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BIOFUEL – OPPORTUNITIES AND CHALLENGES FOR THE POOR IN CAMEROON

What can Cameroon learn from Brazil and South Africa?

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Abstract

Ever since the shell geologist M. King Hubbert came up with his prophesy predicting the depletion of peak oil (regarded as "Hubbert peak" in the 1940s and 1950s), several countries in the world including Brazil, Sweden and the United States of America have been looking for alternative energy means with more emphasis on renewable energy such as bio-energy. The emphasis on bio-energy which to a large extent involves the use of energy crops to fulfil global energy demand and to establish a renewable energy system has resulted in debates where questions are raised regarding the clash between the use of land for food production for human consumption and land for energy production. Other question raised relate to the impact bio-energy will have on the poor most especially as it is 'linked' to rising food prices.

Cameroon is a country rich in natural resources and also has rich oil potentials but most of the rural areas are map out of energy systems and this pose a development problem among others. This study seeks to investigate what impact biofuels can have on the poor as well as the benefit Cameroon can have if engage on biofuels as an alternative means of energy. A livelihood approach was used to understand the strategies which poor rural people use to make a living which in this case centred in agriculture. Embodied Energy Analysis was used to evaluate the energy requirements involved in the production of biofuels and Emergy Synthesis (ES) method was used to further show the extent to which biofuel production depends on humans and the environment.

Keywords: Agriculture, Biofuel, Cameroon, Development, Emergy, Energy, Food, Land, Production, Renewable, Rural people.

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Dedication

This piece of work is dedicated to the Almighty God, the giver of all academic inspirations and successes, and through whose guidance, love and care, I have produced this thesis.

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Abbreviations

- CDC: Cameroon Development Corporation
- DME Department of Mineral and Energy
- EEA: Embodied Energy Analysis
- EMR: Emergy Money Ratio
- ES: EmergySynthesis
- ESI: Emergy Sustainability Index
- EU: European Union
- FAO: Food and Agriculture Organization
- GDP: Gross Domestic Product
- LHV: Lower Heating Values
- NEAD: National Environmental Accounting Database
- NEV: Net Energy Value
- NGO: Non Governmental organization
- SA: South Africa
- UN: United Nations
- US: United States of America

Chapter one: Introduction

1.1 Clashes in Biofuel

Biofuel has generated an intensive discussion in the past several years due to the changes in the world energy situation. In November 2008, Brazil organised an "International Biofuels Conference" involving officials from 40 countries and their mission was to discuss on issues of biofuels in relation to development, food security, trade and climate change (www.physorg.com). Also, Winrock International India (WII) has been organizing successive International Biofuels Conferences with the 6th in 2009 where deliberations were made on the current biofuels scenario, identifying the need to set a road map for future sustainability by looking at the positive and negative impacts biofuels could have on the agricultural sector (WII, 2009). There have also been several discussions at the level of the universities in the world. In 2009, American University in Washington, DC organized a Collective Biodiesel Conference to discuss on issues of compatibility concerns and sustainability standards in biofuels policy (Collective Biodiesel, 2009). Also in 2009, a biofuel seminar was organized at the Swedish University of Agricultural Science (SLU) Uppsala by the research school of Global Natural Resource Management and Livelihoods (NRML) where Dr Yona Baguma discussed about the production of ethanol from non-food parts of cassava (NRML, 2009). Other organizations such as the International Food Policy Research Institute (IFPRI), Food and Agriculture Organization (FAO), Overseas Development Institute (ODI), etc have been involved in the biofuels discussions. Climate change has been a contributor to the intensive discussions on biofuels, this is because of the possible contribution of biofuel in reducing greenhouse gas emissions by the transport sector, which is the major growing contributor to the greenhouse gas emissions (von Braun and Pachauri, 2006: Bissou, 2009). In 2009, the Climate Conference in Copenhagen (Kyoto protocol Copenhagen) which brought together governmental representatives from about 170 countries, NGOs, journalists and others; making up an approximate 8000 people who attended the conference with the aim of renewing the climate agreement (Copenhagen Protocol) to prevent global warming and climate change (Borgen, 2009). In order to prevent global warming and climate change, biofuels to an extent has to be considered as an option and this has resulted to a continuous discussion because of the complexity surrounding the development of biofuels (Borgen, 2009). Biofuel, such as bio-ethanol and biodiesel come directly from plant material such as maize and jatropha respectively, and this has created a strong bond between agriculture and biofuel.

The nature and strength of this bond or relationship has changed over time and has resulted to different categories of debate.

Those in favour of biofuel development like von Braun and Pachauri of International Food and Policy Research Institute (IFPRI) argues that biofuel has the potential to provide economic development within a community or rural livelihood as well as promises a source of environment-friendly energy that would also be a boon to the world's farmers (von Braun and Pachauri, 2006). Biofuel production can possibly affect food security both at national and household levels through it influence on the prices of food and incomes, thereby enabling more people to have sufficient income to be food secured (FAO, 2008b; IEA, 2008). Other researchers who are also in favour of biofuel development such as Maltitz and Brent argue that biofuel increases the energy security and thus helps in development especially in rural areas (Maltitz and Brent, 2008). At the local or rural level, biofuel could provide a large number of rural job opportunities. For example, it has been estimated that approximately 55,000 jobs could be created in South Africa to meet a 4.5 % blending target (NBTT, 2006; The DME, 2009) while in Mozambique it is estimated that over a million jobs could be created if they were to commit 3,379,000 hectares to biofuels production (Econergy, 2008). A general argument in support of investment in biofuel production is that biofuel investments could contribute to rural economic growth, employment and poverty reduction (Raswant et al., 2008)

The Swedish Government also supports the production of biofuel with its objective on energy policy being to secure a reliable supply of electricity and other forms of energy at international competitive price (Swedish Government, 2004). According to the Swedish Government, "the expansion of biofuels to a large extent has come about through an ambitious policy on renewable energy and the Swedish Government is determined to pursuing this policy; investment in bio-energy will contribute to a secure and sustainable energy supply as well as growth and job creation" (Swedish Government, 2004). The Brazilian President Luiz Inacio Lula da Silva said "it is a myth" that the production of ethanol increases food prices and that he will continue to fight for biofuels (Xinhua, 2008). According to the President of the United States of America, Barrack Obama, biofuel should be promoted because he regards it as a clean energy and can also generate jobs (Green Car Advisor, 2010).

Despite all these advantages, the development of biofuels has resulted in a lot of debates. Arguments resulting from biofuel changes as new information are been introduced as well as interest of different stakeholders are brought into play. Biofuel can be seen as a 'Pandora's box' (a source of many unforeseen troubles) regarding the risks and difficulties associated with biofuel development and questioned whether large-scale biofuel development can be environmentally, socially and economically sustainable and efficient (Peskett et al., 2007). On a Special Report from 'the International Forum on Globalization and the Institution for Policy studies', Barbara argues by questioning the net energy of biofuel. Barbara suggested that a desirable energy should provide more energy than it takes to produce it, according to Barbara it is not exactly the case in biofuel (Barbara, 2007). He also questions whether ethanol or any other combination of agro-fuels can provide the benefit extolled by so many supporters (Barbara, 2007). Rising food insecurity is anticipated as a result of biofuel development and expansion, especially as large tracts of land are used for biofuel rather than for food crops, with possible negative impacts such as hunger and starvation on the rural poor people (Runge and Senauer, 2007).

Biofuel development could place an additional pressure on the natural resource base, with potentially harmful environmental and social consequences especially for people who already lack access to energy, land, food and water (FAO, 2008b). The global levels of hunger continue to rise and the number of people suffering from hunger has increased to 845 million people (Special Rapporteur, 2007). Also the Special Rapporteur further reports that biofuel is one of the main causes of this food crisis, the sudden ill-conceived rush to convert food such as maize, wheat, sugar and palm oil into fuels is a recipe for disaster (Special Rapporteur, 2007). Biofuel has therefore created a battle between food and fuel that will leave the poor and hungry in developing countries with more problems such as rise in food prices, land and water. Although Cameroon is not recognised as a "hot spot" when it comes to food crisis as compared to Chad, Niger and Sudan; some regions especially the three Northern Regions of Cameroon face serious food problems (USAID, 2003).

The world's total primary energy demand amounts to 11, 400 million tonnes of oil equivalent (Mtoe) per year (IEA, 2007); biomass which includes agricultural and forest products such as biofuel and organic waste residues accounts for 10 percent of this total. The sources of primary energy differ across regions, in Africa and other developing countries; more than 90 percent of the total energy consumption is supplied by biomass (IEA, 2007). Fossil fuels are the dominant source of primary energy in the world and it accounts for 77 percent of the demand increase in 2007-2030 (IEA, 2009). The global energy use fell in 2009 because of the financial and economic crisis whereas the world primary energy demand had increased by 40 percent than the rate in 2007 (IEA, 2009).

Cameroon has also developed some interest in the biofuel sector with the aim of exploiting the opportunities involved in biofuels (Pibasso, 2010). Cameroon produces crops such as maize, sugarcane, palm oil, cassava, sunflower, groundnuts and non edible plants such as Jatropha and eucalyptus which can be use for the production of biofuels (Binyuy, 2007). An NGO called GREENERY is working with communities in the Northwest Region of Cameroon to promote the cultivation of jatropha by providing technical assistance to farmers who are being supplied with seedlings for planting (Binyuy, 2007). Biofuel produced from jatropha can be use to run simple diesel engines. GREENERY also provides employment opportunities to villagers in the community (Binyuy, 2007). The cultivation of palm oil and its industrial transformation is carried out by three companies (SOCAPALM, SAFACAM and Firm-Switzerland Company) controlled by a French group Bolloré (Pibasso, 2010). The palm oil produced by these companies in Cameroon can also be use to produce biofuels. The director of Agro Energy Department (AED) in France has visited Cameroon a number of times to encourage the local authorities about the possibility of developing biofuel sector and also to diversify the potential source of biomass to produce electrical energy (Pibasso, 2010).

1.2 Objective and Research Questions

The main objective of this thesis is to investigate the social and economic impacts that could be associated with the development of biofuel in Cameroon. This study will focus on liquid biofuel (Bio-ethanol and biodiesel) with emphasis on the interconnections between the social, economic and the environmental impacts. It will also focus on food and energy with emphasis on how they can be affected with the development of biofuel. In relation to the concerns and problems raised above and the objective, the study intends to explore the following research questions.

- How is biofuel development going to affect the rural poor people in Cameroon, in terms of food security and poverty from the examples of some developing countries such as Brazil and South Africa?

- Is biofuel beneficial economically to Cameroon?

- What lesson can be learned to improve the living standard of the rural people in Cameroon with respect to biofuel?

1.4 Thesis Outline

This study endeavours to provide answers to the questions raised above; as a result the author decided to structure the paper as outlined below.

Chapter two of the study introduces the methodology employed for this work. This chapter also describes the study area, Cameroon.

Chapter three will contain the literature review in which the definition and concept of biofuel will be look upon in depth. Further in this chapter, the ethanol production process and the energy required for the entire process will also be looked upon.

Chapter four presents the study results which will be based on how biofuel development will affect the rural poor people with respect to job creation, land access, environmental pollution, poverty reduction and energy security in Cameroon. This chapter will also go further to deal with the issues regarding the economic benefits of biofuel with regards to international trade where emergy/money ratios (EMR) will play a great role.

Chapter five presents the discussion. The discussion includes agriculture and food in Cameroon, energy security and the flow of benefit in terms of emergy/money ratio.

Chapter six deal with the conclusion of this study.

Chapter Two: Methodology

2.1 Materials

The materials of this study was based on secondary sources which included books, articles, reports and official documents from the Cameroon press which were relevant for making my arguments. Cameroon is a country where biofuel development is at its primary level and very limited research work has been carried out in this sector. The materials used in this study carried information with examples from major countries that are involve in biofuel production, mostly the United States and European Union for the developed nations and Brazil and South Africa for the developing countries. This is because, the impacts associated with biofuels is mostly common especially within countries that fall in the same economic level (developing or developed countries). Although Cameroon and South Africa (SA) has some differences in their agricultural, economic and energy resources, this study used South Africa as an example because of it geographical position and also to explore reasons for its advancement (the SA experience can be of importance for Cameroon to explore). The study also used Brazil as an example because of its position in the biofuel sector and also because of its experience and history in the production of biofuel. The examples from the above countries will portray the kind of situations Cameroon can get into if biofuel development is projected and promoted. The statistics used at the result section of this study will go right back from mid 1990s to 2010, this is to allow a wide range of analysis and to understand the trend of growth within the above period of time. The concept of emergy will be used on Cameroon's national resource basis and also on the flow of benefit to evaluate the trading between Cameroon and other nations such as South Africa and France.

2.2 Methods

This study aims at evaluating the impacts associated with biofuels which directly or indirectly affects the lives of people especially the rural poor people. Therefore, a Livelihood Approach will be use because it is a method of thinking that incorporates the identification of the impacts associated with the vulnerable – in this case biofuel. Secondly, an Embodied Energy Analysis will be used to give an account for the use of commercial energy in the production process (Macedo, 1998; 2007; Börjesson, 2009 cited in Rydberg and Cavalett, forthcoming). Finally, an Emergy Synthesis Method, a tool that includes the environment and humans as well as their work needed will be used to give an account on more aspects of the production system energy and performance (Franzese et al., 2009). Biofuel is a broad concept which has so many branches and different people depending on their socio-cultural, economic and political status perceive the development of biofuel from different angles. This makes it difficult to give a clear cut and convincing method to handle biofuel related situations. A huge amount of natural resources and functions important to life are not given the proper assessment in the methods used to evaluate bio-energy systems (Rydberg, 2008). EEA method for example, does not give a total account of all the materials involved in the process; it only considers materials which have commercial values.

2.2.1 Livelihood Approach

Livelihood comprises the capabilities, assets, and activities required for a means of living (Chambers and Conway, 1992: 7). Livelihood directs attention to the links people have between assets (stores, resources, claims and access) and the options in practice to pursue alternative activities that can generate the income level required for survival (Ellis, 2000). Livelihood Approach also facilitates the identification of practical priorities for actions which are based on views and interests of those concerned. It makes a connection between people and the overall enabling environment that influence the outcome of livelihood strategies (Serrat, 2008).

2.2.2 Embodied Energy Analysis

The International Federation of Institutes for Advanced Study (IFIAS) defined Embodied Energy Analysis (EEA) as “the determination of energy required directly or indirectly in the process of making a good or service within a framework of an agreed set of conventions” (IFIAS, 1974). It also accounts for the amount of commercial energy needed directly or indirectly for making a good or services (Ulgiati et al., 2006). The commercial energy involved in embodied energy analysis is regarded as all the kind of energies that require technological processing as well as energies that can be sold at market prices due to the processing needed (Rydberg and Cavalett, forthcoming). Examples of commercial energies are fossil fuels, nuclear and electricity. Free environmental services and direct renewable are not regarded as commercial are not accounted for (Franzese et al., 2008).

2.2.3 Emergy Synthesis

This is a method which can analyse how much an activity or product depends on its environment and economical processes, it has the potential to link both the ecological and economic systems. The emergy methodology goes beyond classical and energetic in recognising different forms of energy, it acknowledges the energy of one form such as sunlight or rain used to produce other forms of energy such as a plant product (Lefroy and Rydberg, 2003). Solar emergy referred to as the available solar energy used up directly or indirectly to make a service or product, expressed as solar emjoules, is the basis for evaluating all flows, storages of energy and materials used in the process of producing a product such as bio-ethanol. The capacity to also analyse non commercial materials makes

Emergy synthesis a more comprehensive tool for analysis compared to embodied energy analysis.

Emergy synthsis can also be used to analyse trade between different nations. It is assumed that international trade agreement based on market prices are fair whereas market prices represents only the work that human beings have contributed leaving out the work which nature has carried out to create and form raw materials (Cuadra and Rydberg, 2006). Therefore international trade of raw materials with the use of market prices favours buyers and also leads to inequality in trade. Emergy has therefore been used as an environmental accounting tool to close this inequality by giving account of both the work done by humans and that of the environment (Cuadra and Rydberg, 2006). To analyse trade in emergy terms, a relationship has been created between emergy and money regarded as emergy/money ratio (EMR) which evaluates how much resource base or real wealth does a country have (Cuadra and Rydberg, 2006). Different countries have different emergy/money ratios and this is because of the differences in the degree of industrialization development (measured as GDP) as well as the national emergy signature. A consequence of imprecise relationship between money and the environment is that, even if trade is balance between nations in monetary terms, there is an inequality in trade between nations with high emergy/money ratio and countries with low emergy/money ratio (Odum, 1996; Brown, 2003; Cuadra and Rydberg, 2006). For more comprehensive definition and description of emergy and its applications, see Odum (1996); Brown and Ulgiati (2004); and Rydberg and Haden (2006).

2.4 Selected area

Cameroon is taken as the study area for this study because it is a country with a lot of natural resources. The agricultural sector in Cameroon for several decades has been very important and always contributes significantly to the national economy (Encyclopaedia of the Nations, 2010). Exploring the importance and use of the natural resources to agricultural related sector like biofuel is the main push for selecting Cameroon. Cameroon faces common problems faced by many other developing countries such as food insecurity (most especially in the three Northern Regions), lack of energy (only 40.7 % of the people of Cameroon are connected to electricity), poverty and environmental deterioration among others. Development in rural areas is relatively slow because of lack of drives like energy which has affected the livelihood of the people and pushed them deeper into poverty. There is therefore a need for alternative means to generate energy to supply the rest of the people and also to foster social and economic development.

Cameroon is found between West and Central Africa. It is bounded to the west by Nigeria, to the north by Chad, to the east by Central African Republic and to the south; Cameroon is bounded by the Republic of Congo, Equatorial Guinea and Gabon (CIA, 2010). According to a recent online report, the Cameroon's population as from January 01, 2010 stands at 19,406,100 with a population growth rate of 2.6 percent (Cameroon online, 2010). The urban population constitute 52 percent of the total population of Cameron (www.camerooonline.org). Cameroon has a total land area of 475,440 sq km with land occupying 472,710 sq km and water 2,730 sq km (CIA, 2010). There are 10 regions in Cameroon.

Cameroon's main agricultural products consist of coffee, cocoa, cotton, rubber, bananas, plantains, oilseed, grains, root starches, livestock and timber (Encyclopaedia of the Nations, 2010). Cameroon is a major producer of cocoa and coffee and most are exported to Europe (Encyclopaedia of the Nations, 2010). Cameroon's farmers cultivate a variety of crops which include plantains, maize, sweet potato, cassava, and millet for domestic consumption (Encyclopaedia of the Nations, 2010). Farmers also raise animals such as cows, goats, sheep and chickens as savings to earn extra income and for their own consumption (Encyclopaedia of the Nations, 2010). An agro-industry recently privatized in Cameroon is the sugar company, Socucam, which produces 100,000 metric tons of sugar for the domestic market; Cameroon also produces palm oil for local market and also uses a large amount of the palm oil for cooking (Encyclopaedia of the Nations, 2010). Cameroon produces petroleum and it is the fifth largest oil producer in sub-Saharan Africa. Crude oil, aluminium and petroleum are also exported by Cameroon (Encyclopaedia of the Nations, 2010). Cameroon as well imports machines and electrical equipment, transport equipment, fuel and food (Encyclopaedia of the Nations, 2010).

Cameroon has the potential to be self sustaining because of its rich natural resources (as shown above) but is unfortunate that poverty, food and fuel crisis have typically strike the poor especially those at the rural areas because the resources are not well used and also because of corruption. Most rural areas are cut off from urban cities because of poor road, high fuel prices and it has led to a lack of development on the rural areas. If the natural resources of Cameroon are well directed using the right methods and strategies, there will be a great reduction on the poverty level as well as an increase in the living standard of the people in Cameroon.

2.5 Important Definitions

Emergy: This is the total amount of available energy of one kind that is used up directly or indirectly in a process to deliver an output product, flow or service (Odum, 1996). It is also regarded as an environmental accounting tool capable of comparing the work of the human economy with the "work" of the environment in terms of a common metric. The unit used to express emergy values is the emjoule and when using solar energy as gauge, the solar emjoule (sej) is used. Emergy is used to show how much a certain activity or product is dependent of it surrounding processes, both of the environment and the economic processes. It has the potential to connect the ecological and economic systems as well as the possibility to compare all resources on a common basis.

Energy: According to the American Petroleum Institute (API), energy is defined as the capacity of a system to perform mechanical work (API, 2008). Energy occurs in two primary states: potential and kinetic energy. Odum defines kinetic energy as the energy expressed by an object, body, particle, etc due to its motion while potential energy is the energy a body possesses in its state of position, also regarded as available energy or stored energy a body possesses due to its position (Odum, 2007). To do work, potential energy is converted to kinetic energy and in the process heat is lost. Energy is measured in units of joule (J), Calorie (ca) and the British Thermal Unit (BTU).

Renewable: It is defined as a natural source that can replenish itself over time. According to Texas Renewable Energy Industries Association (TREIA), renewable energy can therefore be looked upon as any energy source that is naturally regenerated over a short time scale (TREIA, 2010). Renewable energy can be derived directly from the sun with examples like thermal, photochemical and photoelectric; and indirectly from the sun with examples such as wind, hydropower and photosynthetic energy stored in biomass. Biofuel is considered renewable because it is derived from renewable sources such as biomass.

2.6 Limitation of Research

The discussion of this thesis is limited to the analysis of the effects of biofuel development to the rural people in Cameroon and some developing countries such as Brazil and South Africa. Since not much has been invested in biofuel in Cameroon, examples from the United States, France, Brazil and South Africa will be considered. Issues of biofuels in relation to climate change will not be dealt with in this study.

Chapter Three: Literature Review

3.1 Definition of Biofuel

Biofuels are defined as organic primary (such as firewood) or secondary (such as bio-ethanol, biodiesel or biogas) fuels derived from biomass which can be used for the generation of thermal energy by combustion or by other technology (FAO, 2000). The organic materials involved in biofuel production includes starch and sugary plants such as maize *(Zea Mays* L.), wheat (*Triticum aestivum* L.) or sugar cane (*Saccharum Officinarum* L.); oil plants such as rapeseed (*Brassica Napus* L.), soya beans (*Glycine Max* L.) or jatropha (*Jatropha Curcus* L.); vegetable oils and animal fats; wood and straw; algae and organic waste. Renewable biofuel sources produced from the above organic materials include bio-ethanol which can be made from sugars (e.g. sugar cane and sugar beets), grains (e.g. maize and wheat), cellulose (e.g. grass and wood) and waste products (crop waste and municipal waste); and biodiesel is made from oil seed crops (e.g. palm oil), waste oils and greases.

Bioenergy in all its form is energy that is produced from biomass, non-fossil material of biological origin including forest and agricultural plants, wild or cultivated as crops (FAO, 2009). Bioenergy can be processed and used in the three different states of matter; that is, in solid, liquid or gaseous forms. Types of biofuels include:

- Solid biofuel: includes firewood, pellets and charcoal. This form of biofuel especially firewood has been used for thousands of years for cooking and heating. This is commonly used today in the majority of rural households in Cameroon.

- Gaseous biofuel: an example is methane.

- Liquid biofuel: includes bioethanol and biodiesel; it can be used for transport when blended or mixed with fossil fuel, an idea which has led to generate a strong interest and tremendous increase in investment (FAO, 2009), it can also be used to generate electricity. Liquid biofuel has also been attributed as a supplement or alternative to gasoline or diesel derived from petroleum (fossil fuel). This study will focus on liquid biofuel.

3.2 The Concept of Biofuel

The concept of biofuel is surprisingly old and its history goes back to the World War II era. Nikolaus August, a German, was one of the first inventors to convince people about the use of ethanol. According to an article on “How Biodiesel Works”, the German born Rudolf Diesel invented diesel engine and used peanut oil to run it (Hess, 2008). Similarly, Henry Ford designed the model T car and he used ethanol, a corn product to run it (Hess, 2008). Beside the used of corn and peanut, vegetable oils were also used for diesel fuel during the 1930s and 1940s. Recently, a variety of other crops are used to produce liquid biofuel, for example Brazil uses sugar cane to produce ethanol while the United States of America uses maize to produce its ethanol.

Brazil is one of the largest producers of ethanol in the world and it is also the largest exporter of ethanol in the world (EIA, 2009). In 2007, Brazil produced 365,000 barrels per day (bbl/d) of ethanol, while in 2008, the production increased to 454,000 bbl/d (EIA, 2009). Brazil also produced about 20,000 bbl/d of biodiesel in 2008 (EIA, 2009).

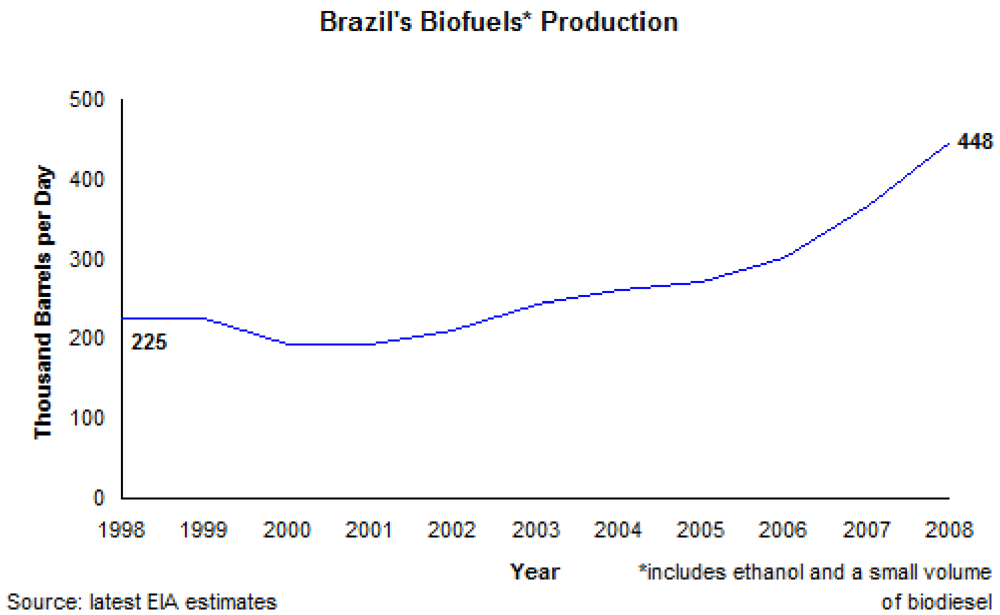


Figure 1: Brazil’s Biofuels Production. Source: IEA, 2009

Brazil's ethanol production continues to grow faster than their domestic demand, this enables Brazil to have excess which are exported to other destinations such as the United States, Europe and Japan. In 2008, Brazil exported 86,000 bbl/d and holds over 90 percent of the global export market (IEA. 2009).

According to Moreira, Brazil succeeded in the production of ethanol for the following reasons:

- Firstly, because of its abundant agricultural land and appropriate climate for sugarcane production.
- Secondly, Brazil's sugar mills were able to produce both ethanol and sugar. When sugar prices fall, these mills were able to shift to ethanol production to some extent.
- Thirdly, Brazil achieved a significant improvements in sugar production and ethanol processing, thus as oil prices rose, Brazil's ethanol production cost was low.
- Fourthly, Brazil took advantage of the synergies with electricity and heat production in which the residues from the sugar-manufacturing process was used to produce electricity and heat that supplied most of the energy needed for the biofuel production process itself and also allowed an increase amount of electricity to be exported to the grid.
- And lastly, the Brazilian government provided the crucial institutional support to get the ethanol industry off the ground; they provided incentives, set technical standards, supported technologies for the ethanol production and use, and also ensured appropriate market conditions.

(Jose Roberto Moreira cited in IFPRI, 2006).

The United States of America is the second major producers of ethanol with the used of maize and their ethanol production started in the 1980s (FAO, 2009). According to EIA data, the U.S ethanol production reached an all time high in December 2009 at 787,000 barrels per day (bbl/d), (EIA cited in Renewable Fuels Association, RFA, 2009). From the statistics in 2009, the United States realised an increase of 131,000 bbl/d of ethanol from December 2008 (RFA, 2009). Both U.S and Brazil account for 80-90% of the total production of 40 billion litres of ethanol (WDR, 2008; OECD, 2008).

The European Union (EU) is the main producer of biodiesel, giving an account of about 75% of the total global production of 6.5 billion litres (WDR, 2008). The vegetable oil used to produce biodiesel is derived from rapeseed. The EU has set up a target, aiming at deriving about 10 percent of its transport fuels from biomass in 2020 (AidEnvironment, 2008). South East Asia also uses palm oil to produce biodiesel and most recently, Jatropha, a non-edible oily seed is used to produce biodiesel (FAO, 2009). Jatropha is presently found and cultivated in Asia and Africa.

According to a study carried out by AidEnvironment, the production of biofuel in Africa is still marginal and large-scale export is non-existent (AidEnevironment, 2008). In Africa, investment in crop production, processing facilities and infrastructure are still largely absent although more and more foreign investors now turn their eye on Africa because of its natural conditions such as affordable or cheap labour and abundant land to produce biofuels (AidEnevironment, 2008). Malawi is the only country besides Brazil that has been blending ethanol with fossil fuel continuously on a national basis for more than twenty years (AidEnevironment, 2008). South Africa and Nigeria are also stimulating biofuels. Most other countries in Africa including Cameroon are still studying the opportunities of biofuels.

Cameroon presently is not taking part in any commercial production of biofuels. There have been some isolated trials undertaken by some companies in Cameroon such as Cameroon Development Corporation (CDC), Sosucam, Firm Switzerland Company, Sodecoton, Maiscam and Socapalm (IEA, 2010). The government of Cameroon and some foreign capitals have supported the industrial production of palm oil with the aim of producing 250,000 tons of oil by 2010 on 5,000 ha/year (Soumonni & Cozzens, 2008). Cameroon is expected to produce 77 millions of litre bio-ethanol and 74 millions litre of biodiesel by 2020 (AidEnvironment, 2008). To meet the above target in Cameroon, suitable regions and feedstock for potential biofuel production has been classified (table 1)

Table 1: Potential first generation options

Biofuel type	Location	Feedstock
Bioethanol	Centre	Sugarcane
Biodiesel	Southwest, Northwest	Oil palm, groundnut, jatropha and vegetable oil.
Biogas	Centre	Urban waste

Source: Carrillo, 2009b cited in IEA, 2010

3.3 The Impact of Biofuel on Food Security and Poverty

In recent years, biofuels developments have been expanding all over the world because of the rising crude oil prices, the desire for countries to be energy independent by also reducing the dependence on fossil. Also, the desire to become energy secured and less dependent on imports, led most OECD countries and some developing to promote biofuels, setting targets for production and offering tax breaks and subsidies to producers (ODI, 2009). However, this development and policies are being questioned most especially as there are some evidences that biofuel development has had impacts on global food prices (Gallagher, 2008). Some argue that, by using arable land for production of crops for both food and fuel; there will be an increase in food prices which could lead to poverty and hunger (ODI, 2009) and this will further be developed in section 3.3.2 of this study.

According to FAO report on the state of World Food Insecurity, many people are said to be undernourished and there have been a big increase in the number of undernourished people since 2006 (FAO, 2009). The majority of this undernourished people are in the developing countries (GAO, 2008; FAO, 2009). A report from Bank Information Center (BIC) pointed out that food riots hit West and Central Africa led to at least 24 people killed in Cameroon and the case in Cameroon was caused mainly by the rise in prices of food and fuel (BIC, 2008). Cameroon is the largest agricultural supplier in Central Africa (FAO Aquastat, 2009), yet about 25 percent of its population lives under the status of food insecurity mainly in three regions: Extreme North, North and Adamawa. The problem of food insecurity in Cameroon stems primarily from lack of infrastructure, logistics, means and the difficulty of transport between production zones and food shortage zones (NIS, 2006; SNI, 2008).

3.3.1 Impact of Biofuel on Food Prices

Feedstock makes up the principal share of biofuel production costs and it accounts for 50-70 percent and 70-80 percent of overall costs for ethanol and biodiesel respectively (IEA, 2004). At the end of the 1990s, the depletion of the progressive food stock has been blamed for the recent food price increase, the growing consumption of grains in Asia, demand for biofuels, oil prices, exchange rates and speculation on food markets have all been blamed as the cause for the rise in price of food (ODI, 2009). Because of its present demand, biofuel has been highlighted as the main cause especially in relation to the increase in the prices of maize; oilseeds such as rape; and sugar to a lesser extent (ODI, 2009). A study by Rosegrant of IFPRI gave an estimate that biofuel demand accounts for 30 percent of the increase in weighted average grain prices after taking into consideration the comparison between a simulation of actual demand for food crops as biofuel feedstock through 2007 and a scenario simulating biofuel growth at the rate of 1990-2000 before the rapid take off in demand for ethanol (Rosegrant, 2008). According to one of the studies by IFPRI, biofuel accounts for 39 percent of maize price increase and around 20 percent for rice and wheat price increase (IFPRI, 2008 cited by ODI, 2009).

Maize is a basic staple food for hundreds of millions of people and it is estimated that some two billion people in the world are currently suffering from hunger and even more suffer from nutritional deficit (Barbara, 2007). This hunger and nutritional deficit situation is blamed by the increase in food prices because higher food prices reduces the poor's access to food (especially the urban poor) and it has a long term effect with irreversible consequences for health, productivity and well-being (Rosegrant, 2008). When higher food prices affects food as a result of biofuel influence, the effect can go deep to affect even the food consumption by infants and preschool children (Rosegrant, 2008). If the current biofuel expansion continues with respect to the various targets set up by different nations, the calorie availability in developing countries is expected to grow more slowly and the number of malnourished children is expected to increase even more (Rosegrant, 2008; Barbara, 2007). In sub-Saharan Africa, many families rely on cassava as another staple food beside maize and the situation for these families is really dangerous (Barbara, 2007). Cassava being a tropical potato-like tuber provides one third of the calories needs of the population in sub-Saharan Africa (Barbara, 2007). It is basically a staple food for over 200 million of African's poorest people (Barbara, 2007). In Africa and most especially Cameroon, cassava is the food people turn to when they cannot afford anything else. Unfortunately for this group of people, cassava has also found attraction to world market as a source of ethanol due to its high starch content (Barbara, 2007). Already, China, Thailand, Kenya and Nigeria are considering the use of more cassava for ethanol. According to a joint report from the Organization for Economic Cooperation and Development (OECD) and UN Food and Agriculture Organization (FAO), increase in demand for biofuel is causing fundamental changes in agricultural markets which are resulting to an increase in price for many farm products such as cassava (FAO-OECD, 2007). The likely result of an increase in price for farm product such as cassava for ethanol is that, an increase number of people will struggle even more to feed themselves (Barbara, 2007). The impact of high food prices on food security and poverty varies among countries and this is because the effects on the poor depends on whether they are buyers or sellers of food as well as whether they depend on the agricultural sector for wages or other source of income (Polaski, 2008). High food prices can possibly raise the incomes of farmers when global price movements are transmitted to local markets (ODI, 2008). Therefore, the sellers of staple food such as maize and cassava may also benefit from the high prices with a possible increase in income. High food prices also leads to incentives to produce local food and could possibly stimulate agriculture (ODI, 2008).

3.3.2 Impacts on Land Access

The recent growth in demand for biofuels has lead to a rise in concerns about the competition between land for biofuel production and land for food production as well as land for production of ecosystems services. In 2006, an estimated 14 million ha of land was used for biofuel production and by-products (IEA, 2006). Another study estimates that the demand for maize-based ethanol from the US alone will put 12.8 million ha under maize in the US by 2016, thereby bringing 10.8 million ha agricultural land into production (Searchinger et al., 2008). About 80 percent of the world's reserve agricultural land is thus in Africa and South America (Fischer et al., 2002). It is unfortunately that the countries currently leading the production of biofuels (the United States for maize ethanol and Germany for biodiesel) do not have the available land to grow feedstock required for future output (Cotula et al., 2008). Therefore, a significant share of the growing biofuel demand in Europe, North America and even globally will continue to be met through importing biofuels or raw materials to produce biofuels from countries with land available for feedstock cultivation (Cotula et al., 2008). According to a supply- and –demand analysis done by the Stockholm Environment Institute estimates that by 2020, developed "energy consuming nations will need to import a substantial amount of their biofuel requirements from the developing world" (Cotula et al, 2008).

Many governments have identified land regarded as "idle" and allocated it for commercial biofuel productions, like in Mozambique, it has been stated that only 9 percent of the country's 36 million ha of arable land are under-used and there is also a possibility of bringing into production an additional 41.2 million ha of marginal land not being used (Namburete, 2006). There has been some growing evidence that raise doubts about what is regarded as "idle" land. In many cases, those lands regarded by governments and large private operators to be "idle", "under-utilized", "marginal" or "abandoned" provide an important basis for the livelihoods of poorer and vulnerable groups, including crop farming, herding and gathering of wild products (Dufey et al., 2007). For example, in India, the widespread planting of jatropha on land considered as “wasteland” was questioned because the rural people relied heavily on these lands for collecting firewood, food, fodder, timber and thatch (Rajagopal, 2007). Another example from Tanzania shows that, an area that was identified for sugar cane plantation in the Wami Basin was reported to be used by thousands of smallholders for rice production and it has also been reported that a thousand rice farmers may be evicted as a result of the project (ABN, 2007). The displacement of small farm holders leads to the loss of local crops varieties and associated knowledge; it has also resulted to an increased health risk, alienation and a greater likelihood of malnutrition and starvation (Barbara, 2007).

Biofuel production can also result to changes in land tenure. The values of land has increase because of the recent increase in demand for biofuel, this has led to greater individualization of land rights previously held in common. People with better access to financial resources are likely to be able to gain or secure access to land while the poorer and more marginalized groups may see their access to land eroded (Odgaard, 2002; Cotula and Toulmin, 2007)

Despite all the negative aspect associated with biofuel with respect to land access, biofuels are not necessarily bad news for small-scale farmers and land users. This is because biofuel can be instrumental in bringing a new beginning to agriculture by making land more important to the people in rural areas (Cotula et al., 2008). Biofuel can possibly strengthen land access for some poorer land users (Cotula et al., 2008). This is because higher crop and land values can renew people’s interest and investment in land as well as encourages small-scale farmers to seek more secure individual or communal land over their land resources (Williams and Vermeulen, 2005 cited in Cotula et al., 2008). For example in South Africa, women have planted tree crops for future use in biofuel production to secure their claims over land contested by their late husband families (Cotula et al., 2008). Price signals to small scale farmers who have land can possibly increase both yields and incomes, securing real, long term poverty reduction in countries that have a high dependence on agricultural commodities. While on a larger scale, biofuel cultivation could lead to benefits such as employments, skills development and secondary industry.

3.3.3 Impact on Rural People

According to a report from the World Bank, almost half of humanity lives on less than $2 a day and almost a third of humanity does not have access to electricity; almost one billion people do not eat enough calories regularly to be healthy and active (World Bank, 2006 cited by Barbara, 2007). Other studies show that caloric consumption among the world's poor declines by about half of one percent whenever the average price of all major food staples increase by one percent (Barbara, 2007). Due to increases in price of staple food, the poor tend to switch to cheaper staples and the situation can get even worse when staples become more expensive and the possible result is always a widespread of malnutrition and starvation (Barbara, 2007).

The effects of biofuel on poor people is a matter of choices made by governments and other stakeholders, for example, Runge and Senauer pointed out the choice of using 450 pounds of maize for food to fill a 25-gallon tank of an SUV with pure ethanol (Runge and Senauer, 2007). The 450 pounds of maize used to fuel a car can contain enough calories to feed one person for a year. In most situations, people with cars have more purchasing power than the majority who are living at a subsistence level; therefore, producers prefer to grow crops for fuel than crops for food, this as a result to target the drivers who are viable to pay more. This further indicates that the poor consumers who are living at the subsistence level are deprived from food because the more income earners with cars pay more to get food converted to fuel. The producers in this case gain by selling at a higher price to those who are able to pay.

According to Barbara, the poor are the first to suffer and hunger is not the only challenge poor people face from biofuel production, more marginal lands must be used to provide increased crop production as a result of biofuel expansion (Barbara. 2007). The development projects of the rich nations tend to affect the marginalized people because they are expected to make way for land required to meet their targets. The old story of colonial exploitation is unfortunately repeating in the name of energy security and climate friendly development projects (Barbara, 2007). The projects contribute positively to energy security to an extent but continue to pile an ever greater burden on the poor people. Some biofuel development projects by World Bank and its regional affiliates may appear on paper to have social and environment benefits, but when implemented, they literally displace poor communities into even more marginal land and often involve intimidation, forced evacuation and violence (Barbara, 2007).

Biofuel development projects are also said to provide jobs for the poor. In Brazil, the sugar cane sector hires approximately one million people, out of which 511,000 works for agriculture, most involve in cutting sugar cane (Rydberg and Cavalett, forthcoming). About 80 percent of the Brazilian sugar cane harvest is done manually and this is regarded as one of the most degrading types of work in the country (Rydberg and Cavalett, forthcoming). Unfortunately, the wages of these workers are low and the working conditions are poor, abysmal and also described as prison-like, where heat and malnutrition has led to the dead of many workers on the job (Tom Philips, 2007 cited in Barbara, 2007). This conditions or abuses are against human rights and it may continue or get worse because of the recent commitment by Brazil to provide increasing amount of ethanol for the United States (Barbara, 2007).

In Zambia, the farmers can keep their land but they are forced to grow only jatropha and it must be sold to the biofuel company who provides seedlings and other inputs (ABN, 2007). Studies have shown that the biofuel company also levy charges for extension services as well impose membership fees to the poor farmers in Zambia. Farmers are also required to replace trees that die from their own resources (ABN, 2007). This has led the Zambian farmers involved in the project into a typical poverty and in some cases even increased the poverty situation (ABN, 2007).

3.4 Biofuel Production Process and Energy Requirement

In order to discuss the development of biofuel in Cameroon, it is important to understand the processes involved in the production of biofuel (e.g bio-ethanol) from a general perspective and the energy required for the process to complete. There are two types of processes that are used to produce bio-ethanol: the wet-mill process and the dry-mill process. In the wet-mill process, the maize used is soaked and then separated into its component parts which are recovered prior to fermentation and only the starch fraction is processed. In the dry-mill process, the maize is ground into flour and process without separation of component parts. Wet-milling plants have much higher cost and operating expenses than dry-milling plants (Chiasson, 2007). There are eight basic steps required in the dry-milling bio-ethanol production process:

(i) ***Milling:*** The maize is first processed through hammer mills which grind it into a fine powder which is referred to the industry as "meal".

(ii) ***Cooking and Liquefaction:*** The "meal" is mixed with water and enzymes, which passes through cookers where the starch is liquefied or converted into a sugar solution called mash. At this stage. Cooking is generally completed at temperatures of 65-80˚C. The mash is exposed to a high temperature of 120-150˚C for short period of time to reduce bacterial growth in the mash.

(iii) ***Saccharification:*** This process involves transferring the mash from the cookers where it is cooled and a secondary enzyme called glucoamylase is added to convert the liquefied starch to a fermentable or simple sugar called dextrose.

(iv) ***Fermentation:*** At this stage, yeast is added to the mash to ferment the simple sugars to ethanol and carbon dioxide. In a continuous fermentation process, the fermenting march is allowed to flow or cascade through several fermenters until the mash is fully fermented while in the batch fermentation process, the mash stays in one fermenter for about 48-50 hours.

(v) ***Distillation:*** The fermented mash now called "beer" contains about 10 percent alcohol as well as non-fermentable solids from the maize and yeast cells. The mash is then pumped to a multi-column distillation system where the alcohol is removed from the solids and water. This stage requires a temperature of 78.3˚C to allow the distillation separate ethanol from water. The alcohol then leaves the top of the column at about 95 percent purity (190 proof), and the residual mash called stillage gets transferred from the base of the column to the co-product processing area.

(vi) ***Dehydration:*** At this stage, the remaining water if finally removed when alcohol from the top of the column is passed through a dehydration system. The alcohol produce at this stage is called anhydrous ethanol and is approximately 200 proof.

(vii) ***Denaturing:*** Ethanol to be used for fuel is denatured using a 2-5 percent of a product, usually gasoline, to make it unfit for human consumption.

(viii) ***Co-product:*** At the end of the ethanol production, two man co-products are created: carbon dioxide and distillers' grain. The carbon dioxide given off during fermentation is collected, cleaned of any residual alcohol, compressed and sell for use in carbonated beverages. Distillers' grain is solid and are high in protein and other nutrients, and they are highly valued livestock feed ingredient.

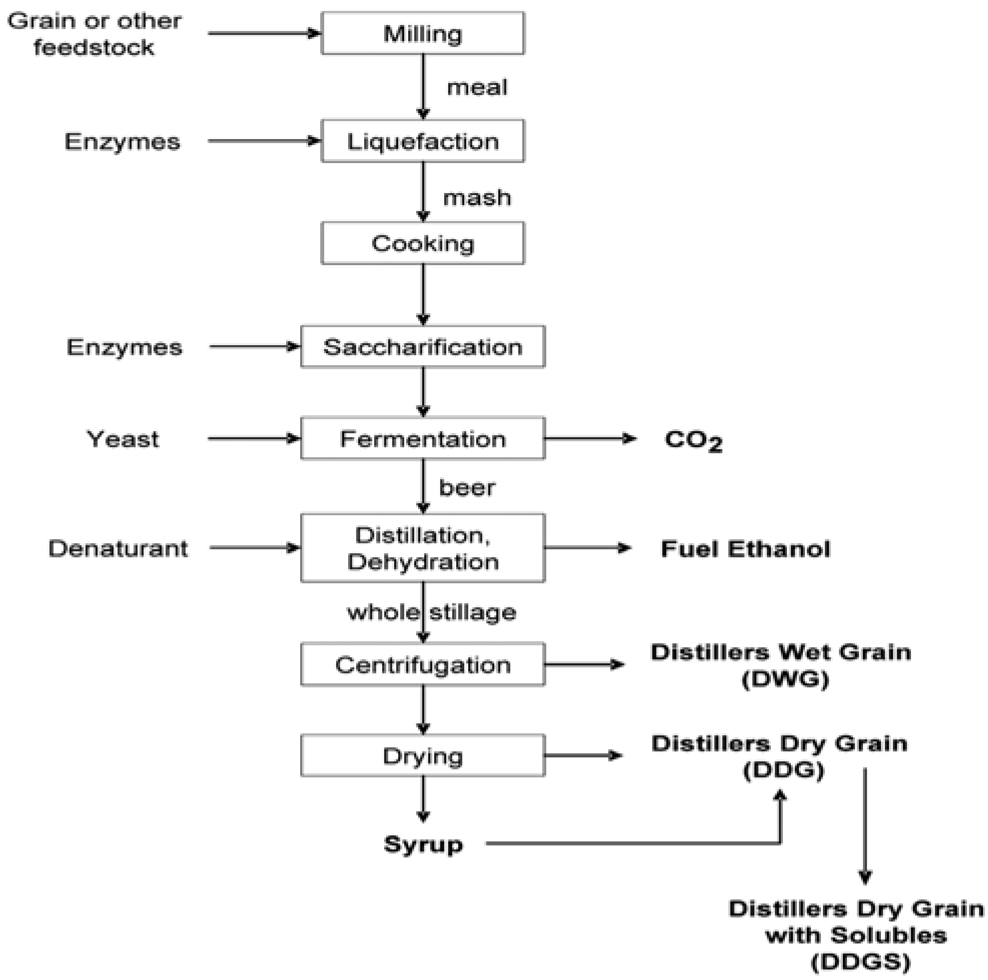


Figure 2: Schematic process of bio-ethanol production using dry milling process. Source: Andrew Chiasson, 2007.

About 85 percent of ethanol plants in U.S. use natural gas as a source of thermal energy, the remainder use propane, fuel oil or coal (BBI International, 2003). Generally, about 20,000 to 40,000 British Thermal Unit (BTU) of energy is required to produce a gallon of ethanol and associated co-products. The energy content of ethanol is about 85,000 Btu/gal (BBI International, 2003). For the ethanol conversion process, mainly thermal energy and electricity energy are used as shown on table 2 below.

Table 2: Energy flow in maize to ethanol process

Energy flow	Thermal energy (MJ/L)	Electricity energy (MJ/L)
Milling	0.21	0.10
Cooking/Liquefaction	2.81	0.06
Fermentation	-	0.06
Distillation	4.76	0.37
Drying	6.22	0.41
Total	14.0	1.0

Source: Mei et al., 2005

The above table shows that, in an ethanol conversion process, the majority of energy is used as thermal energy for cooking, liquefaction, distillation and drying. Electricity is mainly used for milling, distillation and drying. A system diagram of bio-ethanol production (figure 3) provides broader information on the work done by the environment, humans and other inputs such as fuels for the entire production process.

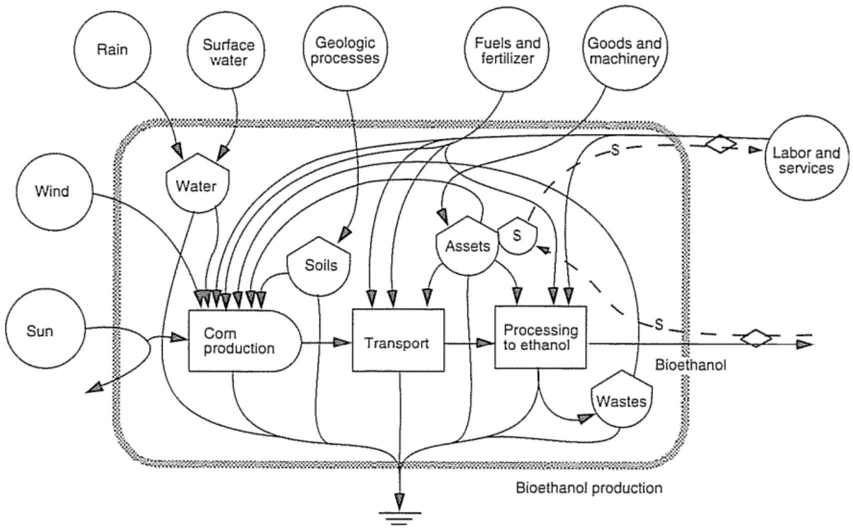


Figure 3: System diagram of bio-ethanol production showing the use of renewable and non renewable energies resources as well as the environment. Source: Brown & Ulgiati, 2004.

To estimate the total energy input required to convert maize to ethanol also known as Net Energy Value (NEV), it involves the addition of all non-renewable energy required to grow maize and to process it into bio-ethanol. Also secondary inputs such as energy used to build ethanol facilities, farm vehicles and transportation equipments. Several studies have wide variation in their NEV estimates. This is because, some use lower heating values (LHV) while other use the high heating values (HHV) for measuring energy. Another factor that leads to differences in estimate is the period for which the information was collected as well as the fertilizer application rate (Shapouri et al., 2002). According to some researchers, what really matters in the process is that bio-ethanol production should achieve a net gain in a more desirable form of energy which can as well be regarded as secured (Shapouri et al., 2002).

Chapter Four: Results

4.1 Lessons Cameroon can learn from the effects of biofuel development to the rural poor people.

The production of secondary biofuels is linked to agriculture because secondary biofuels are derived from plant material. The results (statistics used) of this study will therefore be based on the agricultural potential of Cameroon in comparison with South Africa, Brazil and France. Cameroon's agricultural potential is used because, biofuel in Cameroon is still at the developing stage and no statistic is available that can be use in this study. As earlier indicated in chapter 3, many factors such as employment opportunities, environmental pollution, land demand and agricultural potential and poverty reduction are linked to the production of biofuels and they also affect the lives of the rural poor people. These factors can also draw lessons Cameroon can learn from the experience and challenges faced by Brazil and South Africa through their agricultural and economic potential as well as their environment.

4.1.1 Job Creation

Biofuel have been linked to the creation of job opportunities and according to table 3 below, Cameroon used a higher proportion of agricultural workers than South Africa and Brazil. In terms of the use of machine in agricultural production, table 3 shows that Cameroon used the smallest number of tractors than South Africa and Brazil. Since Cameroon employs more workers for agriculture as shown in table 3, the production of biofuel could lead to new jobs and could result to employment of more people. Biofuel requires the use of human labour, for example about 80 percent of Brazil's sugar cane harvest is done manually (Rydberg and Cavalett, forthcoming). Along the entire pathway chain of biofuels, there are opportunities for new jobs and the jobs could range from biomass production and collection (soil preparation, cultivation and harvesting), to biomass transportation, biomass handling, conversion and finally product distribution (IEA, 2010).

Although, these are possible opening for jobs, it depends strongly on the agricultural structure (e.g. levels of mechanisation) in the countries (IEA, 2010).

Although biofuel could lead to creation of new jobs, it is also leads to problems such as poor working conditions, low salaries. This is because the living standard of people, who might be employed considering the case of Brazil as earlier indicated in section 3.3.3, might even get worse if better policies are not put in place. Therefore, creation of jobs through biofuels might not be a big opportunity if the conditions for the job are not favourable.

Table 3: The agricultural activities for Cameroon, South Africa, France and Brazil

Agricultural Activities	Cameroon	South Africa	Brazil
Fertilizer use- av. annual ($X10^3$ mtons), 1999	50	51	5856
Fertilizer used per hectare (mtons/ha), 1999	0.01	0.003	0.1
Pesticide use (kg/ha cropland), 1994-1996	253	57	836
Number of tractors, 1997	500	100000	805000
Agricultural workers as a percentage of total labour force , 1990	67.7%	13.5%	23.3%
Percent GDP generated from Agricultural activities, 2000	43.8%	3.2%	7.4%

Source: World Resources Institute, 2006. X indicates no statistic registered for the period

4.1.2 Environmental Pollution

The use of fertilizers and insecticides are regarded as inputs to agriculture to provide high soil fertility and also to prevent the plants from pest, in order to enable high production of crops. Fertilizers and insecticides also pollute groundwater (Comar et al., 2008). Some insecticides are toxic to humans and during the spraying process; farmers could inhale this toxic substances thus leading to respiratory health infections (Comar et al., 2008). Table 3 above shows that Cameroon and South Africa used an approximate equal quantity of fertilizer on a national level. Brazil used the highest quantity of fertilizer converted to kilo fertilizers per hectare. The proportion of fertilizer used per hectare indicates that Cameroon used more fertilizer per hectare than South Africa whereas Brazil used the most of fertilizers (table 3). Due to the high usage of fertilizer, environmental pollution is likely to be more in Brazil than South Africa and Brazil. Cameroon's used quantity of fertilizer per hectare, though small, shows that its level of pollution due to the use of fertilizers is more than that of

South Africa. The production of biofuel in Cameroon will require the use of more fertilizers and this can consequently lead to more environmental hazards.

Cameroon used more pesticides than South Africa which indicates Cameroon can possibly pollute the environment through pesticide use than South Africa. Brazil used more pesticide than the others.

The use of both fertilizer and pesticides have commercial values thus they are taken into account when embodied energy analysis are used to measure the energy used in making a product such as maize for biofuel (Franzee et al., 2009). The quantity of fertilizer and pesticides used depends on the total cropland available for agricultural production and it indicates the level of pollution.

4.1.3 Land Demand and Agricultural Production

Land is another important factor to agriculture and for that reason; land has been a point of debate when it comes to food production and biofuel production. The land access implications of biofuels cultivation varies enormously, this is because different feed-stocks and different land tenure systems lend themselves to very different models of biofuels production, ranging from local energy self-sufficiency schemes through to large-scale export oriented plantations (Cotula et al., 2008). The impacts of land access also depends on the relative importance of agriculture to the national economy; countries with smaller rural populations and less dependence of agriculture will experience less impact from land use change towards biofuels crops while land access issues become more acute in countries where most of the population depend on land and natural resources; where poverty also has a significant rural dimension (Cotula et al., 2008).

Cameroon had the smallest total cropland compared to Brazil and South Africa with Brazil dominating both in total land area and total cropland (table 4). Despite the differences in population, total land area and total crop land, all three countries have approximately three persons per hectare of cropland as shown on table 4. For Cameroon to develop biofuel, it will require more cropland and taking population to be constant, the number of persons per hectare of crop land might eventually reduce.

Table 4: Total population, land area and cropland for Cameroon, South Africa and Brazil

Items	Cameroon	South Africa	Brazil
Total population in millions (2 010)	19	49	198
Total land area In thousand Sq km (2009)	469	1,219	8,514
Total cropland ($X10^3$ ha) 1999	7,160	15,712	65,200
Number of people per hectare of cropland (~)	3	3	3

Source: World Resources Institute, (2006); Infoplease, (2009)

Also from table 5 below, Brazil dominates in all agricultural productions. Cameroon on the other hand, dominates South Africa in root and tubers production (e.g cassava) as well as in pulses (table 5). Since Cameroon produces more cassava than cereals, cassava can possibly be use if biofuel has to be considered, this is partly to avoid crisis of food security. Another important indicator on the agricultural production is Cameroon might increase its production level if more land is allocated for crop production, taking the examples of South Africa and Brazil (table 5).

Table 5: agricultural production for Cameroon, South Africa and Brazil

Agricultural production	Cameroon	South Africa	Brazil
Cereals-av. Prod. ($X10^3$ mtons) 1999-2001	1,350	11,123	49,886
Roots and tubers-av. Prod. (000 mtons) 1996-1998	2,588	1,633	26,472
Pulses-av. Prod. (000 mtons) 1996-1998	98	74	2,687
Meat- av. Prod. (000 mtons) 1999-2001	216	1,554	14,572

Source: World Resources Institute, (2006); Infoplease, (2009)

4.1.4 Poverty Reduction

Biofuel has been looked upon as having the possibility to an extent to reduce rural poverty through it effect on energy generation which can be use for transportation and electricity as well as fuel to empower agriculture. Agriculture has played an important role in Cameroon's economy. In 2000, Cameroon generated the highest GDP from agricultural activities compared to Brazil and South Africa (table 3). This shows that Cameroon's economy depends on agriculture to an extent and the possibility of investing on biofuel might be of importance to generate more income. Although the rural people are part of the force behind the GDP generated by agriculture in Cameroon, poverty remains an issue because of lack of incentives from the government (due to corruption), lack of energy, poor infrastructures such as roads, etc.

The production of biofuels could add value to residues and diversify rural incomes as well as adding value to the local agricultural sector (IEA, 2010). The use of residues for biofuels could be an option to create additional market opportunities (IEA, 2010). The benefits from residues could increase farmers' income from selling primary residues (e.g. residues from cassava, maize or sugarcane); it could also benefit plant operators from increasing demand for processing residues (IEA, 2010). This could lead to an additional income means and more money might eventually flow into the region leading to the creation of more jobs; welfare and infrastructure could be reinforced and finally a possible witness in economic growth could be realised in a long run (Domac et al., 2005 cited in IEA, 2010). Although residues of biofuels are predicted to reduce poverty, increase in the cost of agricultural residue could also lead to income losses from traditional buyers of these residues (IEA, 2010). Table 5 above indicates that Cameroon produces more roots and tubers (cassava) than cereals and other crops, therefore the use of cassava residues for biofuel production in Cameroon might have a positive effect on farmers' income but it remains a probability because high cost of cassava residues might affect traditional buyers and poverty in this case might not be reduced.

4.1.5 Energy Security (The state of energy in Cameroon)

The energy situation in Cameroon is another important issue to be addressed because it is not balanced and the rural regions suffer a lot due to lack of energy supply and therefore, the security of energy is an important part of this study. South Africa, a country in Africa that has engaged in the production of biofuels and is also advanced economically will be used as an example to compare the energy situation of both countries.

Cameroon's energy is mainly produced from hydro-electricity while South Africa has the production of coal, natural gas and electricity. The hydro-electricity produced in Cameroon covers less than 50 percent of the total population compared to South Africa who has as much as 67 percent coverage of electricity (table 6). The majority of people in Cameroon use traditional fuel such as firewood while only 12.95 percent of the total population of South Africa use traditional fuel (table 6). This indicates that South Africa is more advanced in energy coverage than Cameroon (table 6). It also placed South Africa to be more energy secured than Cameroon, the more reason Cameroon need to explore other alternative to achieve its energy stability.

Table 6: Energy development for Cameroon and South Africa

Energy development	Cameroon	South Africa
Percentage of people connected to the grid (electricity)	40.7%	67.1%
Traditional fuel consumption (percentage of total energy requirements 2002)	71.6%	12.95%

Source: Developing Renewable, 2006

Although Cameroon has a poor coverage of electricity, it is projected as rich in terms of oil resources and favourable agricultural conditions, as such Cameroon is regarded as gifted because of it richness in natural resources compared to other countries in the Sub-Sahara Africa (CIA, 2010). Despite these potentials, Cameroon faces a number of serious problems faced by other countries in Africa such as low purchasing power (GDP), unequal distribution of income, corruption among others. Table 7 below shows that South Africa has higher purchasing power parity than Cameroon. Although Cameroon produces more than thrice the quantity of oil it consumes, South Africa produces and consumes more oil than Cameroon (table 7). South Africa also consumes more oil than it produces. This indicates that Cameroon is more oil secured than South Africa.

Table 7: Summary of the Economy situation for Cameroon and South Africa

Economy activities	Cameroon	South Africa
GDP (purchasing power parity, x10^6), 2009	42.55	488.6
Electricity production (billion KWH), 2007	5.601	240.3
Electricity consumption (billion KWH), 2007	4.801	215.1
Oil production (bbl/day), 2008	81,720	195,000
Oil consumption (bbl/day), 2008	26,000	583,000
Oil exports (bbl/day), 2007	107,100	128,500
Oil imports (bbl/day)	45,520	490,500

Source: CIA, (2010).

4.1.6 Energy Consumption for Various Sectors

The energy used in the various sectors as indicated in table 8 are commercial energy such as fossil fuel. The residential sector in Cameroon consumed the greatest portion of energy while for South Africa; the industry consumed the greatest (table 8). In Cameroon, agriculture and commercial and public services consumed no energy while South Africa consumed 3 and 4 percent respectively as shown in table 8 below. Cameroon's agricultural sector uses more of renewable energy such as sunlight, wind and rain for its production. Cameroon also uses no commercial energy as indicated on table 8 since more work is done physically. For small scale agricultural production, the use of energy is limited to renewable sources such as sun, wind and rain mean while large agricultural production will require the use of commercial energy because it will involve the use of mechanization as earlier indicated in section 4.1.1. As earlier indicated in section 3.3, the three northern regions of Cameroon faces food insecurity and it is partly because of lack of transportation means, from food production regions to the food crisis region. Biofuel might have an important role to play especially to provide energy for transportation.

Table 8: Energy Consumption for Various Sectors in Cameroon and South Africa

Sectors	Cameroon	South Africa
Industry	17%	47%
Transportation	11%	25%
Agriculture	0%	3%
Commercial and public services	0%	4%
Residential	71%	21%

*Source: Developing Renewable, (2006)*4.2

4.2 The Economic Benefits of Biofuel to Cameroon

The economic benefit of biofuels deals with trade related issues whereby the raw materials and finished products of biofuels are exchange for money and this can take place between different countries. Money has been used in most cases during trading; this study will explore the use of emergy through emergy/money ratio to evaluate the cost of materials and to what extent biofuels can be beneficial if trading in biofuels have to take place between Cameroon, France and South Africa.

4.2.1 Biofuel, Emergy and Trade

Trade involves the buying and selling of goods and services. Trade is an important aspect in biofuels discussions because it brings together people as well as different stakeholders and countries for a common purpose – business. The intriguing part about trade is the unit of its measurement. In most cases, money has been used and money only measures what people are willing to pay for products and services (Odum and Odum, 2001). Therefore, money does not cover all aspects of the work (processes of energy transformation) done by nature (Cuadra and Rydberg, 2006) and as such money cannot be used to measure real wealth (e.g. food, cloth, house, fuel, forest, healthy ecosystem, fish stock, fertile soil, etc). A new concept called emergy has been promoted by some researchers as a better unit for trade. This is because emergy can measure real wealth; it can as well give account of the 'work' done by nature. Money and goods can both be expressed in emergy and this makes it possible to use emergy to evaluate trade which involves the exchange of money and goods.

Cameroon has a lower imported emergy value compared to France (one of Cameroon's main trading partner) and South Africa (table 9). Also the total exported emergy value shows that Cameroon has the lowest value among the three with France having the highest imported and exported values. These values are important during trading between these countries to show who will benefit economically. According to table 9, Cameroon and South Africa export more emergy than they import meanwhile France's wealth (access to resources) stem from imports which is much more than that of Cameroon and South Africa who depend on imports. When trade is balance in terms of money between countries, more emergy is received by the developed nations like France than Cameroon and South Africa who has lower emergy values. Countries that received higher emergy like France and other developed nations benefit more when trading with Cameroon or other developing countries. The national emergy/money ratio for Cameroon and South Africa are higher than that of France (table 9). The emergy/money ratios specify the emergy flow during a trade; from table 9 below, Cameroon and South Africa have higher emergy money ratios than France and in case of a trade, in every one dollar exchange for goods more emergy will flow to France than to Cameroon or South Africa. The country (France) which receives more emergy usually benefits during trade while Cameroon and South Africa who supply the emergy don't benefit.

Table 9: The total Imported and Exported Emergy as well as the National Emergy Money Ratios

Emergy values	**Cameroon**	**France**	**South Africa**
Total Imported Emergy	1.72E + 22	3.13E + 24	2.85E + 23

Total Exported Emergy	6.08E + 22	2.45E +24	1.35 + 24
National Emergy Money Ratios (EMR)	2.46E + 13	2.92E + 12	1.61E + 13

Source: National Environmental Accounting Database (NEAD), 2009.

4.2.2 Summary of National Resource Basis for Cameroon (Use of emergy)

Emergy which deals with the amount of energy used up to deliver an output product is used to summarize the national resource basis for Cameroon. The various energy inputs both from renewable and non-renewable sources, supply the economy of Cameroon. Sources of emergy such as renewable reserves (sun, wind and rain), fuels and minerals, goods as well as services flow as inputs across Cameroon's system boundary (Figure 4). The rural and natural systems which are also regarded as internal emergy storage from renewable emergies further supplies a total of 1,661.3E20 sej to the economy of Cameroon. Other internal emergy storage for Cameroon includes dispersed use (N0) also referred to as "slow-renewables" which are resources that are used faster than they are renewed such as soils or forest biomass harvested at unsustainable rates (Brown et al., 2009). The economy depends on NO and when the value is high, it shows that more of the resources are been used up which is not a good thing for a country. "Slow-renewable" (N0) contributes a total of 365.9E20 sej to the economy of Cameroon while the concentrated use or non-renewable N1 (from fossil fuels and minerals) provides 87.9 to the economy. The direct exports or non-renewable exports (N2) are resources that are exported directly without been used in the economy (figure 4). Non-renewable exports such as mines, when sold as raw materials; they are therefore exported without taking any benefit of it. The sum total of all inputs and the combination of all the national emergy sources gives the value 2,230.9E20 sej as input to Cameroon (figure 4). While 724.3E20 sej is the total emergy that is exported out of Cameroon and 173.0E20 sej is the total emergy realised as imports to Cameroon (figure 4). This section of the study (figure 5 inclusive) is important because it indicates the total work of nature that is exploited for the benefit of human users (Brown et al., 2009).

A strong sustainability requires that stocks of soil, water and forest remain unchanged through time (Cohen et al., 2009). Policies are directed towards the protection of stocks when they are realised to be degraded. Cameroon has a high sustainability index of 35.1 (figure 4) while SA has 0.6 and Brazil 9.5 (NEAD, 2009). Studies have shown that countries with both low and high Emergy Sustainability Index (ESI) appear to be protecting their natural capital stocks and countries with moderate ESI values (~ 1) are depleting natural stocks most rapidly (Cohen et al., 2009). This explains why most developed countries protect their natural capital but rather prefer to buy land in the developing countries for their biofuel crop production, which ends up degrading the natural capital of the developing countries.

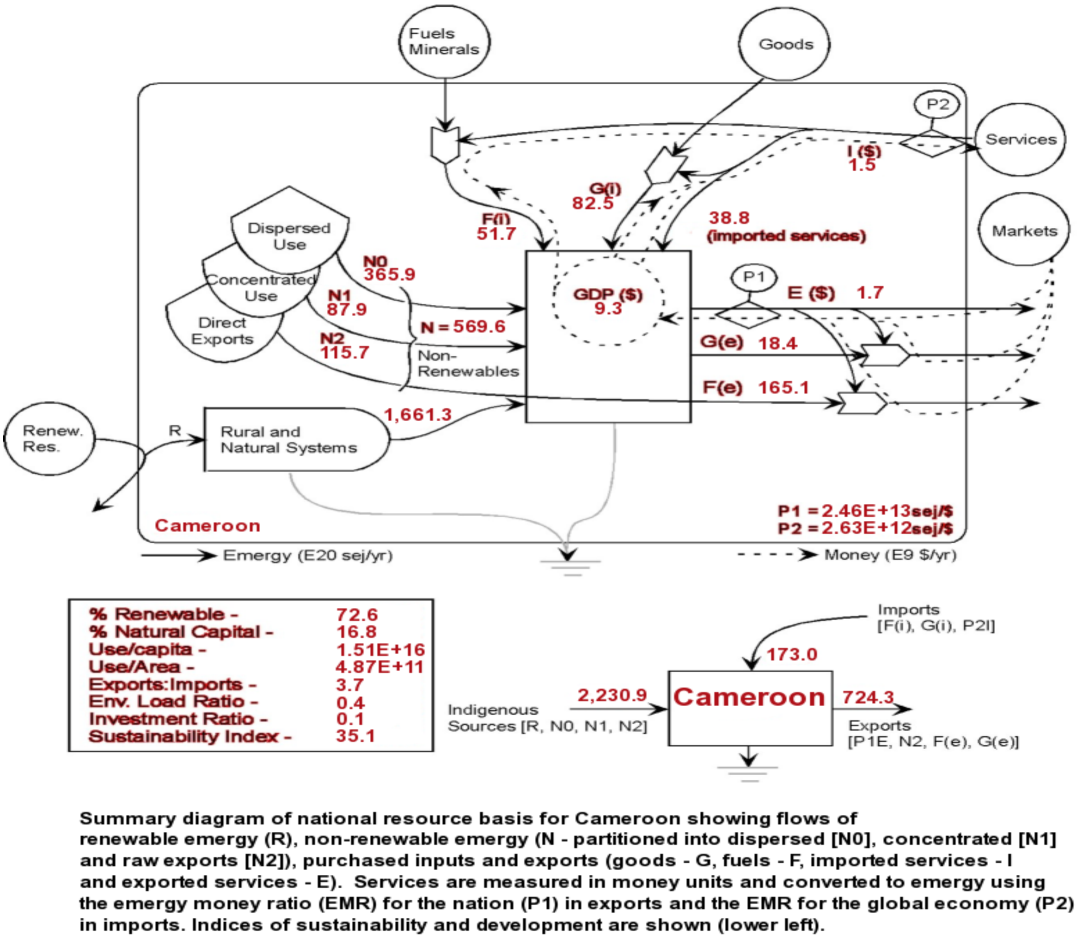


Figure 4: The national resource basis for Cameroon with the use of arrows or flows from emergy sources to the economy and out of the system. Source: National Environmental Accounting Database (NEAD), (2009).

Chapter Five: Discussion

The production of biofuels has brought up some interesting discussions which have involved different individuals, universities, organizations and nations. The discussions have been directed on issues related to food and energy among others with people and environment taking into serious consideration.

The production of biofuels can possibly affect the rural poor people from the examples of Brazil and South Africa. The poor rural people can be affected either positively or negatively through job creation, land demand, high food pieces, food security, energy security and poverty reduction. The creation of jobs in Brazil for example led to employment of about a million people who were unemployed and some were farmers. In South Africa, the tendency for jobs to be created through biofuels was one of the main reasons for their involvement and investment on biofuels. The jobs created by the production of biofuels is important to the rural poor people because it will provide some income to these people and also will stop the massive movement from rural to urban areas. On the other hand, the conditions which the workers are placed are very unfavourable and this also can lead to poor health and even dead in some cases. The above factors which are considered to affect rural poor people are also possible lessons for the people of Cameroon and its government to take into consideration.

Brazil bio-ethanol production has been beneficial to the economy of Brazil, this is because Brazil's sugar mills were able to shift from sugar to ethanol when the prices of sugar fall for example and the Brazilian government ensured an appropriate market condition as earlier indicated in chapter 3 by Moreira (Jose Roberto Moreira cited in IFPRI, 2006). This is one of the reasons why Brazil is among the highest producers of bio-ethanol. Large scale production of biofuels (industrial production) has a lot of setbacks when it comes to international trade. According to the results of this study with respect to biofuel and trade, it was shown that when a dollar is exchanged for trade between Cameroon and France for a given commodity like biofuel, France gain as much as eight times (use of emergy money ratios). This result indicates that large scale production of biofuels for Cameroon will not be beneficial economically. With respect to the environment, biofuel can possibly lead to pollution; this is because it requires the use of fertilizers and pesticides which are environmental pollutants. Brazil uses fertilizers and pesticides for its agricultural production and this affects its environment. Cameroon, whose environmental load is low compared to that of Brazil and South Africa, will not probably benefit environmentally if biofuels are considered unless environmental strategies are put in place to handle the pollution. This section of the study is further developed below and it provides some important lessons for Cameroon if they have to invest on biofuels.

5.1 Agriculture and Food in Cameroon

Agriculture is important to the government and people of Cameroon, contributing to the economy and to an extent place Cameroon out of food crisis or risk zone. Despite the economic crisis that resulted in the 1980s in Cameroon, agriculture has been supportive to the economy of Cameroon and most importantly in the year 2000, 43.8 percent of GDP was generated from agricultural activities (table 3) showing how important agriculture is to the government and people of Cameroon. According to Ellis, the human population depends on the natural resource base (land, water, trees) that yields products for their survival (Ellis, 2000). These natural resources are also regarded as environmental resources because it is thought of jointly as comprising the ‘environment’ (Ellis, 2000). The rural regions of Cameroon depend on their environment for their survival. As earlier indicated in chapter 3, some areas in Cameroon like the South West Region and North West Region are more food productive than the three Northern Regions of Cameroon where their environment (soil) is less fertile and therefore suffer from food insecurity (USAID, 2003). There are other contributing factors leading to food insecurity in the northern regions of Cameroon, some of which are poor roads, lack of transport, corruption, etc.

5.1.1 Poverty Reduction

Despite all effort by the rural dwellers in Cameroon to use agriculture to improve their living conditions, poverty has remained a constant problem to these rural people. According to the World Bank, almost half of humanity lives on less than $2 a day (World Bank 2006 cited by Barbara, 2007), a figure that is debatable. This is because people especially those at the rural areas who live in an environment where there are free environmental resources such as food, shelter, water, land, etc will not need money for their living and as such the above definition of poverty does not reflect their situation. Also the definition can be true in another environment especially in an urban area where most urban dwellers buy the most of the resources needed for their living, in this case less than $2 a day cannot sustain them and can therefore be regarded or classified as poor. Because of this controversy, emergy would be a better tool to describe poverty. Emergy takes into consideration the measurement of free environmental resources which money doesn't. Poverty from the social perspective could be looked upon as the lack of essential items such as food, cloth, water and shelter needed for a good living condition (Think Quest, 2006). The rural people of Cameroon lack those essential items which therefore classify them under the state of poverty.

Biofuels can contribute to alleviate poverty through higher food prices which can lead to an increase in farmers' income (Europabio, 2008). According to Europabio, price increase in grains, primarily cereals will benefit producers in developing countries like South Africa and Cameroon (Europabio, 2008). Locally produced liquid biofuel such as bio-ethanol and biodiesel could lead to national and local benefits such as reduced pressure on forests, reduced dependency on oil imports and limited exposure too high international prices.

However, when food prices are high, famers might gain but non farmers who are mostly urban poor might be affected and will not gain and their poverty state might even get worse. With large scale production of biofuels for export, poverty might not be alleviated because high international prices will come in and also there will be high pressure on the forest (Europabio, 2008).

5.1.2 Employment Opportunities

Biofuels development can also bring direct opportunities to developing countries like Cameroon through the creation of local jobs (Europbio, 2008). This is because biofuel production requires intensive labour; there could be significant employment opportunities (Raswant et al., 2008). In Brazil, the sugar cane sector employs many people who constitute some poor farmers and unemployed people. Employment opportunities could also provide Corporate Social Responsibility policies (Swedbio, 2009). For example in Brazil, a biodiesel cooperative called Cooperbio employed about 25,000 families. South Africa has also enjoyed a small proportion of employment opportunities through biofuels development and more job opportunities are expected in the future due to foreseen expansion (DME, 2009). Unemployed Cameroonians can possibly gain employment opportunities because Cameroon uses more agricultural workers and fewer machines (as shown on table 4 above) if biofuel is taken into consideration. As rural jobs are created, there will be less migration from rural areas to urban areas, this will also reduce urban poverty, crime and health risk (Europabio, 2008). It can also lead to an improvement in the life expectancy in urban areas (Europabio, 2008).

Although biofuel is linked to job creation and some developing countries like South Africa have engaged into biofuel partly because of its possibility to provide jobs for the poor, there are a lot of factors to be considered. In Brazil for example, the working conditions of workers are critical with unhealthy living areas, low salaries and lack of proper health care, as earlier indicated by Barbara in chapter 3. Also, some researchers questioned the group of people who are employed, this is because unemployment rate cannot be affected or reduced in a country if the people said to be employed were farmers who had land that were cultivated. The increased number of machines used nowadays will probably reduce the number of employees and according to Engström one machine is estimated to replace 100 workers (Engström, 2009).

5.1.3 Environmental Pollution

Brazil, one of the highest producers of bio-ethanol has an environmental load of 1.0 (NEAD, 2009), taking into account the total land area of Brazil. On the other hand, South Africa has an environmental load of 11.6 (NEAD, 2009) and is being described as one of the worlds' greatest unsung polluters (Reichardt, 2007). Cameroon has an environmental load of 0.4 (figure 4). The above environmental load figures indicate that emergy is more concentrated in South Africa which is more densely populated compared to Brazil which has more land but sparsely populated. South Africa depends mostly on coal for its cheap energy and presently they have engaged in the development and expansion of biofuels as a means to reduce their level of coal consumption as well as to reduce their environmental load (Reichardt, 2007). Among the three countries, Cameroon has a better environment (with the least environmental load) compared to that of South Africa and Brazil and therefore, Cameroon will need to put up better strategies to handle any increase in environmental load if biofuel should be an option for energy security.

The environmental pollution of Cameroon, South Africa and Brazil is partly proportionate to the amount of fertilizers used during their agricultural or food production. As indicated in table 4 of chapter 4, Brazil used more fertilizer per hectare and also the highest in terms of the quantity of pesticide per hectare used; this gave the reason for its environmental pollution. Beside the fact that pesticides are health hazards, it pollutes nearby rivers and lakes and also threatens the wildlife in aquatic environments.

The burning of sugar-cane is common in Brazil and it liberates carbon, ozone, nitrogen and sulphuric compound gases (Comar et al., 2008). These gases are responsible for acid rain, temperature rise and drop in humidity (Comar et al., 2008). These gases also affect workers directly; fine particles penetrate the lungs during breathing leading to toxic consequences on the health of workers (Comar et al., 2008).

5.1.4 Land Demand and Conflicts

Biofuel requires the use of land for its production. This has also resulted to a number of debates, some of which have been elaborated in chapter three of this study. The importance of owning a land is enhanced by biofuel due to its effect on high prices.

Brazil's biofuel production system is based on large scale monoculture (which might result to loss of biodiversity) with high owner concentration which had led to high demand for land which was previously used for grazing, small holder production and less intensive agriculture; worse of it is that, many poor people are forced out of their land to look for land elsewhere (Engström, 2009). Large scale production of biofuel most often competes with other land and water users (Swedbio, 2009). Power imbalances make it difficult for local communities to negotiate sufficient compensation for lost land, especially if they hold no formal recognized land rights (Swedbio, 2009). This sometimes results to violent and conflicts. The use of "marginal" or "idle" land threatens the livelihood of people; this is because those lands are very important for rural livelihood especially for wood, food and fodder.

5.2 Energy security (Rural Poverty and Energy in Cameroon)

The fight against rural poverty and the provision of energy have a relationship because the availability of local energy is important to strengthen agriculture and agricultural development is also important for poverty alleviation (Raswant et al., 2008). According to Inyang of the Pan African Institute for Development (PAID) – West Africa, dependable energy can make important contributions to the development of any community (Inyang, 2005). The production of local biofuels for domestic use has also led to the provision of energy for local agriculture, industrial and household use, for example, Brazil uses a large quantity of its bio-ethanol production for domestic use and only 15 percent is exported (Engström, 2009). Brazil was able to save USD 52 billion (2003) because it avoided oil imports between 1975 and 2002 (Eklöf, 2007 cited by Engström, 2009). Although Brazil enjoys to an extent some advantages due to its production of biofuels, there is a high uncertainty when it comes to biofuel as a means to secure energy, this is because it takes energy to produce biofuel (energy) and therefore the net energy of biofuel is questionable (Barbara, 2007). It is estimated that if all vehicles in a country are ran by 85 percent bio-ethanol and the number of vehicles grew by 4 percent per year, by 2048, the entire country except for cities would need to be covered with maize or sugarcane (Barbara, 2007). This further leads to a loss in biodiversity. To develop small scale biofuel production, local resources are used whereas for large scale biofuel production, over consumption of fossil fuel is required which is non-sustainable to the environment. Large scale biofuel production also results to food and land problems as earlier discussed in chapter 3. In most developing countries like Cameroon, the poor especially those in rural areas depend almost entirely on firewood; spending several hours a day gathering firewood and dung which is not only insufficient but also increasingly scare and have severe consequences on the health of humans; the smoke resulting from fuel wood during cooking affects human health (Inyang, 2005; Info Resources, 2009). According to 2008 estimates, Cameroon produces more oil than it consumes (table 8) and this is because Cameroon has a rich petroleum potential which has not fully been exploited (for example, the rich oil Bakassi Penisula in South West Region of Cameroon is still to be exploited). The oil potential in Cameroon has little effect on the energy situation of the poor rural people and this affects most especially women and children who are responsible for providing energy from traditional sources (Inyang, 2005; Info Resources, 2009).

5.3 The Flow of Benefit

The Emergy per Money Ratios (EMR) are different for different countries (Odum, 1996; Rydberg and Jansen 2002; Brown et al., 2003 cited in Cuadra and Rydberg, 2006). It is therefore difficult to evaluate the international exchange between different countries without considering the different emergy per money ratios (Brown et al., 2003). Brown further suggests that balance of trade is achieved when emergy of imports and exports of trading partners are equal (Brown, 2003). The emergy exchange ratio (EER) is another important part of this section because it shows the ratio of emergy exchange in trade (figure 5b). When a good is sold and money is received in exchange, both flows can be expressed in emergy (figure 5b). The EER is expressed as a measure of the relative trade advantage of one partner over the other (Cuadra and Rydberg, 2006). The EER between two countries is the ratio between their EMRs.

When trade is done between countries of different economic levels (e.g between a developed and a developing country), there is usually a large net emergy flow to the more economically developed countries (Cuadra and Rydberg, 2006). This is because environmental products which are easy to extract have a high portion of 'free' emergy and secondly because the EMR is larger in less economically developed nations that supply the product than in those countries that received the product (Cuadra and Rydberg, 2006). France is one of Cameroon's main trading partners and this relationship has existed from the era of colonization till present. As earlier shown in table 9 (chapter 4), France and Cameroon have different or highly varied total imported and exported emergy values and according to Brown, balance of trade cannot be achieved in such a trade relationship.

When one dollar is exchange in a trade between Cameroon and France (figure 5b), France enjoys a trade advantage of about 8 to 1 ratio in the market (taking into consideration, the average of all products) with Cameroon (figure 5a). Cameroon's EMR therefore provides a larger net energy flow to France whose EMR is smaller as also shown in figure 5a below. A stands for Cameroon's EMR for it raw materials, B is South Africa's EMR for raw materials and C is EMR for France. The thick arrow 'A' from Cameroon to France indicates more emergy moves from Cameroon to France, in other words indicating that France benefits more and the reverse for arrow 'C' (figure 5a).

Also, when one dollar is exchanged in a trade between France and South Africa, it results to about 5 to 1 ratios in favour of France main while Cameroon and South Africa can have an almost fair trade with an approximate 0 to 1 ratio in favour of South Africa. The benefits experience in a trade between Cameroon and SA is very negligible and such trade need to be encouraged compared to trading with France whose benefit is very noticeable and unfair. The trading situation can even become worse when trading is carried out between France and other African countries such as Mozambique (1.18E + 14) resulting to an approximate 37 to 1 and with Tanzania (3.1E + 13) results to 10 to 1 ratio, all in favour of France.

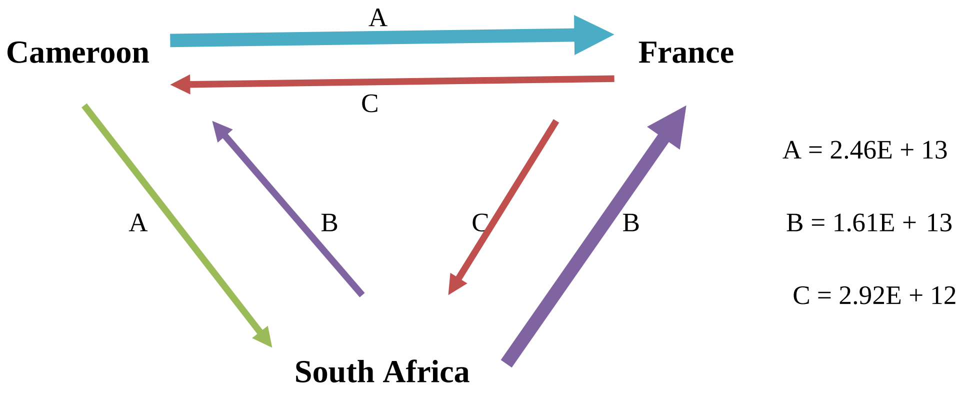
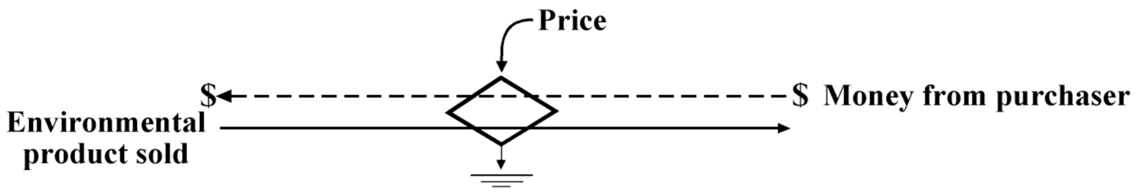


Figure 5a: Triangular trade for Cameroon, France and South Africa with the use of EMR. Arrows indicate emergy flow. Source: author.



$$\frac{\textbf{Emergy in product}}{\textbf{Emergy in money paid}} = \frac{\textbf{(Energy flow) (Transformity)}}{\textbf{(money paid) (Emergy/Currency)}} = \textbf{Emergy Exchange Ratio}$$

Figure 5b: Diagram showing the emergy exchange ratio (EER) of an economic transaction in the sales of an environmental product and how it is calculated. Source: Cuadra and Rydberg, 2006.

Chapter Six: Conclusion

It is important to note that “problems cannot be solved by using the same kind of thinking used in creating them” – Albert Einstein (Barbara, 2007). Although biofuels production is linked with some social and economic impacts which have different ways of affecting the lives of people, there is a need for a new energy paradigm – a new way of looking at energy related issues. It should not just involve more engineering but a new way of looking at the quality of human life; not just more economic development but a new sense of genuine global cooperation; not just pursuing energy security but a new paradigm based on social justice and ecological sustainability – non violence against people and nature (Barbara, 2007).

The production of different biofuels will develop differently depending on the aim of production. If the aim is to substitute fossil fuel with the idea to maintain industrial production, it could lead to the following outcomes;

- High food prices will affect the poor in Cameroon leading to more poverty especially to the urban poor people who have to buy the most of resources they need for their living. It will also lead to high pressure on the forest of Cameroon.

- Industrial biofuels production could lead to insecurity of food and this could cause the poor people in Cameroon to be forced to go for cheap and low caloric foods which in a long run could lead to hunger and starvation.

- Many poor people in Cameroon could be forced out of their land and can consequently lead to violence and conflict.

- Large scale biofuel production could result to loss of biodiversity which will further affect the ecological systems such as loss of many species of living organisms.

- Environmental pollution will be another problem because of the high use of fertilizers and pesticides as well as the burning of sugarcane and other biofuel plants.

- Although industrial biofuel production is linked to the creation of new jobs, the condition of work has not been the best for workers with Brazil as an example. Also, it depends on the people actually considered to be employed. For example, if farmers who earlier had land are employed for biofuel production, it cannot be regarded as creating new job opportunities because they are simply moving from one set of duty to another. In order to link biofuel production to employment opportunities, it has to target the unemployed population.

On the other hand, if the aim is to produce biofuel at the domestic or small scale for local consumption, the outcome will obviously be different. Small scale biofuel production will depend on local resources and the tendency to import or use of fossil fuel will not be required. Also, small scale production of biofuel requires local methods which are cheap and easy for the poor people. The effects on the security of food and land demand will not be over noticed because it will be limited to the community level. Small scale biofuel production might also lead to cooperatives such as the case in Brazil where ‘Cooperbio’ influenced positively to an extent the lives many rural families.

The use of methodological framework and system perspectives can be considered when biofuel developments are explored. Another important aspect to be explored in biofuel development is trade and emergy which could handle sustainability aspects especially on the use of resources and can as well connect to the economy.

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