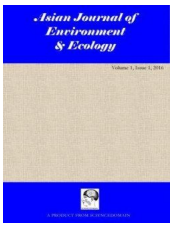

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An Exploratory Study of Adoption of Brazilian-based Model for Production and Diffusion of Cassava Ethanol in Nigeria

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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Case Study

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ABSTRACT

Nigeria has chosen to adopt the development and application of biofuel as an alternative fossil energy sources in its bid to lessen air pollution and mitigate climate change through reduction of greenhouse gas (GHG) emission in the transportation sector. This might be a pathway to generating a sustainable economy that will improve automotive exhaust emission in the country, reduce domestic use of petrol, free up more crude for export and to position Nigeria for development of green fuel. Based on information from Nigeria National Petroleum corporation's (NNPC) official in the Renewable Energy Division, two potential crops were explored for fuel ethanol initiative in Nigeria, Sugar cane and Cassava. This paper focus on the production and diffusion of fuel ethanol from Cassava. The diffusion of innovation theory is used to analyze successful dissemination of this innovation within the country. Barriers and possible challenges were discussed; strategies to overcoming these challenges were suggested. This can be a roadmap for government, policy makers and key actors in the biofuel sector, the sustainable path to clean environment within the Nigerian energy sector.

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Keywords: Sustainable energy economy; alternative fuel; clean air; diffusion of innovation; cassava; ethanol; energy; socio economic and environmental impacts.

NOMENCLATURES

CEDP : Cassava Enterprise Development Project
CFC : Chlorofluorocarbon
CMD : Cassava mosaic disease
CO2 : Carbon dioxide
FAO : Food and agricultural organization (United Nations branch)
GDP : Gross domestic product
GHGs : Greenhouse gas
GMD : Group Managing Director
IAA : The Institute of Sugar and Alcohol (Brazil)
IITA : International Institute for Tropical Agriculture
IPCC : Intergovernmental panel on climate change
NNPC : Nigerian National Petroleum Corporation
NOx : Nitrogen Oxides
N20 : Di -Nitrogen oxide
OPEC : Organization of Petroleum Exporting Countries
REEEP : Renewable energy and energy efficiency partnership
SO2 : Sulphur dioxide
SWOT- : Strength, Weakness, Opportunities and Threats
TAM : Turn around maintenance
TMS : Tropical manioc selection
VOC : Volatile Organic Compound

1. INTRODUCTION

The challenges of climate change can be reduced through adaptation to mitigation strategies [1] in both developed and developing countries if social, political and economic structures and policies are well implemented to accelerate measures to curb greenhouse gas (GHGs) emissions. The concentration of CO_2 (a greenhouse gas) in the atmosphere is raising Global concern as its one of the gases that enhances radioactive forcing and contributes to global warming.

The areas of global concerns are:

- Acid precipitation – produced as a result of the combustion of fossil fuelSO_2 (NO_2) which is transported through the atmosphere and deposited via precipitation on the earth's ecosystem which is vulnerable to change from excessive acidity.
- Greenhouse effect – increasing amount of greenhouse gas (GHGs) such asCO_2, CH_4, CFC, Halon, N_2O, in the atmosphere trapping the heat radiated from the earth and causing the earth's temperature to rise.
- Stratospheric ozone depletion – causes increase in ultra violet radiation reaching the earth, it is caused by the depletion of stratospheric ozone layer which results from the emission of chlorofluorocarbon (CFC) and di-nitrogen oxide (N_2O) emission.

Energy related activities from anthropogenic sources contribute either directly or indirectly to the generation of CO_2 emission. This study is focused on reducing these emissions through blending of fossil fuel with fuel ethanol in the Nigerian transport sector.

Governments from around the world came together to set a binding limit on emission of CO_2 and other GHGs in december1997, at the Kyoto climate summit. The main anthropogenic contributors to the increase in the concentration of CO_2 are the increase in the fossil fuel combustion, land use conversion and soil cultivation.

The Nigeria government in its effort to integrate bio-fuel to the nation's economy has chosen to adopt Brazilian blue print on ethanol production, Nigeria had chosen to adopt 10% of bio fuel to blend 90% of fossil fuel in its initial stage of these programme. The use of bio fuel in Nigeria is anticipated to make significant impact by gradually reducing its reliance on petroleum products. Two potential crops were identified for the ethanol initiative in Nigeria: sugar cane and cassava. Nigeria's economy is heavily dependent on the oil sector which accounts for 95% of the country's total export revenue.

Available data from Nigeria suggest that the country's energy consumption is dominated by fuel wood in spite of its ranking as the eight highest crude producers in the world (Fig. 1).

According to Wikipedia, Brazil is one of the global leaders in the production and use of ethanol also known as ethyl alcohol, (a fuel addictive that reduces petroleum consumption). Fuel ethanol (ethyl alcohol) is derives from sugarcane through fermentation and distillation

of the sugarcane juice. It's used as an additive in gasoline; it serves to oxygenate i.e. to prevent air pollution from carbon monoxide. Acknowledging this clean burning fuel, some countries like Japan and Sweden have been importing Brazilian ethanol to help fulfil Kyoto protocol.

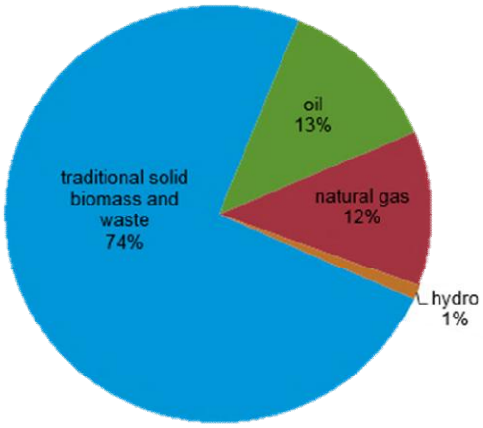

Fig. 1. Nigeria's total energy consumption 2013

Source: U S Energy Information Administration, International Energy Agency [2].

Inspired by the Brazilian fuel self-sufficiency, India and China have chosen to ramp up domestic production and have recently built up National ethanol distilleries , India went further to emulate Brazil's sugar cane based ethanol production.

Energy development in Nigeria will mean alternative energy sourcing, using new technologies that can provide energy and promote economic prosperity while reducing greenhouse gas (GHGs).

Nigerian Government is aiming at promoting ethanol through the use of sugar cane, because of their positive energy balance and high yield and this has made it more preferable to produce ethanol from sugar crops than from grains. (According to Earths policy institute), while the Choice of cassava for ethanol production was based on its availability and the ability to grow in almost all geographical regions in Nigeria, and according to the Group Managing Director of the Nigerian National Petroleum Corporation(NNPC) [3].

2. AIM

This paper focus on the development and application of bio fuel (cassava ethanol) as alternative energy source, to complement fossil fuel in its transport sector and is expected to promote clean air, reduce greenhouse gas (GHGs) emission and promote a sustainable economy. The key goal is to assess the impact of ethanol development on food production, the economy, the social system and the environment in a developing country like Nigeria. In this paper, the following issues are discussed and addressed: Nigeria energy development; fuel production and consumption in Nigeria; Brazilian ethanol development, applications and policies; agriculture and renewable energy potentials of Nigeria; Cassava as case study; diffusion pattern of study; result and SWOT- analysis of study; expected effect of adopting this innovation on the environment, the economy and social structure, and barriers/ challenges to the diffusion of cassava ethanol and proposed strategies to overcome these barriers.

3. THEORETICAL FRAMEWORK AND METHODOLOGY

The theoretical framework and methodology in this paper will be based on secondary data as the main source of information; includes energy reports, scientific journals, publications, articles, natural resource management and related literatures. The approach adopted in this study include: exploring research front, describing the activities of ethanol production in Nigeria, with reference to Brazilian experience that would contribute to the improvement of ethanol utilization in Nigeria.

3.1 Diffusion of Innovation Theory

Diffusion is defined as a process by which an innovation (new ideas) is communicated among members of a social system [4]. From this definition four element are contained which aid the diffusion of any innovation, these include; the innovation, Communication Channels, Time and Social System.

3.1.1 Innovation

Innovation, referred to as an idea in its originality, perceived as new to some individual or other units of adoption, it involves establishing new knowledge or researching on an existing knowledge and commercializing the idea.

3.1.2 Communication channels

Communication channel is defined as the means by which message is transmitted from one individual to another , the nature of the information exchange relationship between a pair

of individuals determines the conditions under which a source will or will not transmit the message(innovation) to the receiver and the effect of such transfer [4].

3.1.3 Time element

Time dimension in diffusion of innovation is focused on: The innovation – decision process and the innovativeness of the unit of adoption and the rate of adoption of the innovation in a system.

3.1.4 Social system

These are set of interrelated units that are engaged in joint problem solving to accomplish a common goal. These units may be individuals, informal group, organization and/or subsystems, for example the government, energy sector, private sector, transport sector, etc., all having a common goal of achieving efficiency through carbon dioxide reduction.

3.2 Attributes of Innovation

When carrying out diffusion research certain characteristics of Innovation are perceived by individual or adoption unit, these factors are known as the attributes of innovation and they include relative advantage, compatibility, complexity, trial ability and observability. These attributes as they relate to cassava are discussed below.

3.2.1 Relative advantage

This is the degree to which an Innovation is perceived to be better than the idea it supersedes. Cassava as a tuber crop, according to FAO has relative advantage when compared to other tuber crops, it can grow in poor soil, on marginal land where other crops cannot grow, it requires a minimum fertilizer, pesticides and water, also because cassava can be harvested anytime from 8 months to 24 months after planting.

3.2.2 Compatibility

This is the degree to which an innovation is placed under probability, adopters observe to see if the innovation will or will not reduce their lifestyle. Ethanol production from Cassava will not affect the existing social system, norms and values, this makes it compatible and it will be perceived as being consistent with the existing values.

3.2.3 Complexity

This is the degree to which an innovation is perceived as being difficult to understand and use. Ethanol blending and usage in vehicles is not a difficult innovation to understand as it will be explained to adopters the advantages of adoption which include reduction of transport emission within the country.

3.2.4 Trialability

This is the degree to which an innovation may be experimented before being commercialized. Ethanol blending in vehicles can be tried practically this way, it is also known that new ideas that can be tried on installment plan will generally be adopted more quickly than innovations that are not divisible.

3.2.5 Observability

This is the degree to which the results of an innovation are visible to others; Ethanol blending in vehicles has been tried in several countries and the results are visible to many, country like Brazil has been using ethanol for cars for over three decades and has visible gains to show.

3.3 Adopters Category

The adopter's categories are classified as into different classes such as the innovators, early adopters, early majority, late majority and the laggards. Rogers [4] suggested an adoption rate which is as follows (Fig. 2).

Assuming all barriers and challenges to the diffusion of the innovation were overcomed and the diffusion occur over a period of time it is expected that a bell-shaped diffusion curve arise over a certain period as shown below.

Innovators are venturesome, they are eager to try new ideas; this interest leads them out of a circle of local peer network to a more cosmopolite social relationship. The innovator must be able to cope with higher degree of uncertainty about an innovation at the time of adoption. Innovators are referred to as the gate keepers of new technology. Innovators are helpful critics to technology producers willing to fine tune their products.

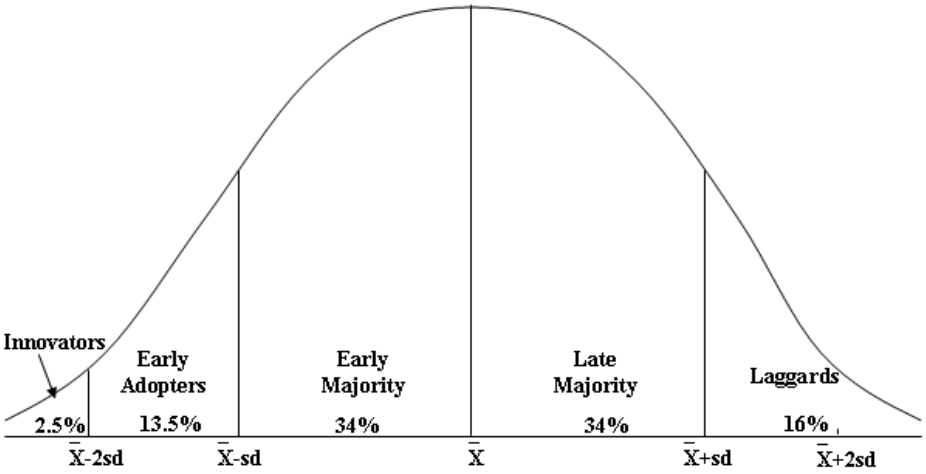

Fig. 2. Adopter category

(Source: diffusion of innovation, fifth edition by Rogers [4]. X = the mean or average time of adoption. Sd = standard deviation (variation about the mean)

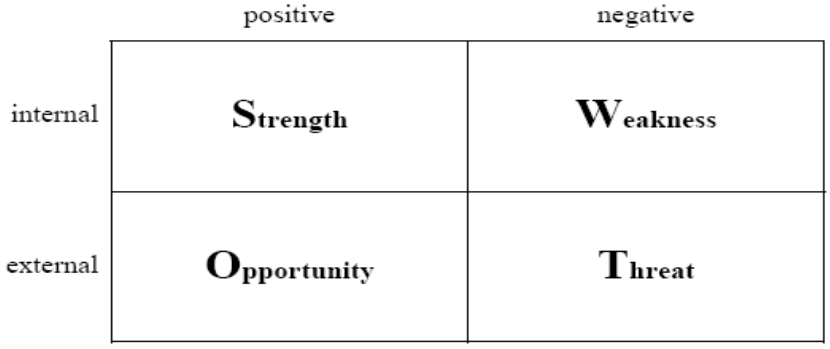

Fig. 3. SWOT- analysis matrix; showing internal and external factors

Early adopters are the integrated part of the local system, early adopters are localities, and they have the highest degree of opinion leadership in most social systems. Potential adopters look to early adopters for advice and information about an innovation.

Early majority have good integration with other members of the social system, they do not have the leadership role that early adopters have, they adopt innovation prior to the average person, rarely influence opinions and they tend to be followers rather than be a leader.

Late majority are similar to early majority, they include one third of all members of the social system , they wait until peers adopt the innovation ,somehow fearful of new technology they prefer pre-assembled packages ,they are less willing to invest in technology that requires, visible change of their practice unless mandated.

Laggards have the traditional view and they are more skeptical about an innovation than the late majority. As the most localized group of the social system, their interpersonal network mainly consists of other members of the social system from the same category, they do not have leadership role, because of their limited resources and the lack of awareness or knowledge of innovation, they first want to make sure innovation works before they adopt it.

3.4 SWOT- Analysis

This is mostly used in the marketing plans; it's an acronym that stands for strength, weakness, opportunities and threats, it's a valuable strategic planning tool used to evaluate the strength, weakness, opportunities and threats associated with a goal.

Strength: organizations unique capabilities', something an organization is good at, which

could be skills or competence or competitive advantage it has over others like its existing local resources.
Weakness: something the organizations lacks or the condition that put the organization at a disadvantage of being successful, like resources and capability limitations.
Opportunity: an avenue for organization to have future development and have new technology processes.
Threats: what affects the organization from the outside such as; resistance to change, lack of interest or motivation, and mismatch of skills and resources.
Swot- analysis is a scan of the internal and external environment. Factors which are internal to the technology are usually classified as strength (S) or weakness (W) and those external to the technology are classified as opportunities (O) or threats (T). The SWOT- matrix (Fig. 3) is shown below.

Internal factors (strength and weakness) is an evaluation of the internal potential strength and weakness, includes organizations structure, access to natural resources, operational efficiency, operational capability, financial resources, key staff etc.

External factors (opportunities and threats) are affected when there are changes in the external environment these changes may be related to customers, suppliers, partners, new technology, political and regulatory environment, economic environment, social change etc.

Swot analysis will assist government, policy makers and various stake holders to establish factors that are internal and external in the implementation of cassava ethanol in Nigeria.

4. OVERVIEW OF ENERGY DEVELOP-MENT IN NIGERIA

Energy is the most used in the context of resources, their development, consumption and conservation has become inevitable in any functional society. Defined as the capacity to do work, it's the basic driving force in man's development.

Energy in relation to agriculture is both fuel and feed stock. Agriculture can be looked at as an energy conversion process, where it transforms solar energy, fossil fuel product and electricity into food and fiber for human being [5]. The continuous use of fossil fuel as primary energy source has continued to increase the amount of carbon in the air and has been one of the causes of global warming.

Development as a concept is define to mean both a process and a goal, as a process, development is seen as an activity people undertake with clear aim in mind and with certain amount of planning. As a goal, development is presented as a desirable stage (usually stage already reach by Western Europe), which less technology advanced nations strife [6].

Development does not start with goods, according to Schumacher [7] in his book titled "Small is beautiful" it starts with people, their education, organization and discipline without which all resources remain latent, untapped potential. Every country, no matter how devastated, which had a high level education, organization and discipline, produced an economic miracle [7].

Economists traditionally considered an increased per capita income to be a good proxy for indicators of development, but technological infrastructure is an enabling environment required for rapid industrial development and comprises of physical and human variables like energy, transport, communication, water, financial and human capital, the ability to provide and effectively apply this input is a direct indicator of the potential for development of any Nation and is primarily the differentiating factor between various level of development worldwide [6].

Energy as a prerequisite for economic growth and development as widely acknowledged by energy and development experts [8].

5. ENERGY DEVELOPMENTS AND ECONOMIC GROWTH IN NIGERIA

Nigeria is blessed with widest range of conventional energy-resources that far exceeds its energy requirements, prominent among which are crude oil, tar sands, natural gas and coal. In addition, there are substantive potentials for renewable energy-resources such as hydro, solar, wind, biomass, wave and tidal, and some geothermal. The abundance of these resources in Nigeria is shown in Table 1.

Since Nigeria's independence, policy makers tend to think of technology mainly in term of finished products rather than as a set of ideas rooted in the local culture with the purpose of

serving the basic needs of the people[9]. "Their perception of technology focuses on attention on the importation of finished product which has resulted in the absence of maintenance culture" [10].

Table 1. Natural energy-resources in Nigeria

Energy type	Resource estimate
Crude Oil	36 billion barrels
Natural gas	185 trillion cubic feet
Hydro power	14,750 MW
Coal	2.75 billion metric tons
Solar radiation	3.5–7.0 kWh/m^2-day
Wind energy	2.0–4.0 m/s
Biomass	144 million tons/yr
Wave and tidal energy	150,000 TJ/yr (16.6 × 10^6 toe/yr)

Nigerian economy from energy point of view can be divided into industry, transport, commercial, household and agricultural sector. However household sector dominated the energy consumption in Nigeria's economy [11], the domination of energy consumption by household is an indication of the need for the country to be more industrialized; below (Fig. 4) is the sectorial distribution of energy consumption in Nigeria.

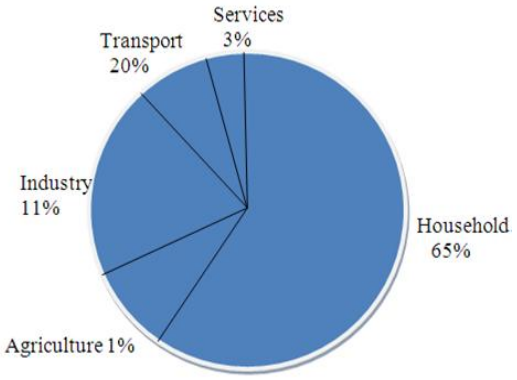

Fig. 4. Sectoral distribution of national final energy consumption in Nigeria
(Source: Sunday Olayinka Oyedepo 2013 [12])

For Nigeria, it is not surprising to find out that there's a negative relationship between energy consumption and economic growth because "Nigeria had the lowest level of energy efficiency in Africa", [8] despite being the largest net exporter of crude in Africa. A country with vast amount of renewable energy resources that could be harnessed for development. Energy shortages and supply interruption are common features of Nigeria economy [8]. These shortages and inefficiencies have been constraining enterprise development and had been detrimental to the growth of unemployment in the Nigerian economy [8].

5.1 Fuel Production and Consumption in Nigeria

Exploration and crude production in Nigeria is mainly carried out by international oil companies and a few indigenous companies, among which are Shell, Exxon Mobil, Total, Chevron and Agip.

The Nigerian production capacity growth between 2005 and 2010 is estimated at about 6% annually (Fig. 5), but is largely affected by recent unrest in the oil rich region, the offshore areas are now being explored and considered highly prospective as new technology involving enhanced 2-D and the advent of 3-D seismic technology have revealed petroleum prospect at greater depth than before.

5.2 Brazilian Ethanol: Development and Diffusion Policies as a Case Study for Nigeria

Ethanol production in Brazil was initiated with a highly subsidized program which was not effectively implemented until the mid-70´s when the sudden increase in the cost of oil imposed a severe foreign exchange burden on the government. This lead the Brazilian government to refocused its strategy to alternative energy source and had encourage sugarcane production to produce ethanol as a possible replacement to gasoline thus reducing oil import [13].

For almost 30 years Brazil has been a global leader in the production and use of sugar cane base ethanol or ethyl alcohol (a fuel additive that reduces petroleum use). The Brazilian government promoted greater efficiency in the rural areas through fiscal incentives, It places more effort in altering the movement of people from rural communities to urban areas, by the extension of equal social benefits, establishing rationale schemes for agrarian reforms, stimulating hitherto uneconomical small holdings and improving the quality of life in areas quite remote from the Centre. As it looked inward for effective diversification of its agricultural sector, it discovered that ethyl alcohol (ethanol) which comes from molasses (a byproduct of sugar cane) could be useful, by mixing with petroleum derivatives to produce a brand of fuel known as gasohol/alcogas or green petrol for motor

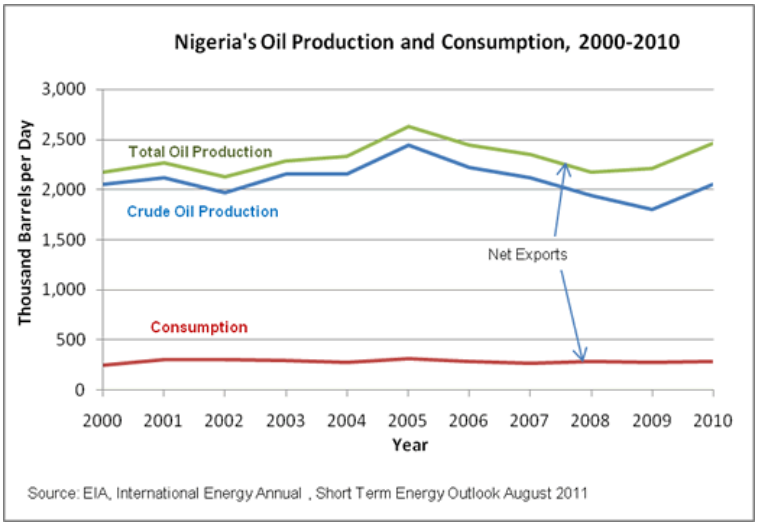

Fig. 5. Nigeria's oil production and consumption, 2000-2010
(Source: International Energy Agency, [14])

vehicles. Two concentrations of ethanol were produced, hydrous and anhydrous, the former is used to as a substitute for gasoline and the latter is mixed with gasoline.

In promoting the diffusion of ethanol in the Brazilian market the government used different tools it had at its disposal to encourage fuel consumers to switch to ethanol use, first the government offered credit guarantees and low interest on loans for construction of new ethanol distilleries, the government then proceed to encourage state owned trading enterprise to purchase ethanol at a reasonable price ,it went further to set gasoline prices to give ethanol a competitive advantage, and finally the state owned oil company began making investment for distribution of ethanol throughout the country. From available data Brazil gets 40% of its automobile fuel from sugarcane-based ethanol, though Brazil's policies mandate the blending of ethanol with all gasoline sold in the country and require all petrol stations to sell ethanol. The last requirement made it commercially viable for the automotive industry to produce ethanol only car's as early as 1980. The successful diffusion of ethanol in Brazil was enhanced by the Government related agencies such as IAA that played a key role in and expedited pro-alcohol program.

Brazil, has remain relevant as a result of its continuous development and refining of its system of innovation i.e. the laws and policies that affect domestic research and innovation. [15].

5.3 Agriculture and Renewable Energy Potential of Nigeria

Agriculture (including hunting, forestry and fishing) contributed an estimated 61% of GDP to the Nigerian economy ,it's assumed to be the engine of growth in virtually all developing economies [16], agricultural activities are usually concentrated in the less developed rural areas where there is critical need rural transformation, poverty alleviation, redistribution and social economic development [16]. Though Nigeria's source of budgetary revenue is from crude, Agriculture still remain the highest contributor to the Nigerian economy, accounting for 38% of non-oil foreign exchange earnings and employing about 70% of the active labor force of the population.

Like Brazil, Nigeria after independence could be described as an agricultural economy because Agriculture served as the engine of growth of the overall economy [16]. Decline in Agricultural production began with the advent of oil boom in the early 1970's which brought about distortion of the labor market that affected production level of both cash and food crops. It increase the dependence on mono cultural economy based on oil, Agriculture now account for less than 5% of Nigeria's GDP. Meanwhile Agricultural sector in the early 1960's contributed over 60% of the GDP as at then, even though the Nigerian peasant farmers relied mostly on locally made traditional tools and indigenous farming method, these farmers produced about

70% of Nigerian export and 95% of its food needs [16].

Nigeria has the potentials for bio energy development; it has all the vegetational regions of West Africa except that of the desert, which include the forest zone, the swamps, a variety of savannah lands and mountain vegetation's. About 75% (74 million hectares) of Nigeria's land is arable and about 40% of this is cultivated, leaving the remaining 60% of arable land idle. Even with these under utilizations of its land area, in 1999 Nigeria's production of yam was 25.1 million tons (67% of World production), cassava was 33.1million tons, ranking first in the World and 20% of Global production.

5.4 Cassava as a Case Study

Cassava (manihot esculenta) also called manioc, tapioca or yuca is a perennial vegetatively propagated shrub grown throughout the low land tropics for its starchy, thickened root, and particularly suited to conditions of low nutrient availability in the soil and is able to withstand drought, pest and diseases, hence cassava is well adapted to areas that experience a long dry season or uncertain rainfall.

In Africa cassava is a traditional subsistence crop of low income farmers who consume the tuberous root as a primary, secondary or supplementary foods, it provides a basic daily source of dietary energy, the roots are processed into a wide variety of granules, paste etc. or consumed freshly boiled or raw. In most countries in Africa cassava leaves are consumed as green vegetable which provides protein, vitamin A and B.

Cassava starch is used as a binding agent in the production of paper and textile and a monosodium glutamate. Cassava products are divided into three categories; food for human consumption, animal feed, and industrial products, among which is ethanol production for blending of petrol which this study entails.

Cassava is a difficult crop to handle because it has the limitation of postharvest deterioration that usually prevents their storage in fresh state for more than few days.

In Nigeria cassava is mostly grown on small farms, usually intercropped with vegetables, plantation crops, yam, sweet potatoes, melon etc. it is a major source of carbohydrates in human diet and it's processed in different forms depending on local custom and preferences.

Cassava is rated high among crops that convert greater amount of solar energy into soluble carbohydrates per unit area, among starchy staples, cassava gives carbon hydrate production which is about 40% higher than rice and 25% higher than maize, with the result cassava is the cheapest source of calories for both human nutrition and animal feeding (FAO).

Nigeria is ranked the highest cassava producer in the world, producing about 34million tonnes of the world's 174 million tonnes in 2001(FAO), its output is almost a third more than Brazil and it doubles the production of Thailand and Indonesia, while other African countries appears to have smaller output when compared to Nigeria's substantial output (Fig. 6).

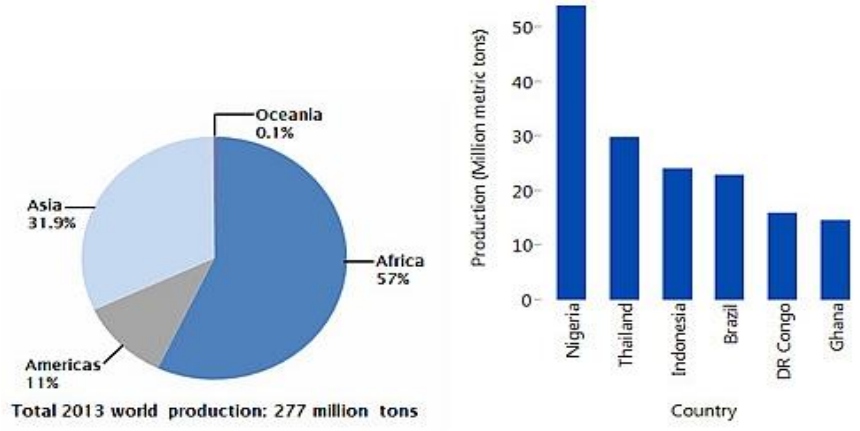

Fig. 6. World cassava shares by region (left) and top six producing countries (right) [17]
Data source: FAOSTAT; created by R.Walters (2015)

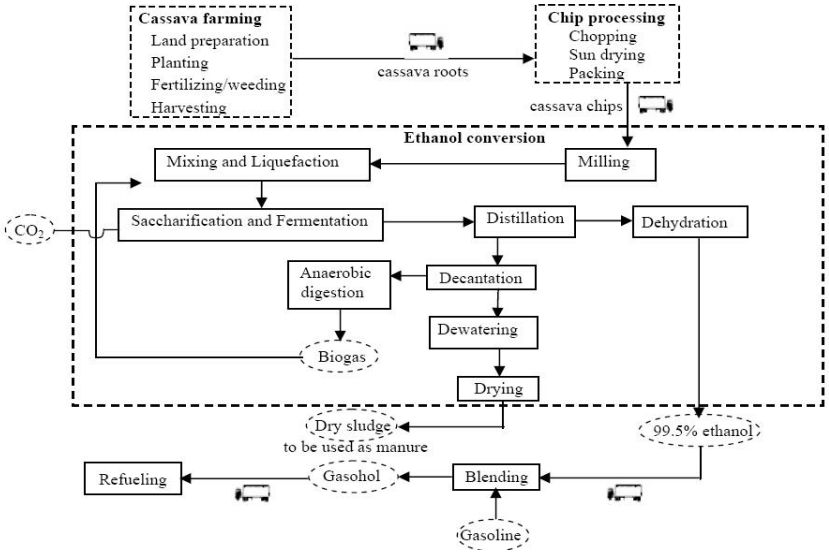

Fig. 7. Flow chart of cassava based gasohol
Source, Nguyen et al. [18]

The IITA has the mandate for Cassava development in Nigeria, the Institute is focusing its attention on a market driven technology transfer and commercialization approach, there are currently three cassava projects being implemented by IITA in Nigeria, these are Pre-emptive management of cassava mosaic disease (CMD), the cassava enterprise development project(CEDP) and the cassava biofuel fortification project. The primary focus of the CMD project is to use a fast track approach to build a defense of resistant varieties to the disease. The principal emphasis of the CEDP is to support micro and small scale agro processing activities in the cassava enterprise.

5.4.1 Ethanol production from cassava

Ethanol production from cassava is through fermentation of sugar, cellulose or starch. The four major stages involved in the production of ethanol from cassava are:

Liquefaction of cassava flour – a process of blending the grinded cassava with liquid to induce dissolution.
Saccharification - a process of converting carbohydrates such as starch or cellulose into fermentable sugar such as glucose or maltose (hydrolysis) usually accomplish by the use of enzymes or acids.
Fermentation – the anaerobic conversion of sugar to carbon dioxide and alcohol by yeast.
Distillation – the heating of liquid to its boiling point, condensing and collecting the vapor.

The Ethanol conversion processes normally carried out are the milling of peeled, dried, cassava tubers, mixing and liquefaction, saccharification, fermentation and distillation/dehydration, after which the collected ethanol are blended with gasoline (Petrol) to form gasohol (a fuel mixture of 10% ethanol and 90%gasoline) that can be use in the internal combustion engines of most modern vehicles. The processes involved are more explanatory through the diagram in Fig. 7 above.

6. RESULTS AND DISCUSSION

6.1 Rogers Theory in Relation to Nigeria

The diffusion of innovation theory used in this paper is to assist the government, policy makers and stake holders in acknowledging the path to achieving rapid diffusion of cassava ethanol in the transport sector in Nigeria, all the four elements mention by Rogers in ensuring dynamic diffusion of innovation are applicable to cassava ethanol diffusion in Nigeria as follows;

Innovators; the innovators are the Federal Government of Nigeria, it's expected to bring together all resources within its capability enhancing the success of this innovation, by introducing and implementing incentives to various adopters like tax reduction, provision of

legal and institutional frame work to support the innovation.

Early adopters; adopters will be the State governments in Nigeria; they will take advantage of the soft policies and incentives of the federal government. Already some states in Nigeria have begun to take advantage of this innovation for example the Ondo State government recently signed memorandum of understanding with the Federal government on Cassava planting in the state, and several other states government in Nigeria are willing to partner with the Federal government in ensuring successful implementation of this project, states will benefit in the area of job creation for their youth and enhanced development in the states.

Early majority; the early majority to the diffusion of ethanol in Nigeria will be the brewing industries located at different regions of the country. Also distilleries in the country like Nigeria distilleries limited, Alconi Nigeria Limited and Allied Atlantic distillers limited [19].

These companies already have some basic knowledge and understanding of ethanol production, mostly for human consumption.

Late Majority; the late majority will be the private individual/ indigenous investors across the country Nigeria who will be willing to invest and earn a substantial amount in return for their investment, they could generate the fund for investment but they are skeptical about the return on investment that the innovation will yield for them.

Laggards; Laggards are multinationals and indigenous oil companies, they will be unwilling to adopt the innovation because of their investment in the oil sector, they will see the innovation as a threat to their growth.

Table 2 shows an analysis of the strength, weakness, opportunities and threats to cassava ethanol production in Nigeria.

Table 2. SWOT- analysis of cassava ethanol production in Nigeria

Strength	Availability of land for cultivation of cassava crops
	Indigenous farming system has placed Nigeria as the World highest cassava producer.
	Large and cheap labor force, low cost of production.
	Cassava is a Perennial plant, so it prevents soil erosion and is advantageous to ground water production.
Weakness	Poor image marketing in creating awareness benefits of ethanol blending.
	Ethanol is characterized by lower energy content per volume than fossil fuel.
	Limited mechanized farming in the country.
	Poor and un-even channels of material and product distribution
	Difficulty in centralizing the production units
Opportunities	Reduce dependency on crude oil, reduce GHG emission, and increase in research initiatives, new and more efficient conversion technologies will spring up while the existing technology will be improved.
	Expansion of available market to gain more foreign exchange.
	Tax exemption and mandatory blending could increase ethanol use within the country.
	Increased agricultural productivity will decrease cost of feed stock and open up new markets.
	Increased in growing urbanization and new distribution channels.
Threats	Incoherent government policies.
	Cassava is a food crop-likely competition of ethanol with food production.
	Unstable energy source for processing of ethanol.
	Cassava roots cannot withstand long storage
	Aggressive competition for cassava industrial use especially from Asian countries.
	Meeting up with local demand for ethanol

6.2 Impact of Cassava Ethanol Production on the Environment

The blending of ethanol in vehicles for the transport sector in Nigeria will be in line with the objective of the Kyoto protocol on the reduction of CO_2 emission which is to achieve stabilization of greenhouse gas concentration in the atmosphere at a level that will prevent anthropogenic interference with the climate system. The emission from vehicles using ethanol will be similar to the emission from vehicles powered by petrol, but the amount of emission from ethanol blended vehicles will be lower because the higher the percentage of ethanol the lower the resulting emission.

6.3 Impact of Successful Diffusion of Cassava Ethanol on Nigeria Economy

The successful diffusion of cassava ethanol in Nigeria is expected to improve the economic situation in the country, create more employment and reduce the poverty rate within the country.

6.4 Barriers/ Challenges

The sustainability of cassava production in Nigeria is threatened by the vicious cycle of declining soil fertility and increasing problem of diseases, pest, weeds and the lack of proper storage. Cassava is known as a perishable crop with a storage life of less than forty eight hours, fresh cassava tubers contain about 65% moisture hence because it deteriorate faster, farmers leave the tubers in the ground after maturity until when required it is then harvested for processing immediately. Cassava cultivation and harvesting is not mechanized in Nigeria, consequently the average yield is low, ranging from 7-10 tons per hectare, which is lower than the world average of 30-40 tons per hectare [20].

6.4.1 Disease- as a barrier

Many diseases in cassava plantation are caused by tiny living things called pathogens i.e. viruses, bacteria's and fungi. When pathogens attack cassava plants it multiplies and spread inside or on the plant, as it spread it destroys the plants, symptoms is normally shown on leaves. Cassava diseases are recognized by their symptoms such as discoloration of leaves, sores on stems and the discoloration of storage roots. Common among these diseases are the

- Mosaic disease caused by a virus which occur inside the leave and stem.
- Cassava bacteria blight caused by bacteria inside the leaves and the stem
- Cassava anthracnose disease caused by fungus which occur on the surface of cassava stem and leaves
- Cassava bud necrosis caused by fungus at surface of cassava stem and leaves.
- Cassava leave spot disease caused by fungus on cassava leaves.
- Cassava root rot disease are caused by various kind of fungi living in the soil , they are found in soil that do not drain properly and in forest fallow land recently cleared. These fungi enter cassava plants through wounds caused by pests or farming tools or by piecing the roots themselves.

Samples of effect of cassava diseases are shown in Figs. 8 - 11.

6.4.2 Pest as a barrier

The pests of cassava are insects, mites and vertebrates, these pests attacks and feed on different parts of cassava plant, some feed on stems and leaves while others feed on cassava root. The common leave and stem pest for cassava in Nigeria are cassava mealy bug, cassava green mite, variegated grasshopper and whiteflies.

Grass cutters and bush fowl expose and eat up roots in the soil; damage done to these roots in the soil can provide entry for micro-organism that causes roots to rot.

In all a good pest and disease control information and management is needed for high productivity in cassava plantation since it is known that diseases that weakens and kill cassava shoot encourages weeds to grow because cassava plants are no longer able to block sunlight from reaching the weeds that grow underneath, in loose soil, exposure of cassava plant will expose soil to erosion.

6.4.3 High cost of infrastructure

Cost of infrastructure has always been an impediment to development in most developing countries, and Nigeria as a country is not exempted since most of the technology to be used are transferred from developed countries, lack of indigenous technical expertise to handle such infrastructure and the poor maintenance culture in the system will always hinder accelerated development of Ethanol production to meet up the needs in the transport sector. This high cost mostly hinder industries that are willing

Fig. 8. Cassava plant damaged by cassava mosaic disease

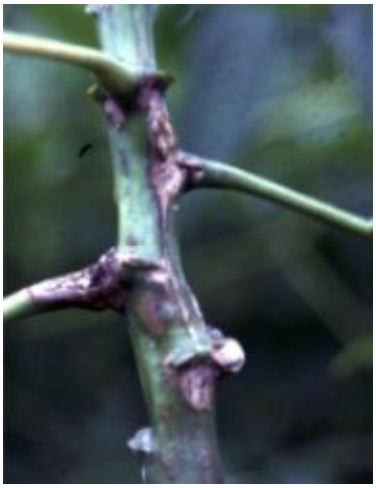

Fig. 9. Cankers of cassava anthracnose disease

Fig. 10. Storage roots damaged by cassava brown Streak disease
Source: Weston M. et al, [21].&[22]

Fig. 11. Leaf blight and wilting caused by bacteria blight.

to invest in such sector even though the efficiency of production of the designed plant are put at 100% efficiency. Non availability/ construction cost of storage plants for ethanol has hindered the importation of Brazilian ethanol in Nigeria.

6.4.4 Lack of micro-finance

Inadequacy of financial support for local companies willing to take advantage of the Ethanol opportunities provided by the local content policy on renewable energy production.

6.4.5 Weak research center and infrastructure

Despite Nigeria's wealth acquired through crude oil export, public investment in research and development has been minimal, compared to other developed countries that have achieved great success as a result of funding of the research centers.

Weak research infrastructure constitute one of the most important constraint of the Nigeria research centre, having large stock of unserviceable laboratory equipment, deteriorating library facilities, and rural roads constitute most critical physical constraint hindering easy access of research institutes to sites.

7. CONCLUSION

It's important to note that only a large scale mechanized production can make Nigeria attain

its cassava requirement for ethanol production, since farming in Nigeria is predominantly rural and is characterized by low technology, the present traditional farming methods will be inadequate in ensuring Nigerians leadership position in ethanol production.

The establishment of regional Centre's of agricultural research will help build knowledgeable research personnel whose focus will only be to give attention to farm technologies. Furthermore it is important for Government to facilitate access to land and the provision of finance for farmers, provide them with relevant farming inputs at affordable cost and the creation of more road networks, at present there is gross deficient network of rural roads.

It is important to note that this study on the diffusion of cassava ethanol in Nigeria has not been compared with other alternative fuel as it is done in life cycle analysis or when using other methods of analysis, this write up is simply a road map for key players and stakeholders in the transport sector in Nigeria, industries and policy makers, creating the awareness of the potentials available through the use of cassava ethanol as fuel, it's important to note that factors that undermine the success of Brazilian ethanol program were outside the scope of this study , they were not considered.

Furthermore, it is important to note that several actors and key players in Nigeria's biofuel industry are currently working tirelessly formulating policies and drawing out success path for the nation to follow in ensuring that ethanol blending is successful in Nigeria.

In order to overcome the socio cultural barriers to the successful diffusion of cassava ethanol in Nigeria, intensive educational campaign programme must be mounted to create awareness of the benefits, this may include publication and distribution of fliers/ manuals, continuous jingles in the broadcasting industries, organization of seminars and training courses in both urban and rural areas, the ideas for sustaining appropriate technology must be based on building a stable institutional framework.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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