar cane. Second generation biofuels are those produced from cellulosic material which are non-edible (Naik, Goud, Rout, & Dalai, 2010) while third generation are derived from feedstocks such as algae (Dragone, Fernandes, Vicente, & Teixe, 2010). A major attractive feature about biofuels is that they have the potential of reducing the emission of GHGs (carbon neutral) (M. Balat & H. Balat, 2009) which could possibly lead to reversing the global warming effect. They also have the ability to reduce levels of carbon dioxide in the atmosphere through carbon sequestration. Beyond being environmentally friendly, there are other benefits of utilising biofuels such as becoming energy independent, foreign currency reserves are saved, jobs are created and rural communities (which make up a significant portion of the African population) stand to benefit economically leading to their development (Demirbas, 2009).

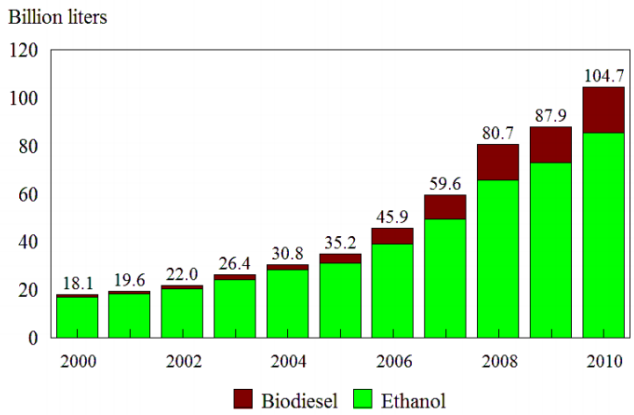

Figure 1. Global production of bioethanol and biodiesel from the year 2000–2010
(Source: Adapted from Coyle, 2011)

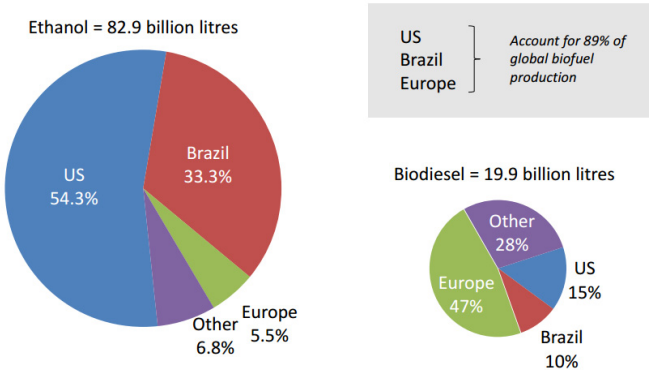

Figure 2. Regional bioethanol and biodiesel total production for the year 2010
(Source: Adapted from Coyle, 2011)

The biofuel economic model, which is still in its infancy, is proving to be successful as observed by the growth in its production over the past few years (Figure 1). Bioethanol is the most produced biofuel globally by volume followed by biodiesel. The leading biofuel producing regions in the world include the United States of America (USA), Brazil and the European Union (EU) (Figure 2).

Between the years 2005 and 2011 the global market value for biofuels increased from US$15.7 billion to US$83 billion a five times increment (Table 1) (Pernick et al., 2012, cited in Charles et al., 2013). One key driving factor that has led to the success of biofuels industry in these regions has been the implementation of biofuel policies (Pires & Schechtman, 2009; Fontes, 2010). These policies have been formulated such that they support the production and utilisation of the biofuels (Pires & Schechtman, 2009). Fontes (2010) further emphasises on the need to have such biofuel policies and also states that energy industry leaders and policy makers must understand that supporting such policies would help to develop a marketplace on a regional basis. Therefore, any nation that seeks to have a successful biofuel programme needs to implement a comprehensive biofuels policy.

Table 1. Global market size as biofuel wholesale market value

Year	Global Biofuel Wholesale Market Value (US$ Billion)
2005	15.7
2006	20.5
2007	25.4
2008	34.8
2009	44.9
2010	56.4
2011	83

Source: Adapted and modified from Pernick et al., 2012, cited in Charles et al., 2013.

The current paper aims to present a case on why Zimbabwe needs to have a biofuel policy document to support the sustained growth of its biofuels industry. It explores the history of biofuels in the country and also gives a short analysis of biofuels policies from a few selected countries regionally and globally. It then attempts to highlight major thematic issues that the proposed policy should address and finally will briefly suggest a process that could be adopted in the formulation of the policy.

2. History of Biofuels in Zimbabwe

The production and use of biofuels has been a part of Zimbabwe for over decades in what could be described as an "on-off relationship". As early as the 1970's, the country has been documented to have been utilising biofuels. According to Karavina, Zivenge and Mandumbu (2011), jatropha plant (*Jatropha curcas* L.), was used in production of fuels (presumably biodiesel) in the 1970's and 1980's. The plant was first introduced into the

country in the 1940's for its exploitation in soap and lubricant production (Karavina et al., 2011). However, its primary usage was to change as the plants applicability in biofuels production was "intensified" during the 1970's and 1980's as reported in Karavina et al. (2011). It is not stated what exactly was the motive towards channelling it to fuel production. The life span of the project has neither been given nor the reasons that led to its evident collapse.

In 1980, Zimbabwe started producing bioethanol using molasses as the feedstock at its Triangle Ethanol Plant (Amigun, Musango, & Stafford, 2011; Deenanath, Iyuke, & Rumbold, 2012; Davison, 2011). This according to Amigun et al. (2011) was the first production facility of its kind in Africa. The bioethanol plant was producing close to 120 000 litres per day and 40 million litres per year (Deenanath et al., 2012; Amigun, et al., 2011). Petroleum blending was done at a rate of 12–15% (v/v) with ethanol. The production plant ceased operation in 1992 due to severe drought conditions which led to failure to access the feedstock (Johnson & Matsika, 2006; Davison, 2011) while at the same time unblended fuel also became cheaper (Davison, 2011).

In 2005, the country once again relooked into the prospect of using the jatropha plant for biodiesel production (Davison, 2011). The National Bio-Diesel Feedstock Production Programme was launched with the aim of establishing jatropha plantations right across the country's ten provinces to ensure sustained supply of the feedstock (Karavina et al., 2011; Davison, 2011). The National Oil Company of Zimbabwe (NOCZIM) was mandated to spear head the project. A US$ 6 million jatropha processing plant was set up in 2007 in Mount Hampden, Harare with the capacity to produce 100 million litres of biodiesel annually (Amigun et al., 2011; Davison, 2011). Amigun et al. (2011) state that Zimbabwe had yet once again taken the initiative ahead of all other countries in Africa as this processing plant was the first such commercial plant on the continent. The plant was jointly owned by the Reserve Bank of Zimbabwe (RBZ) and private investors (The Financial Gazette, 4 May 2012). The fuel crisis crippling the economy at the time due to lack of foreign currency in the country was the major driving motive that led the government to resuscitate the programme (The Financial Gazette, 4 May 2012). The project was estimated would save the country close to US$ 80 million annually from diesel importation (Zimonline, 2008, cited in Amigun et al., 2011).

The plant was reported to have been operated at under 5% capacity mainly attributed to a severe shortage of the feedstock (Zimonline, 2008, cited in Amigun et al., 2011). Yet again the programme was to suffer the same fate as those it had preceded as in April 2010, the government stopped funding it (Davison, 2011). There are a number of reasons which are believed to have led to this. Karavina et al. (2011) report that poor coordination in running the programme did play a role that led to it folding. Three Ministries were involved while their mandates and coordination was not clear (Karavina et al., 2011). Another factor that has been highlighted was the failure of NOCZIM to pay an attractive price to the farmers for jatropha which eventually led to lack of constant and reliable supply of the feedstock (Karavina et al., 2011). Due to change in the political arena in the country after the formation of the Government of National Unity (GNU) in 2009, there was an introduction of the multi-currency system and companies were allowed to import fuel independently. This eventually led to fuel becoming available in the market and hence biodiesel production was no longer seen as a priority (Karavina et al., 2011; Davison, 2011).

The year 2011 was to be the dawn of yet another new chapter in Zimbabwe's relentless pursuit of the seemingly highly elusive biofuels programme. A US$ 600 million bioethanol plant project was resuscitated at Chisumbanje in the Chipinge District. The plant was set up on a joint venture partnership between the government, Agricultural Rural Development Agency (ARDA), and a private investor, Green Fuels Pvt (Ltd). It was set to be the largest of its kind in sub-Saharan Africa. The project was initially set to run on "Build, Operate and Transfer" model with the government set to take full control of the plant in 30 years time from Green fuels. However, this was changed to the current joint venture partnership (Bulawayo 24, 1 March 2013). It is envisaged that when fully operational, the plant will produce 700,000 litres of fuel daily (Manica Post, 27 March 2013) equalling 27% of the country's fuel needs (The Financial Gazette, 12 March 2012) saving the country close to US$ 200,000 per day on fuel imports (Manica Post, 27 March 2013). The bioethanol production facility was expected to create thousands of jobs, lower down local fuel prices and also improve the livelihood of rural folk living within the vicinity of the plant (The Financial Gazette, 12 March 2012). A great initiative and noble project and a large investment which was not expected to fail!

On the 6th of February 2012, the plant shut down its operation (Bulawayo 24, 1 May 2012) citing numerous challenges which it was facing putting 4,500 workers at the risk of losing their jobs. Some of the problems that have been highlighted in different press reports include failure to secure a ready market for its ethanol as government had not made fuel blending mandatory (Bulawayo 24, 1 May 2012). This consequently led to a situation where there was an accumulation of the ethanol stock at the plant as it was not selling. In addition to the

poor sales, the logistical and infrastructure for blending in the country were reported as not being adequate (Zimbabwe Independent, 4 January 2013). Other challenges that pushed the plant to shut down its operations were a dispute between the villagers and Green Fuels and the high price of the blended fuel (VOA Zimbabwe, 14 June 2013).

However, the government has since gazetted Statutory Instrument 17 of 2013 (Mandatory Blending of Anhydrous Ethanol with Unleaded Petrol) which was published on the 12th of February 2013. The instrument stipulates that all licensed procurers and wholesalers of unleaded fuel must only do so after ensuring it has been blended with a minimum 5% of ethanol (E5) produced by a licensed producer. The Minister of Energy and Power Development was quoted saying that the Instrument will only come into effect after Green Fuels became compliant (The Herald, 14 February 2013). The company has also since been reported to be on the verge of signing a Memorandum of Understanding with the Zambian government that will see the country importing ethanol from the Chisumbanje Plant (Newsday, 28 May 2013).

A brief examination of the Zimbabwe's experience with biofuel programme shows a pattern which explains why most of these projects have unfortunately failed. For a sustained and viable biofuels regime programme to run successfully, it is of paramount importance that a country or region has resources to support the production and use of the fuel. Zimbabwe's programmes have largely been driven by reactive needs which have led to them being set up hurriedly resulting in a number of important factors being overlooked. Taking the 2005 biodiesel programme as an example, the country looked into the programme in response to severe fuel shortages prevailing at the time. While the government commendable realised the need to have a constant supply of the feedstock and hence setting up the out-grower programme, not enough resources were directed towards this. Eventually the crippling shortage of the plant led to operation at the production facility shutting down. The Green Fuels ethanol production project is also suffering as a result of improper planning. For example, the plant is producing ethanol without a readily available market. Having the mandatory ethanol blending policy before setting up the bioethanol plant would have saved millions of dollars and would have not led to the failure of the project as was seen. Moreover, the plant has been producing ethanol yet the country has not got the required blending infrastructure. The need for a clear constructive biofuels policy on the production and usage of biofuels in Zimbabwe has long been overdue. Karavina et al. (2011), report that while the biodiesel project began in 2004, there was never a legal framework which created an environment conducive enough to promote production, sale and use of biofuels. Beyond the production, it is also equally important that the necessary legislation be in place to support the research and development of biofuels in the country (Karavina et al., 2011). Currently, there is no such comprehensive documentation in place (Davison, 2011).

The Ministry of Energy and Power Development published the Zimbabwe National Energy Policy in 2012. The policy provides "interim" guidelines on liquid biofuels such as ethanol/petroleum blending targets of 20% by 2015 and 5% for biodiesel by 2020. The policy also highlights the need to use non-food feedstock, promote out-grower schemes and research on improving feedstock yields and processing technology. The policy unfortunately fails to address a major critical point concerning production which is the land issue. Companies which want to set up such projects will need vast lands and as such government should look into setting aside land for them. This is just one of the numerous gaps that the policy has failed to address. Failure to have a comprehensive policy document which conspicuously spells out on all the pertinent issues particularly on how biofuel production and usage will be encouraged in Zimbabwe simply means all future projects are bound to fail.

3. Importance of a Clearly Defined Biofuel Policy in Zimbabwe

Policies as explained by Corkery, Land and Bossuyt (1995) are of paramount importance to enhance progress in economic and social spheres. This has been evidenced by the development of policies for key sectors of government namely the economy, agriculture, health, national security etc. Governments across the globe have formulated policies that have guided their pursuit to meet certain needs of their citizens.

Implemented policies are binding laws between the government, businesses and the country's citizens. Policies are normally associated with supporting legislation, hence its formulation process is vital to address all the possible loop holes to avoid failures (Corkery et al., 1995). Policies made and implemented using a well thought out and planned framework are certain to result in governments achieving their objectives while the opposite can be said to be true. Due to the importance of the biofuels sector in the Zimbabwean economy and environmental impact, it deserves a clearly defined policy to enable its feasibility and sustainability in the current economy. Considering that the biofuel sector is only in its infancy in Zimbabwe, the need for the policy is even much greater as it will help grow the industry alongside the well established petrochemical industry. Taking such factors into consideration further echoes the need to level the playing field for the biofuels sector through policy

crafting that will enable it to manage sustained competitiveness and viable growth. In addition to supporting growth of this sector, policy will also aim to promote sustainable development in the biofuel sector by identifying and mitigating negative impacts that may arise as a result of production and usage of these fuels.

It then comes as not a surprise that the leading biofuel producing regions in the world have policies which support the sector. The USA has since 2007 been the leading biofuels producer and consumer of biofuels in the world (Lorne, 2011) having had accounted for close to 57% of bioethanol produced globally in the year 2010 (Moschini et al., 2012). Driven by fuel shortages in the past decades such as the OPEC oil export embargo, the Iranian revolution and the gulf war (Hammes & Willis, 2005), the USA began blending gasoline with ethanol since the 1970's. The biofuel sector has since then enjoyed a steady growth for which some federal policies such as subsidies and tax exemption have played a pivotal role (Tyner, 2008; Moschini et al., 2012). The past two decades has been punctuated by further drastic growth in the industry for which major policy changes have continued to play a critical role. The policy changes such as those made on the Clean Air Act in 1990, the Renewable Fuel Standard (RFS), outlined in the Energy Act of 2005, and the Energy Independence Act of 2007 (EISA), which created the RFS2, have propelled production increase of the industry (Figure 3) (Moschini et al., 2012; Lorne, 2011; Pires & Schechtman, 2009). The number of bioethanol producing plants has also increased from just fewer than 50 in 1998 to 204 in 2010 which has seen production increase from 1.4 (5.3 million litres) to 13.2 (50 million litres) billion gallons within that period of time (Lorne, 2011).

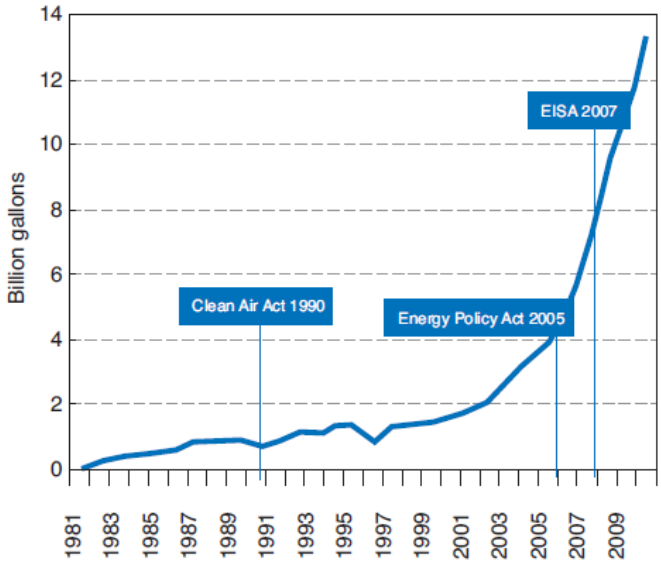

Figure 3. Trends in bioethanol production in the USA from 1981 to 2010
(Source: Adapted from Lorne, 2011)

Brazil was for the better part of the last century the major biofuel producing country in the world only to be eclipsed by the USA in 2007. Er (2011) reported that the major success behind the Brazilian biofuel industry has been a mandatory policy which from the start focussed on creating a local market, setting up the necessary infrastructure and the adoption of neat alcohol vehicles. Brazil has been blending fuel with ethanol since the 1920's and this intensified in the 1970's when it launched its National Alcohol Programme (Pro-Alcool) (Birur et al., 2008). The main driving force towards the launch of the programme was the global oil crisis in 1973 caused by the OPEC oil export embargo. Sugarcane, a relatively abundant source and at low cost at that time, was chosen as the feedstock for the programme. The government went further to support the production sector by ensuring a ready market for its product by the introduction of mandatory fuel blending, subsidies, tax incentives and also the production of motor vehicles and cycles capable of using ethanol blended fuels and pure ethanol (E100) (Medeiros & Froio, 2012). Despite the numerous challenges that included feedstock shortages and fluctuating crude oil prices, the Brazilian government remained focused and committed on the ethanol production programme which has seen the sector enjoying a relatively healthy growth as shown in Figure 4.

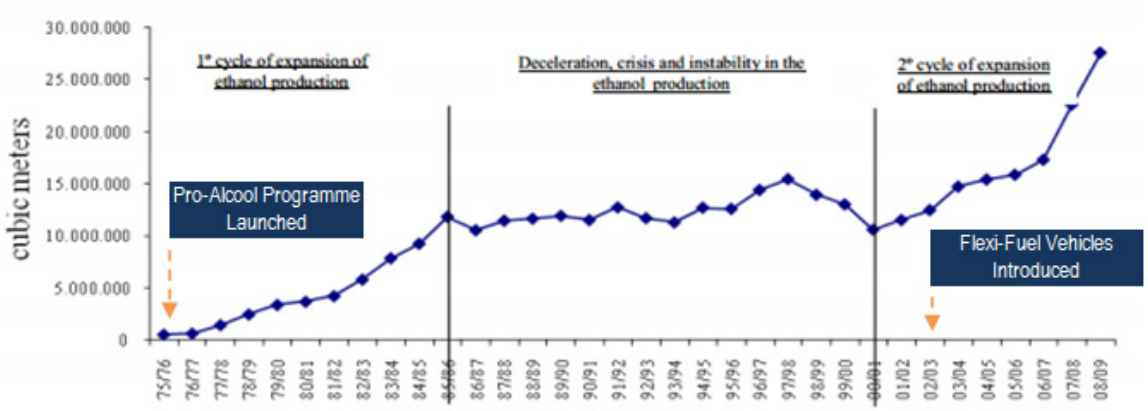

Figure 4. Evolution of total ethanol production in Brazil and the key aspects
(Source: Adapted and modified from Shikida, 2010)

Between 2000 and 2009 bioethanol and biodiesel production increased from 17.7 to 86.7 billion litres (Sorda, Banse, & Kermfet, 2010, cited in Medeiros & Froio, 2012). Flexi-fuel vehicles (designed to use either 100% ethanol, or petroleum or a mixture of the two) which have since replaced most of the neat fuel vehicles (designed to use only 100 % ethanol) in 2003 have grown from accounting for 3.7% internal total car sales to over 85% in 2007 in Brazil (Medeiros & Froio, 2012). This has ensured a continued demand and consumption of the produced ethanol which in 2007 was reported to have constituted 40% of fuel consumed in the country (Budny, 2007). Brazil is now looking into supporting and promoting the export of biofuels into the international market (Medeiros & Froio, 2012) which is already producing positive results as evidenced by the fact that it is currently one of the major exporters of bioethanol in the world having had contributed close to 70% of ethanol in global trade in 2008 (Bryant & Yassumoto, 2009).

The experiences from the leading biofuel producing countries provide a good in-site on the benefits of having a clearly defined biofuels policy in Zimbabwe. Brazil and the USA have had numerous challenges since establishing their respective programmes but have remained largely committed and as such have withered the storm. Some countries and regional blocks in the globe have formulated their own policies in trying to emulate these countries. These include China, India, Malaysia and the European Union respectively (Davison, 2011). In Africa, the leading producer of biofuels is South Africa which published its National Biofuel Industrial Strategy in 2007 (Letete & Blottnitz, 2010) while Mozambique published its strategic policies in 2009 (Schut, 2010). Zimbabwe has had genuinely sound drivers for it to have developed a sustained biofuels programmes in the past. Yet despite all these, it has been largely unsuccessful. However, having a clear defined policy to support the biofuels industry will enhance its sustainable growth and viability.

4. Issues That the Zimbabwean Biofuel Policy Should Address

A well formulated biofuel policy inventory needs to address two critical issues i.e. (i) the production of the biofuels (supply) and (ii) the laws governing their use (market and demand). In addition, other cross cutting issues may be addressed as well, which are directly or indirectly affected by either the production or utilisation of biofuels or both within borders of Zimbabwe. Figure 5 illustrates some pointers that are recommended to be addressed in the biofuel policy. These have been grouped under three sections; (i) production and supply, (ii) market and demand and (iii) some issues of concern.

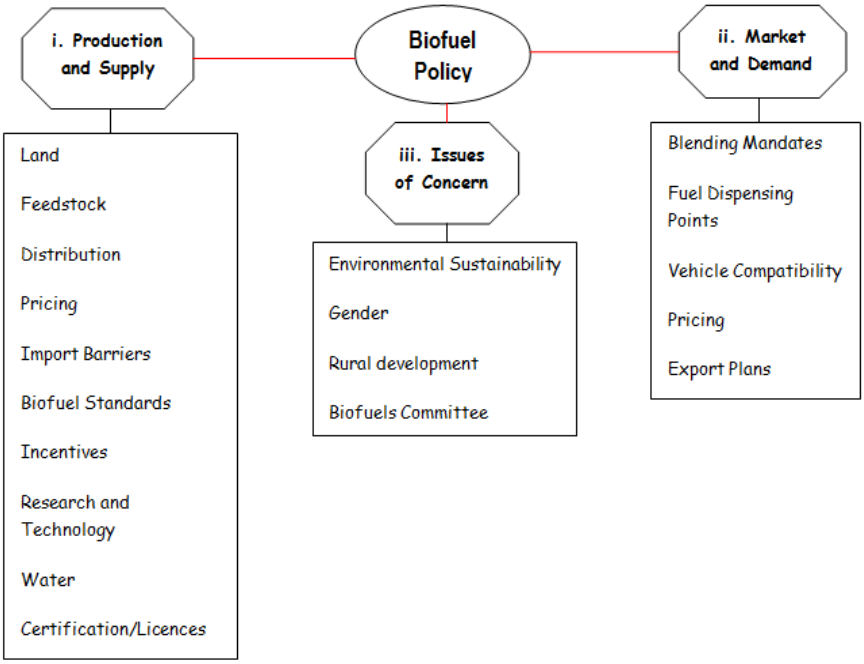

Figure 5. Inventory issues that need to be addressed in the Zimbabwe biofuel policy

4.1 Production and Supply

4.1.1 Land

Allocation of farming land is one of the most important assets needing prior planning for biofuels production considering that they are predominantly produced from plants. It therefore implies that Zimbabwe needs to allocate substantial amount of land dedicated to the production of raw materials of plants (Amigun et al., 2011). One reason why Brazil has a competitive advantage in the production of biofuels is that it has vast amounts of lands on which it can grow its major feedstock, sugarcane, on as reported by Birur et al. (2008). Brazil is currently only using approximately 1.5% of agricultural land for the cultivation of feedstocks used in biofuels production and this is projected will increase to 4% by 2030 (IEA, 2006). In Zimbabwe close to 1.36% of arable land is currently under sugar cane plantation with only 0.17% arable land having had been reported to be used for sugarcane for bioethanol cultivation (see Table 2) (Esterhuizen, 2012). The country has been reported by an official from the Zimbabwe Energy Council (which is an affiliate of the World Energy Council) to have close to 100,000 hectares (1000 km^2) of land that has been shown not to be suitable for food production that can be used for sugarcane plantations (http://www.worldenergy.org/news-and-media/local-news/interview-dr-liberty-mhlanga-chair-of-wec-zimbabwe/).

Table 2. Land under sugarcane plantation in Zimbabwe

Total Land Area in Zimbabwe	386,850 $km^{2\,(a)}$	% Land Area in Zimbabwe	% Arable Land in Zimbabwe
Total Arable Land	32,300 $km^{2\,(a)}$		
Total Land Under Sugarcane Plantation	440 $km^{2\,(b,c)}$	0.11	1.36
Total Land Under Sugarcane for Ethanol Production	55 $km^{2\,(c)}$	0.01	0.17

Source: [a]Retrieved from http://en.worldstat.info/Asia/Zimbabwe/Land; [b]Retrieved from Esterhuizen, 2012 and http://www.greenfuel.co.zw – Our Farmers; [c]Retrieved from Esterhuizen, 2012.

The impact of biofuel production, land and land use change has been a subject of major discussions right across the globe (Birur et al., 2008; Amortegui, 2012). Failure to address any matters of contention regarding allocation of land for biofuel feedstock production will in most circumstances result in either the use of land reserved for food crop production or that meant for the conservation of wildlife. This consequently may lead to shortage of

food for human consumption due to reduced yields and disruption of biological ecosystems. The scarcity for these agricultural products could result in an increase in their prices making them inaccessible to the poor communities.

One way of avoiding such a situation will be to set aside land which will be exclusively earmarked for the production of plants for fuel production. This sentiment has been echoed in many other studies. Antwi et al. (2010) recommended that from the total arable land, the land for the cultivation of energy crops be demarcated to ensure a clear separation to that used for food crop production in Ghana. Letete and Blottnitz (2010) also highlighted that the use of land owned by black emerging farmers and communal land for the purpose of biofuel feedstock production could lead to conflicts in South Africa and this is also believed to be the case in Zimbabwe. This has been one of the major hurdles that have affected the Chisumbanje Ethanol Project. Communal farmers who had been moved reoccupied their former land which Green Fuels was using to grow sugarcane. It has been reported that 1754 households were displaced from their communal lands to make way for the project with only 516 having had been resettled (The Herald, 21 September 2012). The Zimbabwean government has the task to identify the specific land which will have to be properly zoned and set aside for the cultivation of biofuel feedstock. The location and size of the land has to be explicitly shown to all concerned stakeholders. This will help in avoiding confrontational conflict on food versus fuels, more so in a country which relies substantially on the agricultural sector. The EU has taken note of this imperative matter and has set-aside limited arable land that is to be used for the cultivation of energy crops (Pelkmans, Govaerts, & Kessels, 2008)

The Zimbabwean government through its relevant ministries has to also indicate if it will provide land for free, on sale or short/long term lease to companies interested in setting up biofuels projects. As a way of ensuring compliance with regards to land use, it may become necessary to provide production licences to companies that are using properly designated land. There is a directly proportional relationship between the quantity of biofuel a state can produce and the size of land being cultivated. Ultimately this will put a cap on the amount of locally produced fuels that will be blended with ethanol. This is a factor that indirectly affects mandatory blends which must be factored into when setting up targets for blending.

4.1.2 Biofuels Feedstocks

Biofuels can be produced from a wide range of different feedstocks such as sugarcane, maize, wheat, rapeseeds, jatropha and sunflower (Von Maltitz & Brent, 2010). The choice of feedstock in the production of biofuels for a given country is governed by a number of factors. These include land availability, type and climate patterns. This is important as the land issue and equally attracts a lot of controversy. It is a matter which needs to be urgently addressed as failure to do so may lead to the depletion of crops available for human consumption. Considering that the major types of biofuels which are currently being produced are the first generation, government has to ensure that it crafts its biofuel policy such that unintended consequences such as food shortage and drastic increases in food prices are avoided. Limiting the amount of food crops that is directed towards fuels is one way that has been suggested in some reports and practised elsewhere. The USA has for example put a 15 billion gallon cap on the amount of bioethanol that can be produced from maize (Energy and Independence Security Act of 2007).

In Brazil the major feedstock for its bioethanol programme is sugarcane (Birur et al., 2008). The land and climate in the region support the growth of this crop very well. This therefore implies that there is constant supply of a feedstock for bioethanol production. To try and diversify its feedstock, the country has been looking into using baggase, a waste product produced in sugar processing, for the purpose of ethanol production. In the USA, maize accounts for 90% of ethanol produced (Birur et al., 2008). In an effort to promote the use of non-food feedstocks such as cellulosic material the RFS stipulates that a certain portion of its fuel blending mandates in the USA are reserved for them (Moschini et al., 2012). In Africa most countries use molasses as their main ingredient in the production of bioethanol while jatropha and oilseeds are predominant feedstocks used in biodiesel production (Table 3) (Amigun et al., 2011).

Table 3. Major biofuel feedstocks in African countries

Country	Raw material	Country	Raw material
Benin	Cassava	Niger	Jatropha
Burkina Faso	Sugarcane	Nigeria	Sugarcane
Ivory Coast	Molasses	Sudan	Molasses
Ghana	Jatropha	Swaziland	Molasses
Guinea Bissau	Cashew	Senegal	Molasses
Mali	Molasses	Tanzania	Molasses
Malawi	Molasses	Togo	Jatropha
Kenya	Molasses	Uganda	Molasses
Ethiopia	Molasses		

Source: Adapted from Amigun et al. (2011).

Different types of feedstocks will influence the final price of the biofuel produced (Figure 6). Of importance is to realise that volatile prices of feedstocks could lead to escalation of food prices in situations where a food crop is the major feedstock. It will become necessary for the Zimbabwean government to make decisions as part of policy on whether they would allow producer prices to be controlled by the market or fixed. However, some studies have shown that the SADC region can produce biofuels in sufficient quantities without compromising on food security and biodiversity (Takavarasha, Uppal, & Hongo, 2005). Another factor to consider when choosing a feedstock for biofuels production is productivity per given surface area and the biofuel yield per given quantity of the crop (see Table 4).

Table 4. Estimates biofuel crop yield conversion efficiency biofuel yield

Crop	Country	Biofuel	Crop Yield (Tonnes/ha)	Conversion Yield (Litres/ha)	Biofuel Yield (Litres/ha)
Sugar cane	Brazil	Ethanol	73.5	74.5	5 476
Sugar cane	India	Ethanol	60.7	74.5	4 522
Maize	USA	Ethanol	9.4	399	3 751
Maize	China	Ethanol	5.0	399	1 995
Cassava	Brazil	Ethanol	13.6	137	1 863
Cassava	Nigeria	Ethanol	10.8	137	1 480
Oil palm	Malaysia	Biodiesel	20.6	230	4 736
Oil palm	Indonesia	Biodiesel	17.8	230	4 092
Soybean	USA	Biodiesel	2.7	205	552
Soybean	Brazil	Biodiesel	2.4	205	491

Source: Adapted and modified from The State of Food and Agriculture, 2008 – Fao.org.

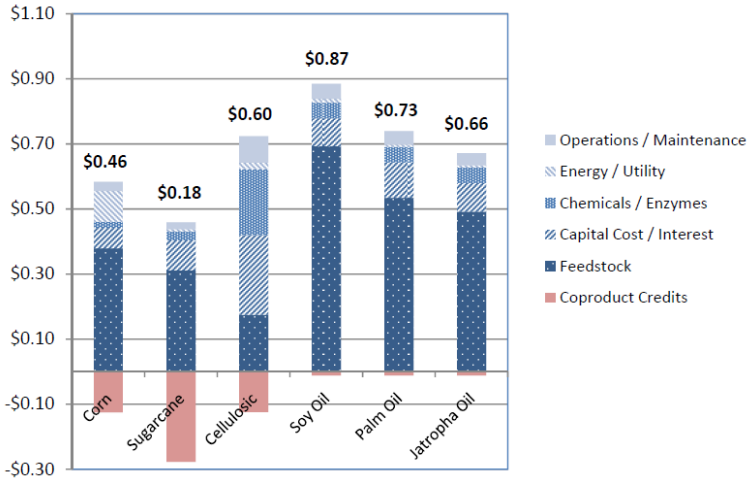

Figure 6. Biofuel production costs comparison in different feedstocks broken down to different subsections with co-product credits subtracted to produce net production costs for each individual feedstock per litre (Source: Adapted from BBI Biofuels Canada, 2010 – Asia Pacific Economic Cooperation)

Having had made a choice for the feedstock(s) the next important step is to ensure their sustained production and supply to the producers. The land issue plays an important part here. It is the responsibility of the Zimbabwean government to ensure that producers have access to adequate land for the cultivation of energy crops. Setting up of programmes run by government agencies and other stakeholders that will promote feedstock production is a possible viable option that deserves to be considered (Antwi et al., 2010). Zimbabwe has had such programmes in the past which were met with mixed success and challenges e.g. jatropha programme (Karavina et al., 2012). These can serve as case studies from which lessons will be drawn on what needs to be done correctly to ensure they are a success. Incentives and subsidies can help boost their production and subsequently that of biofuels (Antwi et al., 2010).

4.1.3 Distribution

This is a pertinent matter in the production and provision of biofuels. Even the world leader in biofuels production, the USA, has in the past taken note of the logistical implication issues regarding the distribution of biofuels could have on the expansion of the biofuels industry (Department of Transport White Paper, USA, 2010). The subject of biofuel distribution has been comprehensively discussed elsewhere in a report done by BBI Biofuels Canada (2011) for the Asia Pacific Economic Cooperation. The transportation has a number of cross cutting factors that it can influence. These include the final costs of the fuels, quality and environmental effects. BBI Biofuels Canada (2011) for example cite that the transportation of the produced fuels either to blending stations or distribution hubs can be costly and hence they recommend that it may be necessary to expand available transportation infrastructure to keep the costs low. There are several means of transportation of biofuels and these are rail, trucks, pipelines, barge and ship (BBI Biofuels Canada, 2011; Department of Transport White Paper, USA, 2010).

Trucks according to BBI Biofuels Canada (2011) are the most cost efficient under a distance of 500 km while rail is most ideal for distances of between 500km and 1500km. Pipelines are more convenient and cost effective for greater inland distances (BBI Biofuels Canada, 2011). In the USA the most predominant mode of bioethanol transportation is rail which caters for 66% while trucks and baggers carry 29% and 5% respectively (Department of Transport White Paper, USA, 2010). Pipelines are only used sparingly which completely differs with the distribution of conventional gasoline where it is utilised in the transportation of a substantial amount of the fuels.

Fuel blends of 15% and up to 20% of either petroleum or diesel can be transported using the same vehicles used for conventional petroleum fuels with minor modifications. However, eventually there is a limit at which they may need to be extensive changes needed to ensure the transport of higher fuel blends (BBI Biofuels Canada, 2011; Department of Transport White Paper, USA, 2010). This is mainly due to the highly corrosive nature of ethanol. High ethanol blends will require transportations tankers made up of resistant proof material. This has been the key reason why bioethanol has not largely used existing and cost effective pipeline transportation infrastructure in the USA (Department of Transport White Paper, USA, 2010). Biodiesel on the other hand presents fewer challenges and even significantly higher blends can be transported using the same infrastructure

used for conventional diesel fuels (Twomey & West, 2006). However, of importance is to note that biodiesel has a higher freezing temperature compared to diesel fuel and hence may require heating either during transportation or storage (Pereyra, year not given). From a quality point of view the major issue of worry is the affinity of ethanol towards water which is much greater than that of petroleum. This eventually will lead the carrying of suspended moisture to fuel systems. Moreover, too much water in the blend could lead to as much as 70% of the ethanol separating from petroleum a process called phase separation (Twomey & West, 2006).

The transportation and storage poses environmental and safety issues that need to be addressed. The difference in their chemical composition to those of conventional fuels implies that the type of pollution threat they pose is different. However, the environmental threat of pure ethanol and biodiesel is of less magnitude compared to that of the conventional fuels (Chauhan & Shukla, 2011). This is mainly attributed to the fact that both ethanol and biodiesel are easily biodegradable and thus can be removed from the environment easily before they cause any harm. However, they still are an environmental and safety hazard and as such they deserve to be treated and transported with caution.

4.1.4 Import Tariffs and Duties

Import tariffs play an important role in the nurturing and support of infantry stage industry such as that of biofuels (Funke, 2010). As the sector matures and becomes more competitive, these can be reduced and even wavered off completely (Funke, 2010). The USA and Brazil have both imposed tariffs. Brazil had their tariffs completely removed from an initial figure of 20% while the USA was set to reduce their own after 2011 from 2.5% and 54 cents to 45 cents per gallon (FAO, 2008, De Gorter & Just, 2010, both cited in Funke, 2010). In circumstances where domestic production is not sufficient enough to meet the required volumes to meet blending mandates, it may be wise such that some policy be crafted that it allows a certain amount of import fuels to come in with no adverse effects on local producers. Africa's leading biofuel producer, South Africa, has recognised the value of utilising biofuel tariffs and has in place tariffs of R3.17 per litre (Funke, 2010). The downside with import restrictions is that they are economically inefficient as they encourage limited competition amongst suppliers (Pires & Schechtman, 2009). In most cases the price for import products will be much lower than that of domestically produced fuels implying that consumers have to pay a higher price when they could have been paying for it at a much lower figure. It is the duty of the Zimbabwean government through the proposed Biofuels National Committee to set these tariffs and decide when to strategically alter them.

4.1.5 Biofuel Standards

Biofuel standards have a major role in safeguarding the integrity of the sector as well as protecting the end users of the product. This is done by way of outlaying, monitoring and controlling the quality of the fuels produced to ensure they are consistent. Quality of each product needs to be defined chemically precisely looking at the concentration of a given chemicals in them. Some countries have opted to adopt already established standards such as those developed by ISO and ASTM. However, it has been noted that such practice can be a problem especially for biodiesel (Antwi et al., 2010). This comes as those standards have been developed for specific feedstocks. The difference in the fatty acid composition of vegetable oils implies that biodiesel produced from different feedstocks will also vary and hence its quality will differ (Antwi et al., 2010). Zimbabwe has commendably taken note of this factor and as such worked with ASTM to craft biodiesel standards for fuels produced from jatropha (Antwi et al., 2010). The same procedure needs to be done for bioethanol as well. Organisations such as the Standard Association of Zimbabwe (SAZ) can play a leading role in setting and monitoring the implementations of these standards.

4.1.6 Incentives

Historically, incentives have provided the stimulus and supported the establishment and growth of biofuels industry in the major producer states (Pires & Schechtman, 2009). These incentives may come in the form of tax credits, loans (Pires & Schechtman, 2009), import wavers (Antwi et al., 2010) and long term land leases on which to cultivate energy crops. Tax incentives can for example make biofuels much less cheaper compared to fossil fuels hence making them competitive (Funke, 2011). The overall objective of these incentives is to provide motivation and at the same time cushion the burden of producing these fuels to potential investors (Pires & Schechtman, 2009). On launching its Pro-Alcool programme in the 1970's, the Brazilian government shrewdly put in place incentives that have made the programme the success and marvel it is today. For example, they made provision of soft loans to producers, guaranteed purchases of their produce by the state-owned Petrobus and they also fixed both gasoline and ethanol fuel prices with the latter selling at 59% the price of the former (Lovins, 2005). The USA followed a similar route. In 1978 they introduced a US$0.40/gallon stimulus subsidy established by the Energy Tax Act of 1978 and later increased to US$0.60/gallon through the Tax Reform Act of

1984 (Moschini et al., 2012). Having had played their role in helping get the industry established and competitive, these subsidies have since December 2011 been phased out (Moschini et al., 2012).

Taking lessons from the leading biofuel producing states, other countries are also resorting to the use of incentives in helping their industries grow (Table 5). Zimbabwe can look into crafting its own incentives as a way of promoting the growth of the biofuel sector in the country. Tax and fuel subsidies are some of the options worth considering as incentives.

Table 5. Biofuel incentives in some EU countries

EU Country	Tax Reduction
Germany	$ 2.30 per litre of biofuel
UK	€ 0.33 per litre of biofuel
France	€ 0.33 per litre of biofuel
Spain	Zero tax
Czech Republic	$ 383 per tonne of biofuel
Italy	$ 40 per litre of biofuel
Poland	45 cents per each litre of biofuel in blends containing from 2 to 5% biofuels 54 cents per each litre of biofuel in blends containing from 5 to 10% biofuels
Austria	Pure biofuels are exempt from mineral oil tax
Estonia	No excise duty on biofuels used as transport fuels

Source: Adapted from RFA (2005), cited in Antwi et al., 2010.

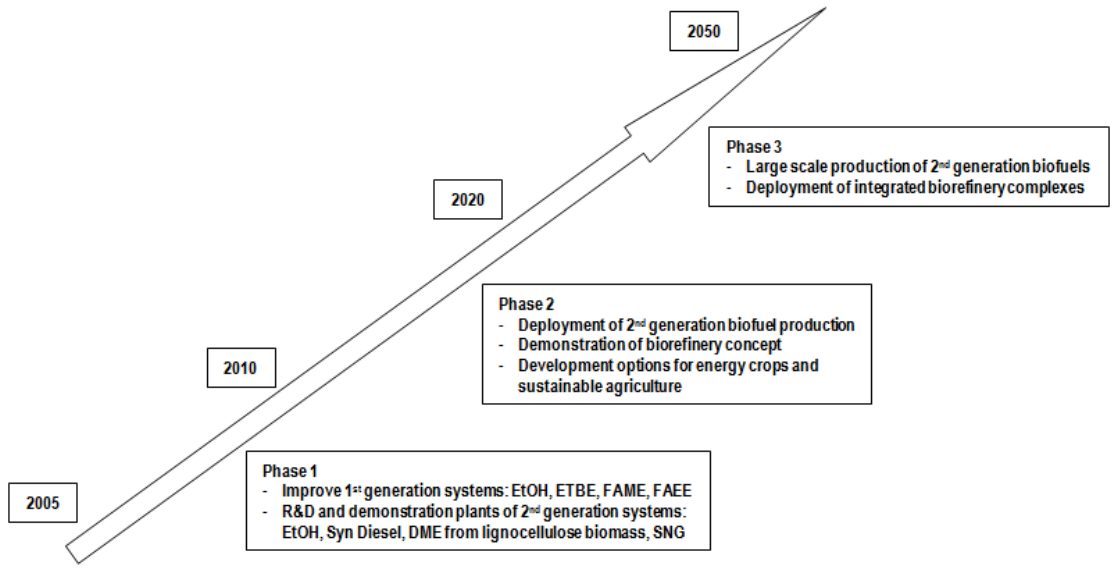

Figure 7. Anticipated development of biofuel feedstocks
(Source: Adapted from Von Maltitz and Brent, 2010)

4.1.7 Research and Technology

Research and development have been the pillar of the biofuels industry. Pioneering experimental work during the 1920's in Brazil successfully led to the construction of the first ever ethanol producing plant in 1927 in the State of Alagoas (USGA, 2000). Today the sector can be said to be a success largely to the contribution of research and development which led to the establishment of that first plant. As any infantry industry, the value of research can never be overemphasised and must be prioritised (Von Maltitz & Brent, 2010). The whole value chain needs to be thoroughly investigated so as to help optimise it and in so doing making it more competitive.

Research as stated by Von Maltitz and Brent (2010) can be centred on technology, agricultural activities, environmental concerns, social impacts and the overall economic contribution of biofuels. Technological improvements are prudent considering the value they can bring towards the use of non-food feedstocks such as waste cellulosic material (second generation biofuels) (Figure 7). Another area which has drawn a lot of interest is the use of by-products such as glycerol produced during biodiesel production and the use of bagasse generated from sugarcane.

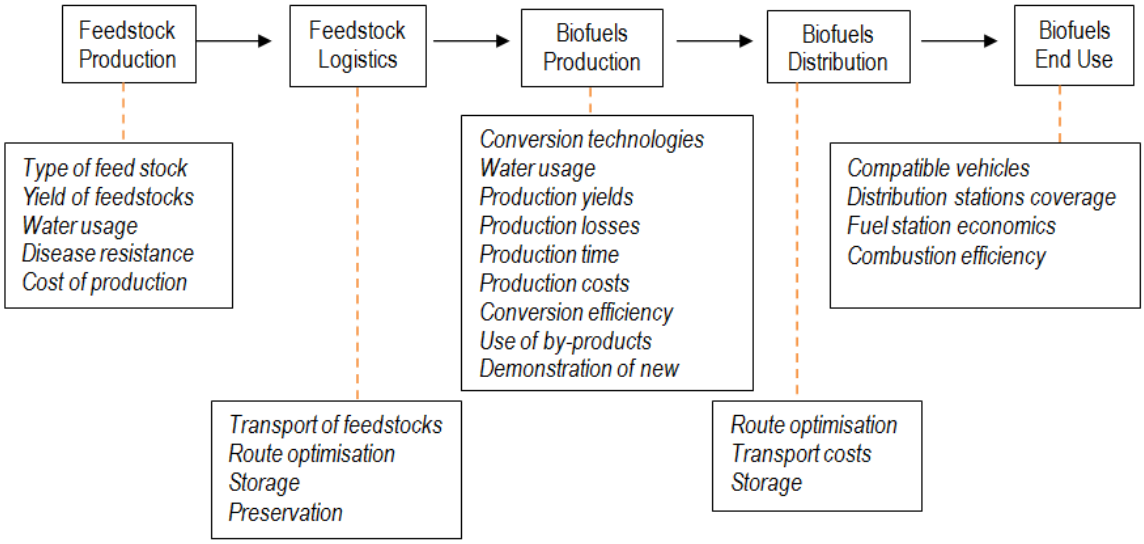

Figure 8. There exist a number of opportunities of research and development right across the value chain of biofuels

The research machinery that the USA possesses has and continues to be playing a pivotal role in the development of its biofuel sector. This has been done through the provision of research grants to some universities in the country by agents such as the United States Department of Energy. Other developing countries are taking lessons by incorporating research and development into their policies. An example is India which has a section on "Research Development and Demonstration" in their National Policy on Biofuels (Government of India, Ministry of New & Renewable Energy National Policy on Biofuels). Nigeria has in their draft National Biofuels Policy included sections establishing a research agency and also funding of biofuel research (Federal Republic of Nigeria, Official Gazette of the Nigerian Bio-fuel Policy and Incentives). Lessons could be drawn from such policies to suit the needs of Zimbabwe. Zimbabwe has a number of tertiary institutes which can be tasked into using research and development to improve the local biofuels sector. Funding can be made available through the Research Council of Zimbabwe (RCZ) as well other government departments. Private investors can be incentivised to fund research as well as a lot of Intellectual Property (IP) could be generated. Organisations such as the Zimbabwe Energy Council can also play a pivotal role in helping support research and development within the biofuel sector in the country.

4.1.8 Water

Considering the scarcity of water resources in Zimbabwe and the world over generally, the added pressure on them through their application in biofuel production is of major concern. Biofuels have been shown in some places to consume a lot of water (De, Giordano, & Yongsong, 2008) and thus measures must be put in place to safe guard water resources used by people from being channelled towards the production of energy crops in Zimbabwe. By far the greatest consumer of water in the biofuels value chain is the irrigation process done during feedstock production (Amigun et al., 2011) accounting for 90% of the total water used in the entire process (Mandil & Shihab-Eldin, 2010). Feedstocks may require as much as 500 – 2000 litres of water per litre of ethanol produced (Dominguez-Faus, Powers, & Burken, 2009). This ultimately leads to competition for water between the feedstocks and food crops or the so called "drink or drive" debates. Any effective control mechanism to manage water use will have to be focussed on the agricultural component of the biofuels production process.

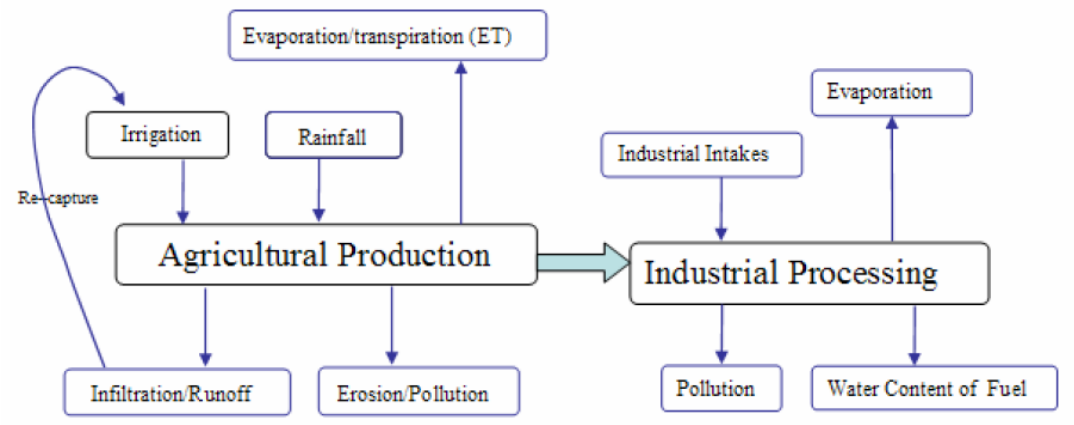

Figure 9. Use of water in Biofuels production
(Source: Adapted from, Sexton and Zilberman, 2008)

The Zimbabwean government will have the responsibility to craft its biofuel policy to ensure that water resources are protected. The South African government for example does not allow the use of irrigation in the production of feedstocks (Funke, 2010). The government is advised to enforce regulations on the amount of water utilised per litre of ethanol produced from a specific biofuel feedstock. The promotion and support of feedstocks with low water foot prints may need to be prioritised and strongly encouraged or incentivised. Jatropha is one plant that is seen as moderate water consumer which makes it an ideal feedstock candidate for Zimbabwe, the SADC region and other low rainfall areas (Amigun et al., 2011). Sterner measures may need to be employed in some cases such as payment of heavy penalties and cancelling production licences for producers who disregard laws governing water usage in biofuels production.

4.1.9 Certification/Licences

A clear licensing criterion is of utmost importance in ensuring that government enforces producers to ensure they are guided as to what it expects from them. This could include matters such as land to be used, labour laws, water sources, feedstock to be used, conformation to set biofuel standards, proper management of waste, support of local communities and blending amongst others. In trying to enforce the licensing issue, some countries have made it policy that fuel distribution stations only purchase fuel from licensed providers. This is general standard procedure which is practised in most countries the world over. Unfortunately, in some cases some stringent licensing regimes have been noted to be stifling development of the sector. One such example is South Africa as highlighted by Funke (2010). There is hence need for a balancing act by crafting policies that will serve to control the producers while also not impeding on the development of the industry.

4.2 Market and Demand

4.2.1 Blending Mandates

Fuel blending entails the mixing of conventional with alternative fuels in varying quantities. An example is E5 blend which consists of 95% petroleum mixed with 5% ethanol. Mandatory blending is one effective way of generating a market for biofuel produced. These serve to guarantee a market for producers. They have been of tremendous value to the leading biofuel producing countries in helping grow their biofuels industry. In setting up these mandates, the Zimbabwean needs to take stoke of the capabilities of local producers to meet the volume requirements for the blends. Alternatively contingency measures may need to be put in place to help meet the mandates such as drafting policies that make it easier for the importation of the biofuels. In some countries the practise is such that these mandates are not constant and can be revised by either reducing or increasing them from time to time as guided by projected outputs of biofuels to be produced and estimated annual fuel consumption. In the USA, the Environmental Protection Agency (EPA) has the responsibility of setting these mandates every year (Moschini et al., 2012). To help enforce that suppliers do adhere to the set blending targets, the EPA employs the Renewable Identification Numbers (RIN's) system. Brazil has been utilising these mandatory blends since the introduction of the Proalcool programme and the targets have been largely oscillating between 18 and 25% in recent times (Mapa, 2012, cited in Amotegui, 2012).

Zimbabwe has had fuel blends since the 1980's but these have not been mandatory. In February 2013 a 5% mandatory blend for ethanol was set by government but will only be implemented when the country's sole

ethanol producer resumes production. It's strongly advised that government needs to have in place a responsible body which will on a yearly basis calculate and set these targets. Without these mandatory blending mandates in place, the biofuel sector will certainly struggle and eventually collapse.

4.2.2 Fuel Dispensing Points

Ultimately the produced fuel will need to be sold and dispensing points are there to serve this purpose. There are a number of factors which come into play in helping retail stations sell biofuels. These include the temporary storage of the fuel and its dispensation into vehicles. Considering the corrosive nature of ethanol, there may be need to install new storage tanks or retrofitting ones already in place (BBI Canada, 2011). This comes at an extra cost to the service station owners which may be prohibitive. Consequently, there develops a bottle neck in the whole value chain. It is of no use to have companies producing say 30 000 litres of E5 per month for a market which needs exactly that volume per month when service stations can only dispense 15 000 litres per month when fully operational because of limitations such as lack of storage tanks and compatible pumps. To try and avoid such circumstances, government may need to assist service stations to either install new tanks and pumps or retrofit the currently existing equipment. These could be in the form of subsidies for the required equipment or low interest loans. The spatial distribution of service stations with capabilities of selling blended fuels must be well planned to ensure all areas are adequately covered. With sufficient dispensation stations in place, the flow of fuels in the system should be smooth which in turn will further fuel more development and growth of the sector.

4.2.3 Vehicle Compatibility

Due to the corrosive nature of ethanol, some vehicles are not capable of using ethanol blends higher than 15%. The introduction of flexi-fuel vehicles has come as major boost in supporting the industry. Since the inception of the Pro-Alcool programme the Brazilian government incentivised the development of 100% only ethanol vehicles. However, due to ethanol shortages suffered during the 1987 due to economic problems in the country, vehicle owners could not use their cars which led to a drastic decline in their sales. The year 2003 was to see the introduction of flexi-fuels in the country which now account for close to over 85% car sales (Medeiros & Froio, 2012). Its impact has been positive leading to an increase in the volumes of ethanol sold (Figure 10).

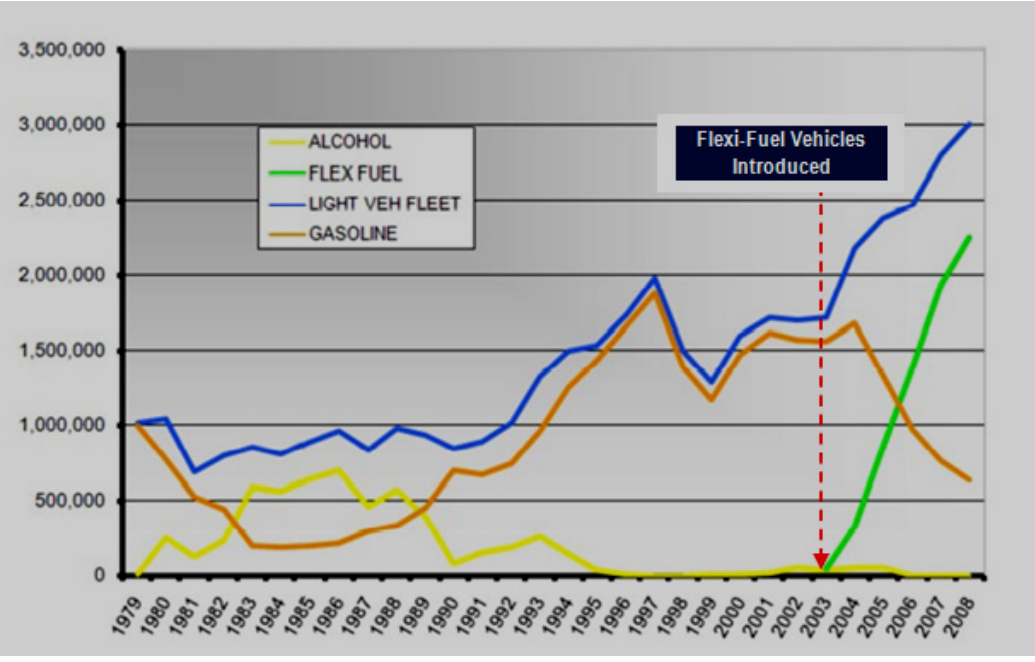

Figure 10. Sales of Bioethanol and Flexi-Fuel Vehicles in Brazil
(Source: Adapted and modified from Torres et al., 2011)

There are no differences between the prices of petrol-only and flexi-fuel vehicles of the same model (EPA, 2010). Taking this to account the Zimbabwean government can assist by charging less import tariffs for flexi-fuel vehicles coming into the country. This will go a long way in helping increase demand for both low and high blends of the fuels hence allowing it to grow and become sustainable. Government can also play a part by making it mandatory for all its different departments to only procure flexi-fuel vehicles as part of their fleet. They may also be need to train artisans in the country who eventually will service these vehicles locally for the convenience of car owners. Subsidies can be put in place to help retailers source car parts needed for this brand of vehicles.

4.2.4 Export plans

Policies need to be put formulated in cases where local production capacities exceed demand. This includes for example ensuring the ease of exporting to either regional or global markets. This can also extend to help promote development of markets within the region by action such as lobbying for blending mandates right across the region.

4.2.5 Pricing

One of the reasons behind the success of the Brazilian biofuels programme can be attributed to that the price of ethanol was fixed at 59% below that of gasoline petrol by government (Lovins et al., 2005). Such competitive prices will tempt consumers to shift to biofuels. Governments have the task to craft pricing policies to help subsidise fuel ethanol production. As the sector grows becoming more competitive, these could be reduced gradually and eventually completely removed. The conventional fuel sector is well established which makes it difficult for biofuels to compete with it. Introducing these price controls could play a vital role in helping it grow.

4.3 Issues of Concern

4.3.1 Environmental Sustainability

Considering its infancy, the environmental effects of biofuels are not as widely documented as those of conventional fuels. While undoubtedly enjoying a greener foot print compared to fossil fuels (as judged by their net reduction of GHG's), their production and use could have negative environmental impacts. These range from clearance of forests to make fields for feedstock cultivation, land degradation, use of water in irrigation, (WWF, 2007) and biodiversity losses (see Gasparatos et al., 2012 and references cited). With these concerns in mind, the need to have policies that incorporate environmental issues has been recommended in other studies (Gasparatos et al., 2012). In developing biofuel policies, responsible authorities need to take stoke of the whole value chain identifying any possible environmental impacts they may have. They will then put in place measures that will prevent or swiftly mitigate any negative effects caused by biofuels as well as ensuring compliance with the Zimbabwe Environmental Management Agency (EMA) statutes.

4.3.2 Gender

As with any industry, matters of gender balance are of great importance and as such must be incorporated into biofuel policy. The Zimbabwean government has a section in the National Energy Policy which addresses matters regarding gender. The biofuels policy should be no exception. The role of women in all projects must be encouraged. Different strategies can be adopted as outlined in the National Energy Policy. These include having in place a coordinator within the Ministry of Energy and Power Development who shall be fully committed on ensuring incorporation of gender issues in the industry, developing gender sensitive budgets and promotion of representation of women on all levels of the sector. Monitoring and evaluation will be required to check if such policies will be followed within the sector, failure to which the responsible authorities will be penalised.

4.3.3 Biofuels National Committee

To have a well coordinated biofuels programme, there is need to have a specific institute or committee that will foresee the daily running's of the industry. Some biofuels programmes in the past in Zimbabwe have been reported to have failed due to poor coordination (Karavina et al., 2011). Their roles and functions need to be explicitly spelt out while at the same time they may be need to put in place legislation that empowers them in enforcing their duties. Care should be also taken in identifying individuals who will constitute the committee. Ideally we would suggest such a committee should include people who adequately represent the whole value chain of the biofuel industry.

4.3.4 Rural Development

The development of livelihoods of rural people is one of the strongest drivers of biofuels programme in Zimbabwe and the rest of Africa (Gasparatos et al., 2012). The development of biofuels is seen to largely present opportunities that could result in the status of rural people being uplifted. However, while this potential of the bio-economy has been noted, it has been reported most have fell short in identifying exactly how communities can benefit from the process (Kleinschmit, 2007). Considering that the major feedstock in the production of biofuels is currently crops such as maize and sugar cane, small scale farmers can benefit by taking part in out-grower schemes. A major biofuel producing company will have the responsibility of identifying and giving contracts to local small scale farmers as their suppliers. To enforce such policy, government will need to give production licences to companies willing to abide to such schemes. Monitoring and evaluating to see if companies comply will need to be done. Where it is seen that the concerned company is not in compliance the production licence can be cancelled.

Other means in which rural people can benefit is by way of giving local communities partial ownership of the company as suggested by Kleinschmit (2007). Kleinschmit (2007) further recommends that states can assist small scale farmers to set up their own ethanol processing plants, provide with start up capital, subsidies and technical training assistance. While putting up policy to help rural people enjoy the benefits of biofuels, there is need for a balancing act as the sector could also leave them worse off. This by way of increased demand for the fuel crops which ultimately could lead to sharp food increases beyond the reach of most rural people.

5. Formulation Process

To come up with a well formulated policy that caters for every component of the whole value chain, there needs to be an extensive consultation process. Relevant stakeholders must all take part in it. The onus is on the relevant ministries to identify who are these stakeholders and at what level should they be consulted. Relevant ministries such as Energy, Science, Agriculture, Finance and other stakeholders shown below will have to be part of the process (Table 6) looking from a Zimbabwean perspective. Other stakeholders of importance are the farmer unions, the oil companies, Zimbabwe Energy Council, car manufactures and fuel consumers (Table 6). Having had done all the proper consultations, an implementation plan such as the one given in Figure 11 can be adopted. Of importance is to note that no system is perfect and hence lessons must be drawn from all failures identified, corrective measures taken and an improved plan implemented. Monitoring and evaluation will play a vital role in the smooth operation of the whole programme and must be prioritised.

Table 6. Institutional framework for biofuels policy development

Public Sector	**Quasi-Government**	**Private Sector**
Energy	Industrial Development	Petroleum Companies
Agriculture	Corporations	Car Manufacturers
Environment	National Investment Centres	Seed Companies
Science and Technology	Research Councils	Automobile Associations
Natural Resources	Licensing Authorities	Petroleum Councils
Forestry and Water	Academic Institutions	Engineering Companies
Industry and Trade	Agro-Industrial Parastatals	Farmers' Unions
Finance	Cooperative Sectors	Biofuel Producers/Association

Source: Adapted from Takavarasha et al. (2005).

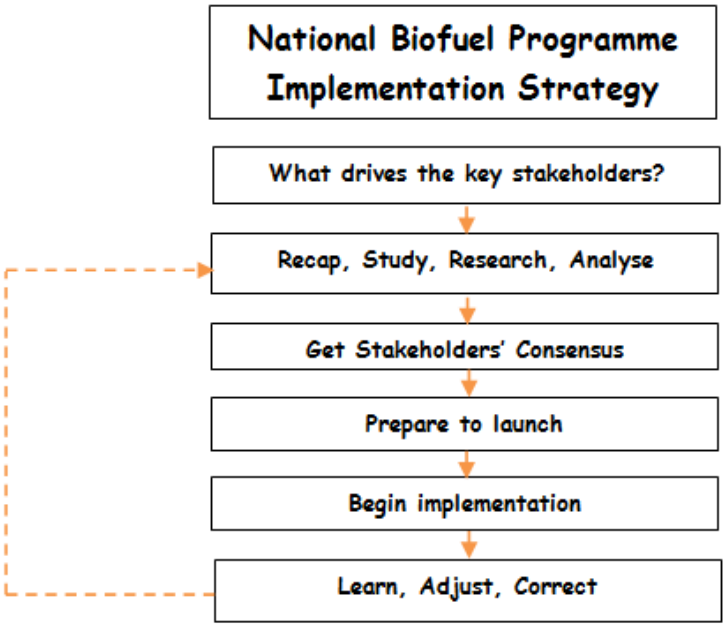

Figure 11. A strategic plan that can be adopted in the implementation of the biofuels programme in Zimbabwe (Source: Adapted from Trindade, 2000)

6. Conclusion

The current study has presented a summary of Zimbabwe's history in biofuel production highlighting major factors that led to the pursuit of the projects and also identifying possible reasons that led to their failure. The lack of a biofuel policy has been cited as the main reason why these projects have not lasted. As a matter of urgency, we do call upon the Zimbabwean government to craft a policy for the biofuel sector to help it grow in this highly competitive industry. The first step would be to have a Biofuels National Committee that would be tasked with identifying major issues that it needs to address. This committee will have to also carry out a nationwide stakeholder consultation, incorporate ideas coming through and finally develop the national policy and implement the programme. It is of a paramount importance that the policy adequately addresses issues of concern for both the supply and demand sides of the industry. Cross cutting issues such as rural development and water usage must not be overlooked in the policy. Finally after implementation of the biofuel policy, monitoring will need to be done so as to identify and address any of its short comings.

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