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UNCERTAINTY OF FOOD SECURITY IN GHANA BY BIOFUEL (*Jatropha curcas*) PRODUCTION AS AN ADAPTATION AND MITIGATION CAPACITY TO CLIMATE CHANGE

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Abstract
This study assessed the impact of biofuel (Jatropha curcas) production on food production and its climate change mitigation potential in Ghana. The classical multiplicative model of time series was used to forecast the approximate cropland from 2011 to 2015 and CO_2 sequestration capacity determined by considering 4200 trees per hectare. The 5,781,628 ha uncultivated agriculture land as at 2010 will be exhausted in the next 25 years at approximate cropland expansion rate of 1.72 % per annum. Acquired and/or requested land for biofuel production by 2009 was 8.20 % of uncultivated agricultural land besides 9,125,721 ha covered by vegetation (forest reserve, savanna woodland etc.). The biofuel projects had the potential of sequestering 1.29 Million tonnes of CO_2 by conversion of savanna land to Jatropha plantation and generate USD 142 million as carbon credits from the trade of emission certificates for CO_2 every year. Chemical extraction after Jatropha seeds cracking will produce 2773.39 - 3887.73 kg/ha/yr Jatropha biodiesel for about 80% reduction in CO_2 emission from the use of fossil fuel. It is therefore recommended that experimental research be carried out for appropriate policies that will make biofuel production a win-win venture for Ghana.

Key Words: *Food security, Climate change, Jatropha, Carbon dioxide, Land, Biofuel*

Introduction

Food security, as defined by FAO, is a situation where all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preference for an active and healthy life (FAO, 1996). In recent times however, food security is being threatened by the emergence of biofuel production globally. Biofuel production as a climate friendly energy source is attracting investors as well as local farmers in Ghana. Agriculture sector of the country employs 66% of the population and contributes 23.1% to national GDP as at 2012 (GSS, 2012).

Most of the agricultural production is by small-holders at subsistence level, reliant on seasonal rainfall which is unpredictable and sporadic. There is an on- going hype that biofuel will create food insecurity and increase in food prices globally. Fargione *et al*. (2008) reported that the net effect of food crop-based biofuel production by clearing carbon-rich habitats such as rainforests and savannas is to release more carbon dioxide into the atmosphere than the reductions that is expected from using biofuels. Another study by Searchinger *et al*. (2008) concludes that diverting existing crops or croplands into biofuel production cause food prices to

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increase, which accelerate the rate of forests and grasslands clearing. The study by Fargione *et al*. (2008) demonstrates that biofuel production has negative impact on the environment if the forests and grasslands can't be preserved as biofuel continues to enter the global markets. The hype on food insecurity is obscuring the true potential the biofuel industry has for poverty alleviation in developing countries (Makenete *et al*., 2008).

Spiess (2012) projected that in 2050 more than nine billion people have to share the limited resources to meet human needs globally. It is forecasted that water, food and energy will be insufficient for a sustainable livelihood. According to FAO data, food production has to increase by 50% compared with current level to produce sufficient food to feed nine billion people. All these findings do not totally erase the idea of biofuel production impacting the generation positively if environmental friendly measures are employed to sustain the resources that will maintain and increase food production and mitigate climate change as well. In 2008, combustible biofuel was around 1% of the total energy consumption in the transport sector globally (IEA, 2010). There is an expectation to increase the biofuel share to 5 or 6% in 2030 (OFID, 2009). Ethanol and biodiesel production was about 70 billion and 15 billion liters per year respectively as at 2010 (Licht, 2008; Brown, 2011). Biofuel is expected to play a very important role in the energy sector especially now that climate change has about 90 percent acceptance that is anthropogenic.

According to recent analyses reported in Soumonni and Cozzens (2008), ethanol from corn that is produced on newly converted land in Iowa would require 93 years to repay the carbon debt resulting from clearing the grasslands; ethanol from corn on abandoned cropland would take 48 years; prairie ethanol on abandoned cropland would take 1 year while ethanol from marginal cropland would incur no carbon debt. They suggested that only crops grown on marginal cropland in Africa would be sustainable. The study deduced from three studies that cellulosic ethanol or bio-fuel derived from degraded crop land and waste biomass have the potential to reduce competition with food crops, minimize the destruction of habitats and reverse carbon debts that result from land clearing. It is obvious that the impact of biofuel production on food security depends upon the crop type used for the production and the land on which it is cultivated.

The growth rate of biofuel production in the country calls for the assessment of its impacts on food security both now and in the future as climate change calls for renewable energy such as biofuel as an adaptation and mitigation measure. Therefore, the objectives of the study were; to determine the cropland expansion rate and possibility of biofuels (*Jatropha curcas*) production affecting food production negatively; and to determine the CO_2 storage capacity over the savanna vegetation when converted into Jatropha plantation.

Biofuel Production in Ghana

By definition biofuels are energy sources which are derived from renewable biomaterials such as plant materials preferably with a high carbohydrate and fat content and which lent themselves to a fast crop rotation. Ghana is a country whose main source of economic growth was agriculture (which was about 23.1% of the 2012 GDP) until it was replaced by the service sector contributing almost half of the GDP, 49.3% (GSS, 2012). However, Agriculture remains the predominant activity of 66 % of the population (2010) with about 57.1% agriculture land area (MoFA, 2011). The main food crops are maize, yam, rice, sorghum, soybeans, millet, plantain, cassava, sorghum and cowpea. The main cash crops include cocoa, cashew, palm oil, cotton, rubber and mango (MoFA, 2011).

The energy sector strategy and development plan published by the Ministry of Energy of the Republic of Ghana in 2010 has set a goal of using 10% renewable fuels for electricity and transportation by 2020 (Ministry of Energy, 2010). This makes biofuel production a critical contributor in achieving this goal. Many crops are being investigated into for the production of both ethanol and biodiesel. Currently, the major types of feedstock used for biofuel production are maize, wheat, sorghum under cereals; potato, cassava, sugar-beet under root-vegetable, soya, rape-seed under leguminous plants and Brassicaceae; sugar-cane and switch-grass under grass and willow, poplar, palm trees and Jatropha under wood (Spiess, 2012). The main crops produced by Ghana among the listed are cassava, maize, soya, palm trees and Jatropha which is now gaining prominence in the northern part of the country. There is no major ethanol production from any cereal in the country except for experimental and research purposes.

Research by Biofuel Africa Ltd reports Ghana as a preferred location for Jatropha plantation because of the agro-climatic factors, land suitability, political and regional stability, legal systems and access to sustainable infrastructure like roads and harbours (Kolnes, 2009). Hughes *et al*. (2011) in a brief on pressures on land from large-scale biofuel production in Ghana states "reports indicate that over 20 companies from around the world have acquired, or are seeking to acquire, rights to large tracts of land across Ghana for biofuel production". These lands are being acquired for the cultivation of Jatropha, sugar cane and palm trees. The Ghana Investment Promotion Centre (GIPC) initiated the process to secure 200 hectares of land in 2010 in the Ahanta West District to reduce the stress investors go through to acquire land for production (GhanaWeb, 2010). Currently, four types of cultivation project are being undertaken for biofuel production; cultivation by smallholders for local consumption, cultivation by large industrial farms (>100 hectares) for local consumption, cultivation by out-growers linked to commercial plantations or smallholders linked to commercial biofuel processing plants for national and international consumption and cultivation by large industrial farms (>100 hectares) for national or international consumption (Hughes *et al*., 2011). About 452,000 hectares of land was reported in 2009 to have been claimed by investors in three approved projects in Ghana. Biofuel Africa Ltd as at 2008 had 23,762.45 hectares of land covered by EPA permit in the Gonja and Yendi districts in Northern Region of Ghana for Jatropha plantation (Kolnes, 2009).

Importance of Jatropha production to climate change adaptation

Jatropha is possible to plant on lands not suitable for food crop production such as degraded or non-arable lands. When cultivated on such lands will protect the land from further degradation by its canopy and prevent the expansion of the degradation to nearby farms or arable lands. Adaptation, as defined by UNFCCC, is the process through which societies increase their ability to cope with an uncertain future, which involves taking appropriate action and making the adjustments and changes to reduce the negative impacts of climate change (UNFCCC, 2007). This makes the utilization of degraded lands an adaptation measure while biodiesel usage to replace fossil fuel helps to mitigate climate change. There is 78% CO_2 reduction from Jatropha straight vegetable oil solvent extraction compared to fossil fuel and 68% CO_2 reduction when extracted mechanically (Kuwara, 2009). Biofuel production holds a higher prospect to help Ghana achieve her goal of 10% renewable energy for electricity and transportation by 2020 as well as carbon sequestration by its plantation.

Methodology

Data Sources

Secondary data on agriculture in Ghana was taken from "Facts and Figures on agriculture in Ghana" issued by the Ministry of Food and Agriculture in 2011. Data on land claimed and ones currently under cultivation for biofuel production were obtained from journals, briefings and Ghanaian news items. All quoted or used data sources not stated here are referenced accordingly.

Classical Multiplicative Model of Time series

The classical multiplicative model of time series was used to predict the land area required for the plantation of seven major crops (maize, paddy rice, sorghum, cassava, yam, cocoyam and plantain) in Ghana from 2011 to 2015. The formula for prediction is;

$$Y_t = S_t + I_t + T_t$$

Where Y_t = Time Series (Land Area)

S_t = Seasonal component

I_t = Irregular component

T_t = Trend component

The Time series prediction was carried out in both QM for windows software under the forecasting module and in Microsoft excel 2007. Forecast in multiplicative composition of the QM software was used as the centralised moving average at two intervals for the forecast in Microsoft Excel 2007. The result from this analysis was compared with the results of QM software under additive composition and multiplicative composition forecast to see the variations in predictions.

Carbon Sequestration and Reduced Emissions capacity of Jatropha Plantation

Sequestration capacity of lands acquired for Jatropha plantation for biofuel production was estimated with 4200 trees per hectare for Jatropha assuming 7.5 kg dry matter per tree. Reduction of carbon dioxide by both mechanical and solvent extraction was calculated at 68% and 78% respectively and compared with current extraction from fossil fuel in Ghana. This reported the mitigation capacity of biodiesel from Jatropha oil in the country.

Results and Discussion

Carbon sinking Capacity of a Jatropha Tree

Table 1 compares carbon emissions and storage by removing savannah vegetation and replacing with Jatropha plantation (Kolnes, 2009). The result from the table shows that 2724 kg CO_2 will be stored per hectare if savannah vegetation is replaced by Jatropha plantation of 4200 trees per hectare with 7.5 kg dry matter per tree.

Table 1: Jatropha tree as carbon sink

CGH emissions from savannah vegetation removal	**kg C/ha**	**kg CO_2/ha**
Living woody biomass (assessed from field test)	1382	5066
Living tree foliage (assumed to be 1/40 of woody biomass)	35	127
Living grasses (typical savannah)	6500	23833
Living roots (assuming 1/3 vegetation underground, 1/3 above ground)	3941	14450
TOTAL	***11857***	***43476***
Carbon storage in a Jatropha plantation	**kg C/ha**	**kg CO_2/ha**
Jatropha living biomass, assuming: 4200 trees/ha 7.5 kg dry matter / tree: 3.0 kg C / tree	***12600***	***46200***

Source: (Kolnes, 2009)

Forecasted cropland size in 5 years time

The first strategy of the policy for the attainment of food security is to focus at the national and agro-ecological levels on the development of at most five staple crops; maize, rice, yam, cassava, and cowpea (MoFA, 2007) but seven were analysed in this study due to their dominant use in Ghana. The selected seven crops (maize, rice, sorghum, cassava, yam, cocoyam and plantain) had major cropland coverage from 1992 to 2010 as well as production capacity (MoFA, 2011). The total land area of Ghana available for agriculture is 13,628,179 hectares out of which 7,929, 800 ha were used as cropland (all cultivated crops in the nation) in 2010. Figure 1 shows the Time series of the total land area covered by the seven selected crops and the forecast for the next 5 years.

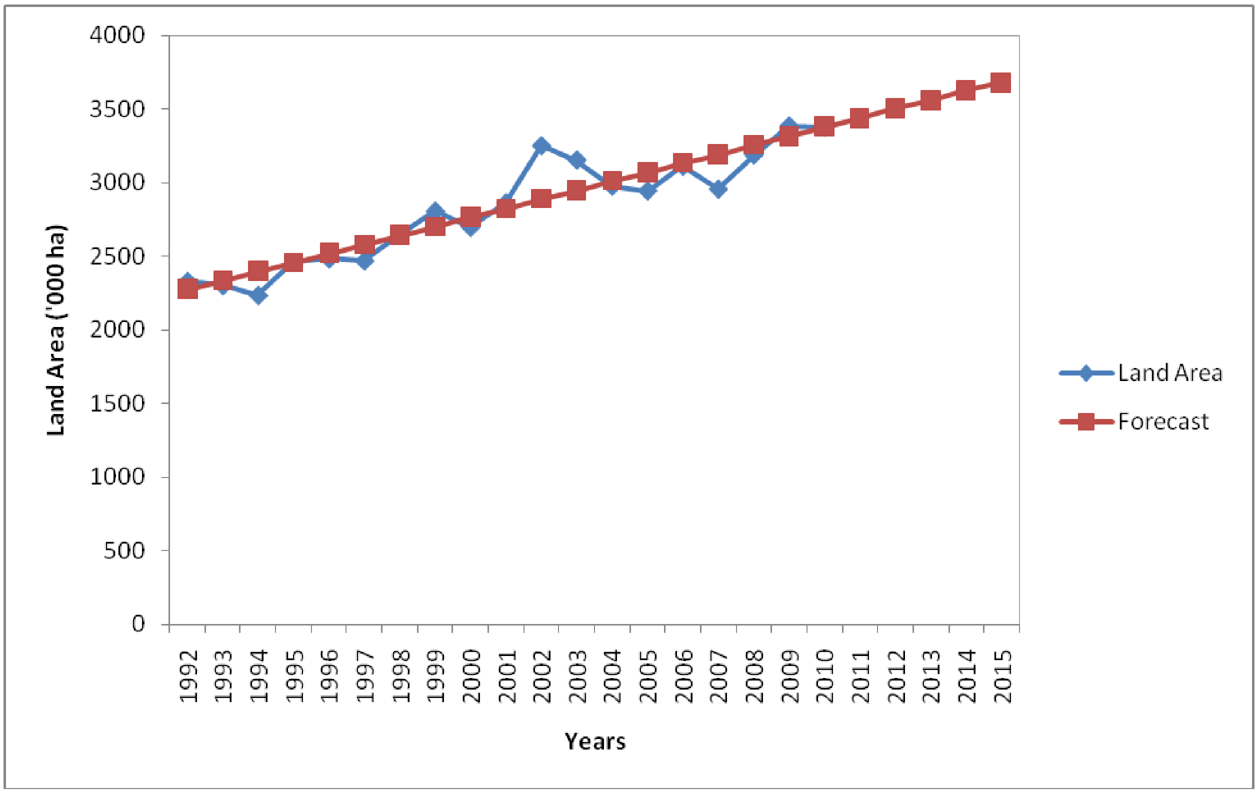

Figure 1: Time series of total cropland covered by maize, rice, sorghum, cassava, yam, cocoyam and plantain

According to the strategic policy to ensure food security in Ghana, the total cropland of the seven major crops selected for this study were predicted to be within 3,433,000 ha and 3,678,000 ha for 2011 and 2015 respectively (Table 2). This implies that cropland is expected to increase by about 4 % in 2015 if the trend of production is maintained in the country. Total cropland in 2015 is forecasted to be approximately 8,246,992 ha. In order to get a more detailed understanding of the impact of biofuel production on food supply, Spiess (2012) discussed 3 scenarios that must be considered; use of existing arable land, expansion of the agricultural land and use of marginal land not otherwise suitable for crop production. The forecasted annual expansion rate of cropland was about 1.72% implying that the 42.4% of uncultivated agriculture land as at 2010 (MoFA, 2011) might be exhausted in the next 25 years if the expansion rate is maintained. Marginal lands that are suitable for Jatropha plantation are not included in the agriculture land area. Also, Jatropha available in the market are produced mainly on newly cultivated areas releasing the pressure of biofuel production on the availability of food. Besides expansion of croplands for production, increased cropping frequencies under irrigation with higher yield species and improved agriculture methods will help in food security (Bruinsma, 2003). Some NGO's have called on the government of Ghana to impose 5 years moratorium on development of large scale biofuel production (Hughes *et al*., 2011) and most of the investors are relocating to other countries.

Table 2: Predicted land area for the cultivation of Maize, Paddy rice, Sorghum, Cassava, Yam, Cocoyam and Plantain

Year	Classical Multiplicative ('000 ha)	Additive Composition ('000 ha)	Multiplicative Composition ('000 ha)	Mean (Stdev) ('000 ha)
2011	3433.539	3431.143	3432.962	3432.55 (±1.25)
2012	3501.559	3503.826	3502.066	3502.48 (±1.19)
2013	3556.059	3553.804	3555.459	3555.17 (±1.17)
2014	3624.316	3626.487	3624.839	3625.21 (±1.13)
2015	3678.578	3676.464	3677.957	3677.67 (±1.09)

Boamah (2011) found that the well-established claim that land outsourcing for biofuels compromises food security and local livelihoods could be inaccurate and misleading if analyses are not contextualized. He reported that household food security in the project villages through employment creation in the plantation, food production and increased petty trading activities by BioFuel Africa Jatropha project has improved the livelihood of dwellers. Migration is one of the consequences from the collapse of the Jatropha project in Northern Ghana since farming activities is only feasible in raining season (Boamah, 2011). Biofuel (*Jatropha curcas*) investment in Ghana especially Northern Ghana has the potential to complement agricultural development in rural areas due to its unique ecological, demographic and socio-economic conditions and degraded areas due to the easy exposure of soil to wind and water erosion (Nil *et al*., 1996). The world food system model for 2020 predicts a 30% rise is in staple food prices against a situation without biofuel production (Spiess, 2012). This calls for further research and proper documentation on whether the emerging biofuel investment in Ghana threatens food security. Therefore, transparent and comprehensive policies are necessary to regulate land acquisitions for biofuel investments (Hughes *et al*., 2011) so that communities won't loss croplands along with their livelihoods since it depends on it. This would also prevent conflicts between lands demarcated for biofuel projects and crops.

Carbon sequestration capacity of biofuel projects in Ghana

Ghana is located within the global zone for Jatropha cultivation (Kolnes, 2009) with a very high potential for higher yield when utilized. Some companies around the world are showing interest in Jatropha project in

Ghana; some of which have already secured lands for the project and others are still in the process of legalizing their land purchases. A total of 473,783.29 ha was reported by Boamah (2011) as the acquired and requested land for biofuel production in Ghana as shown in Table 3. These land are in the Guinea savanna of Northern region and woody savanna of Brong Ahafo region.

Table 3: Acquired and requested land for Jatropha plantation

Company	**Location**	**Area (ha)**
European Union Project	Walewale	500.00
Biodiesel 1 Ghana Ltd	Kwame Danso	283.29
Galten	Requested	50,000.00
BioFuel Africa Ltd	Yendi	23,000.00
Scan Fuel AS	Requested	400,000.00
Total		**473,783.29**

Source: Boamah, 2011

From Table 1, 2724 kg of CO_2 will be stored per hectare when savanna is converted into Jatropha plantation. A total of 1.29 Million tonnes of CO_2 will be sequestered by conversion of 473,783.29 ha savanna land for biofuel in the country (Figure 2). This amount of CO_2 sequestration is 21% of what the vision 2020 of the Energy sector strategy of reducing biomass usage by 20% (Bessah and Addo, 2013). Thus, Ghana has a higher mitigation potential beside the vision 2020 energy policy (Ministry of Energy, 2010). The land area required to see these biofuel projects (Table 3) through is 5.74 % of the projected cropland in 2015 when the Jatropha plant will be producing enough fruits to start biofuel extraction from their oil. Carbon credits from the trade of emission certificates for CO_2 sequestration pays USD 300 per hectare per annum (Sudhakar *et al*., 2012) which will be an added value to both companies and small holder farmers embarking on Jatropha plantation in Ghana. A total amount of USD 142 million will be generated in the economy by these proposed and/or started Jatropha projects as carbon credits.

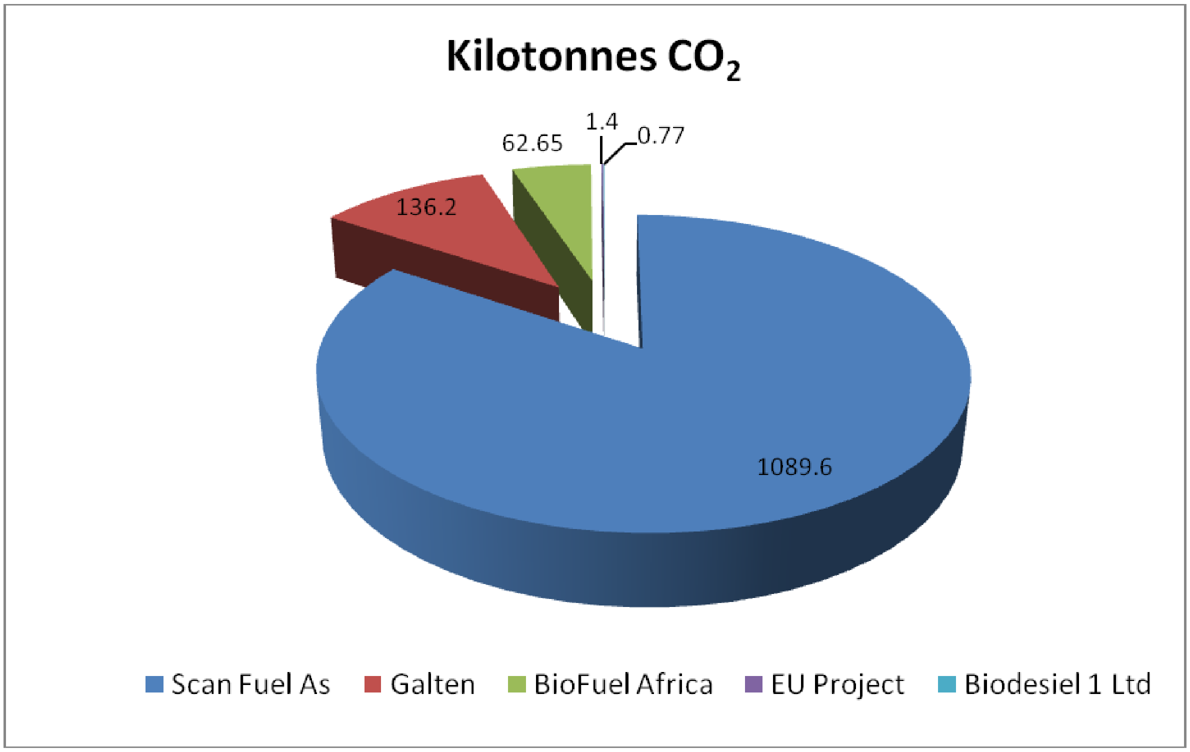

Figure 2: Stored CO_2 by savanna convection to Jatropha plantation

Mitigation capacity by biodiesel production in Ghana

Biodiesel has gained a global recognition as a pivot in fuel shifts to reduce the emissions of CO_2 into the atmosphere with the following importance (Shrirame *et al.*, 2011); Biodiesels are biodegradable, non-toxic, less greenhouse gases emissions than petroleum-based diesel, renewable source of energy and only alternative fuel to run any conventional, unmodified diesel engine. It produces approximately 80 % less CO_2 emissions and almost 100 % less sulfur dioxide. With a flash point of 300 F, it is one of the safest alternative fuel and can be used alone or as a mixed ratio with petroleum diesel fuel. Shrirame *et al.* (2011) reported oil yield from Jatropha as 1590 kg/ha and can yield about 97 % of Jatropha oil methyl ester (Singh and Padhi, 2009) when trans-esterification is done at 6:1 molar ratio of methanol to oil of 0.7 % wt of oil. However, Bobade et al. (2013) at same 6:1 molar ratio of methanol to oil, they had more than 83 % of Jatropha oil methyl ester at 0.5 % wt of oil.

A research conducted at the Kwame Nkrumah University of Science and Technology in Ghana discovered that chemical extraction with 100 % husk and 0 % husk content yielded 66.7% and 93.5% oil yield respectively after seed cracking (Amoah, 2012). This method of processing though expensive increases oil yield between 32% - 60%. Individual tree yields are reported to range from 0.2 to 2.0 kg of seed annually (Francis *et al.*, 2005). An average yield of 1.1 kg per tree implies that 4200 trees/ha/yr will yield 4620 kg seeds per annum. Taking an average yield of 90 % of Jatropha oil methyl ester (Singh and Padhi, 2009; Bobade *et al.*, 2013), production capacity will be at 3081.54 - 4319.70 kg/ha/yr Jatropha oil and 2773.39 - 3887.73 kg/ha/yr Jatropha biodiesel for chemical extraction and 3465 kg/ha/yr Jatropha oil by expeller extraction (Sudhakar *et al.*, 2012).

African nations especially those within the Jatropha and other biofuel crops zone can utilise this opportunity to reform technological strength in this area by exploiting it as Brazil has already started (Soumonni and Cozzens, 2008).

Conclusion

Biofuel production in Ghana is an income generating venture with significant contribution to food security especially in the Northern Region of Ghana where farming is feasible for small holder farmers only in the raining season. These peasant farmers who can't compete in the global market can be dedicated to energy crops (*Jatropha curcas*) to grow their incomes. Cropland expansion rate of 1.72 % and 2773.39 - 3887.73 kg/ha/yr Jatropha biodiesel for chemical extraction with USD 142 million as carbon credits from this projects will make Ghana food secured by both production and importation. At the national level, biofuel projects will generate new industries, new technologies, new jobs and new markets. It is therefore expedient that research at all levels and sectors, in respect of the production of biofuels be made with a proper understanding of the dynamics of the crop with and without food crops for the formulation of policies that will benefit the country.

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