BIOENERGY POLICY IN COTE D'IVOIRE

By

DIOMANDE, Younoussa

THESIS

Submitted to
KDI School of Public Policy and Management
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Committee in charge:

Professor Oh, Byungho, Supervisor

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ABSTRACT

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The three keys words of this paper are "Bioenergy", "Policy", and "Côte d'Ivoire" since they determine its understanding. "Bioenergy" reminds the global need to reduce dependence on conventional energies, mostly produced from fossil sources, in order to tackle global warming, environmental degradation, difficult access to clean energy, etc. "Policy", in this context, refers to behavior change at individual, collective, state, regional, and international levels so that the world energy production and consumption patterns could improve. "Côte d'Ivoire" is a Sub-Saharan African country where bioenergy has great growth potential due to its international fame regarding agriculture.

In sum, "Bioenergy Policy in Côte d'Ivoire" points out how the Ivorian government faces the global trend towards alternative energies, and specifically bioenergy. The paper discusses the country 's energy situation and policies before showing in which ways promoting energy from agricultural waste and other resources can improve the situation while adding economic value to activities and creating job opportunities.

Accordingly, a quick look is taken at experiences from other countries where governments implemented a strong Public-Private Partnership (PPP) in order to achieve energy targets. Inversely, the paper also emphasizes not only the likelihood of generating food insecurity and other risks when developing bioenergy projects worldwide, but also the weaknesses of Côte d'Ivoire for such projects.

Therefore, I made recommendations for each weakness with the purpose of motivating the government to adopt and preserve adequate energy policies.

DEDICATION

I specially dedicate my work to:

My late parents for their wisdom and support that allowed me to develop three principles: respect, altruism, and hard work;

My family including my wife Isabelle Bénédicte and my children Ismaël, Sarah, and Cheick with whom I share all the joys and sorrows of life;

All those who, like me, are worried about environmental degradation and keep on fighting worldwide to protect the nature and the living environment.

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It would have been impossible to achieve this Master's thesis without guidance, support, understanding, and other contributions from people and institutions both in Korea and Côte d'Ivoire. Therefore, I consider it my duty to express my deep gratitude to them and offer my apologies for not being able to mention all of them by name.

In Korea, first of all, I am very grateful to the Korean government and the Korea International Cooperation Agency (KOICA) for the full scholarship composed of tuition fee, roundtrip airfare, and living expenses, that allowed me not only to stay in Korea for study purpose, but also to discover the marvelous host country.

I of course also extend my sincere thanks to KDI School of Public Policy and Management, via the Professors, the staff members, and the student community, for the exciting curriculum and the relaxing environment I benefited from.

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Moreover, it's my pleasure to address my fellow students, classmates, and particularly the KOICA students of whom I was the representative. Group works, discussions about different subjects, combined with leisure activities organized by the school and KOICA were actually useful in allowing me to finish the Master's program.

I must take this opportunity to pay homage to the whole staff that daily do a great job in coordinating both the school academic and extracurricular activities. How would I have achieved the program without assistance from the administrative team?

Beyond the school, I would like to acknowledge the contribution of the Korea Environment Corporation (Keco) via the Dr. Hyunhee LEE, Expert in bio gasification of organic waste. The Korea's master plan document on "Waste Resource & Biomass-to-Energy Policies" he provided me played a fundamental role in gathering data on Korea for a comparative study with Côte d'Ivoire regarding the issue of bioenergy.

In the same vein, my kind expression of thanks goes to my fellow country mates, working at the Côte d'Ivoire's Embassy in Korea, for the warm welcome I was given. It was so nice to visit them sometimes either at work or at home to share some local foods and talk about the country and life in Korea. Thanks again to His Excellency the Ambassador, his co-workers, and the rest of the Ivorian community of Korea. Inside the community, I convey my best regards to the Prof. Ekra MIEZAN, Professor of Methodology at Hankuk University of Foreign Studies, from whom I also learned research methods and thesis writing techniques.

Besides Korea, I received institutional and individual supports in Côte d'Ivoire. Accordingly, my first gratitude message addresses the Korea Embassy from where I successfully applied for the Master's Degree Program at KDI School. I secondly appreciate the contribution of the Ivorian government through the Ministry of Environment, Urban Hygiene, and Sustainable Development, my organization, because, without an official permission, I would not have been able to attend the program. I specifically thank Mr. Patrick PEDIA, my immediate supervisor, and the close colleagues for having encouraged me throughout my study period in Korea.

My appreciation now refers to my recommenders: the Dr. Nondaï Didier GBE, Technical Inspector at the Ministry of Environment, and the Dr. Jean-Pierre TRA BI, Lecturer in English at Cocody University. The recommendation was a motivating factor.

I continue my speech by appreciating the cooperation of the staff of "Sucrivoire-Zuénoula" (S-Z), a sugar company more than 400 kilometers from my residence place which I visited for data gathering. I am mostly grateful to my friend Mr. Jojo KILIMANN, the Logistics and Living Environment Manager, for having provided me with accommodation during my three-day stay there, and Mr. Antoine BAYILI, the Head of the Garage and someone experienced, who supplied me a copy of his research paper on energy issues at S-Z as well as other documents on alternative energies.

I cannot conclude without paying an emotional tribute to my late parents, my mother and my father, from whom I learned the first lessons of life and who succeeded in supporting me financially since I was born, despite their limited financial resources, and keep on giving me spiritual support. I take this opportunity to remind to my sisters and brothers how much I am appreciative of their permanent encouragement.

Last, but by no means least, I pay special and strong attention to my wife Isabelle Bénédicte and my children Ismaël, Sarah, and Cheick in view of their patience, their courage, and all the best wishes they made for me during my thirteen-month absence. In particular, I congratulate my wife for having taken care of the family all the while, above all because the country was going through a sociopolitical and military crisis.

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LIST OF ACRONYMS AND ABBREVIATIONS

3 R	Reduce, Reuse, Recycle
ADERCI	Ivory Coast Renewable Energies Development Agency
AMADER	Malian Domestic Energy and Rural Electrification Development Agency
ANADER	National Rural Development Support Agency
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CIA	Central Intelligence Agency
CIE	Ivorian Electricity Company
CNRA	National Agronomic Research Support Center
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CPP	Jatropha Producers' Cooperative
DGIS	Dutch Directorate General for International Cooperation
ECA	Electricity Consumer Association
FACT	Fuel from Agriculture in Communal Technology
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GE	General Electric
GHGs	Green House Gases
GP	Garalo Project
GTZ	German Agency for Technical Cooperation
GVEP	Global Village Energy Partnership
ICCO	International Cocoa Organization
IFIs	International Financial Institutions

IFPRI	International Food Policy Research Institute
IGT	Tropical Geography Institute
IMF	International Monetary Fund
MFC	Mali Folk Center
MIFAFF	Ministry for Food, Agriculture, Forestry, and Fisheries
MMPE	Ministry of Mine, Oil, and Energy
MNC	Multinational Corporation
MOE	Ministry Of Environment
NGO	Non-Governmental Organization
PPP	Public-Private Partnership
ProÁlcool	Brazilian Alcohol Program
R&D	Research and Development
RDF	Refuse Derived Fuel
S-Z	Sucrivoire-Zuénoula
SMEs/SMIs	Small and Medium Enterprises/Small and Medium Industries
TOE	Ton of Oil Equivalent
TRITURAF	Ivorian Oilseed Crushing and Vegetable Oil Refining Facility
UN-Energy	United Nations Energy-related Interagency Mechanism
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
US	United States
WEO	World Energy Outlook
WTO	World Trade Organization

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I. INTRODUCTION

Oil prices volatility, access constraints, global warming, and other environmental concerns are the issues the world and mostly the developing countries are facing in the field of energy. Despite policy efforts, the oil price is still rising (Birol 2010) with related consequences on the world economy. From the side of the developing countries, the problem is so severe that many of them are now spending "as much as six times on fuel as they do on health" (UN-Energy 2007). Even between those countries, the gap seems to be highly unfavorable to Africa since, as mentioned by Abdoulaye WADE, Ex-President of Senegal, oil crisis is a potential obstacle to Africa's development (UN-Energy 2007). As we can see, access to fossil energies, including fuel and natural gas, is a challenge for the world poor whose energy uses are based on household requirements such as "cooking and heating, lightening, communication, water pumping, and food processing" (UN-Energy 2007). Consequently, in poor countries, almost 2-3 billion people get their energies services from firewood, charcoal, manure, and agricultural residues (Hazell and Pachauri 2006).

In addition to difficult access to energy, another challenge is the burden caused on the environment both by fossil and traditional biomass energies. Fossil energies contribute to global warming in two ways. First, during oil and gas production, on land and sea, those spaces are degraded, losing thus their biodiversity and their capacity to sequester carbon. Second, the increased demand for energy associated with our unsustainable consumption patterns are pollutant factors (Birol 2010).

As far as traditional biomass is concerned, the use of firewood and charcoal by poor households for their energy needs impacts on climate not only via deforestation, but also by polluting the atmosphere and damaging health, mainly among women and young girls, in poor urban and rural areas. In addition, collecting unsustainably some biomass sources like forest waste, for energy purpose, degrades the soil exposing it to erosion (Hazell and Pachauri 2006).

The energy-related problems described above and many others require a behavior change so as to meet some of the Millennium Development Goals (MDGs). In other words, alternative or renewable energies are known as huge opportunities not only to save the Earth, our global environment, from higher temperatures, but also to satisfy our socioeconomic needs (Smith 2002). It's estimated that "by 2050, one-third of the world's energy will need to come from solar, wind, and other renewable sources" (http://www.altenergy.org/). However, due to the diversity of alternative energy sources, producing some or all of them to meet the increase demand for energy can be cost-effective or costly according to their availability and potentialities in each country.

In this paper, I focused on bioenergies as sources that can generate Côte d'Ivoire's sustainability. It does not mean that the other sources are useless or unavailable. It's actually affirmed that while all African States have abundant atmospheric resources like rainfall, air, solar radiation or insolation, and wind, in West Africa, where Côte d'Ivoire is located, "wind and solar energy is still underexploited" (Wamukonya, Masumbuko, Gowa, and Asamoah 2009). Before developing some reasons why I suggested the production of bioenergy rather than others, I would like to give a short overview of the country's energy situation.

For electricity production, Côte d'Ivoire is equipped with six hydroelectric and three thermal power stations. Regarding hydrocarbons, since 2000, under contracts on production sharing, crude oil and natural gas are being explored and exploited in the Ivorian sedimentary basin (IMF 2009). Despite its energy infrastructure, cheaper access to modern energy in the country is a great concern to many households, mainly in suburban and rural areas. In sum, the energy situation is as follows (IMF 2009):

i. Almost 70% of the energy needs are met by traditional biomass sources;
ii. 31% of the territory is electrified with 71% of the population living in the electrified areas;
iii. Rural and suburban areas are much less electrified and people are most of the time fraudulently connected to the electricity grid;
iv. Less than 20% of households have electricity subscription;
v. The production of crude oil and natural gas is in decline since 2006 due to financial, technical, and infrastructural problems;
vi. The absence of a regulatory framework for petroleum products transportation, the malfunctioning of their distribution chain, and the low storage capacities of butane gas also result in disruptions in the management of hydrocarbons;
vii. Paradoxically, since 1994, the country exports electricity to other West African countries like Benin, Burkina Faso, Ghana, Mali, and Togo.

In addition to the general concerns linked to the exploration and exploitation of fossil energies, the energy sector is particularly marked by irregularities such as an excessive use of traditional biomass, a contrast between the energy potential and the local market supply, a lack of policies towards renewable energy sources, a lack of an efficient national policy regarding electrification, the deterioration of infrastructure (electricity, roads, telecommunications, etc.) exacerbated by the sociopolitical instability since the 1990's, and so forth.

However, I do not argue that as the government pays more attention to alternative energies, specifically bioenergies, in addition to hydraulic and thermal energies already exploited in the country, the whole energy issue will be solved. The limits of the Ivorian energy sector have more to do with management. Instead, "Bioenergy Policy in Côte d'Ivoire" aims to explore and communicate the country's related opportunities in order to stimulate policymaking from the government. The option for bioenergies rather than other sources is based on three fundamental reasons.

First, the Ivorian economy is largely dependent on agriculture. The country is the first global cocoa producer with around 40% of the total production (Global Witness 2007) and ranks third worldwide for coffee (MONGABAY.COM 1998). The agricultural sector engages roughly 68% of the population and includes the main export crops: cocoa, coffee, cotton, timber, palm oil, banana, pineapple, cashew, etc. (CIA 2012).

Developing bioenergy projects could increase the value of the agricultural sector since not only the energy crops will extend the productions, but also agricultural waste, biomass waste, animal waste, and others will serve as energy sources. Modern bioenergies, mostly liquid biofuels, are more cost-effective than other sources thanks to five key factors (Castro 2007): widely available resource (biodiversity); available on demand (stored biomass energy available anytime); convertible to convenient forms (potential to provide all the major energy carriers); less carbon emitter (contrary to fossil fuels); and source of rural livelihoods (rural poverty reduction).

The second reason why I am enthusiastic about bioenergies is the need to move from an export-oriented agriculture to an agro-industrial economy. Since its independence from France in 1960, Côte d'Ivoire remains poor despite a strong agriculture because most of its crops are exported as raw materials to industrialized nations. The industrial sector occupies 20.9% in the GDP, whereas agriculture is 29.2% and the services 49.8% (CIA 2012). Taking advantage of the development opportunity offered by bioenergies implies increasing the contribution of the industrial sector to the economy since the idea is not to export the energy sources, including crops and waste, but to process them in rural areas for domestic uses and potential external markets.

By importing and implementing related technologies, the agro-industry will improve and increase the industrial size of the country, and the existing but limited agro-food factories will also increase and work in cooperation with the bioenergy industry as food waste will highly participate in energy production. Such a transformation within the agricultural activities could step by step modify the economic landscape of Côte d'Ivoire and make it less dependent on industrialized countries.

Third, bioenergy projects could help tackle a crucial social phenomenon: rural exodus. It's well known that most of the young people moving to big cities are jobseekers. Consequently, many rural families get divided and the problems of urban decay increase given overpopulation and the lack of jobs as well. With bioenergy industries, there is the likelihood of an abundant labour supply due to the labour intensive aspect of biomass "even in industrialized countries with highly mechanized industries" (Hazell and Pachauri 2006). Such industries create jobs at different levels such as "highly skilled science, engineering, and business-related employment; medium-level technical staff; low-skill industrial plant jobs; and unskilled agricultural labor" (UN-Energy 2007). In addition to rural exodus, the issue of administrative decentralization underway in the country can accelerate as rural areas industrialize.

These reasons justify why I consider bioenergy as a suitable alternative source for Côte d'Ivoire. However, my opinion is not shared by the government that thinks this could threaten food security. The Ivorian government actually recognizes the advantages of bioenergies, especially "job opportunities in rural areas, decrease in energy prices, and markets diversification", but is afraid that people will use lands to promote energy crops, decreasing food security (FAO 2008). The remark implies that the production of bioenergies could generate such a competition that food supply would decline because most of the landowners and farmers would convert their lands from food production to energy projects.

In the paper, I argue that business and social welfare opportunities given by bioenergy projects can never decrease food supply as long as the sector is organized by sustainable regulations and plans. My argument is based on successful experiences from other countries. Even in Côte d'Ivoire, some related activities are underway, but the only problem is the lack of a legislative framework and a national plan to organize them (Developing Renewables 2006).

Moreover, under the pretext of food security, Côte d'Ivoire is among the West and Central African countries with an uncertain attitude towards bioenergy policy while oil imports are making them poorer and poorer (Rural Hub 2008).

In sum, this study shows how bioenergy can be developed in Côte d'Ivoire without harming food security. Therefore, the following questions need to be analyzed carefully: How do the different production factors affect bioenergy projects? What are the possible benefits of producing bioenergy rather than other renewable energy sources? What challenges could the Ivorian government face in implementing bioenergy policies? What could be the possible policies to deal with those challenges? As tentative answers, I will show that a sustainable land use, the diversification of bioenergy sources, and a strong policymaking help prevent food insecurity and obtain other advantages when producing bioenergies.

The methodology chapter includes the approach I used for research, a description of how I collected the useful data and drew conclusions. However, as in any thesis or dissertation, upon analyzing data and drawing conclusions, I identified in the discussion chapter the likely limits of my view regarding bioenergy policy in Côte d'Ivoire and how to tackle them.

II. PURPOSE AND OBJECTIVES

I could have stated my purpose and objectives in the introduction chapter above, but I decided to discuss those issues separately because I think this way is more likely to catch the reader's attention on what I am trying to achieve.

1. PURPOSE

The purpose of this paper is to deal with energy issue in Côte d'Ivoire. As I mentioned in the introduction, modern energy is not yet affordable for most people. Moreover, traditional biomass that is the main energy source countrywide, mostly in rural areas, contributes to atmospheric pollution and represents a disease-generating factor. Despite that situation, the government doesn't consider alternative energies in its energy policies while there are available related resources. Consequently, the purpose is to find sustainable solutions to the country's energy crisis.

2. OBJECTIVES

2.1 Main Objective

Through seeking solutions to the energy problems, my main objective is to stimulate governmental interest and decision-making that takes into account bioenergies in energy policies. Among the country's energy opportunities, bioenergy sources are actually the most available. Therefore, it would be more cost-effective to develop this sector in priority.

2.2 Specific Objectives

2.2.1 Food Security and Energy Security

Since the Ivorian government underlines the risk that farmers will convert agricultural lands into energy plantations as it promotes bioenergies, my first specific objective is to show that food and energy are complementary. On the one hand, energy is needed to process food.

On the other hand, waste from food crops, not only on production areas, but also on processing areas, serve as energy sources. In addition to waste-to-energy policy, clean energy production can rely on other sources like biomass, degraded lands, etc. Consequently, it can be proved that bioenergy development doesn’t represent an irreversible threat to food security.

2.2.2 Energy Cooperation

As a second specific objective, I plan to encourage the government to promote energy cooperation by sharing its experience and discussing with other countries at the regional and international levels. In this context, Côte d’Ivoire will learn from countries with sustainable energy policies including conventional energies, alternative energies, energy security, food security, etc. That kind of cooperation will also facilitate energy technology transfer from experienced countries. At the same time, it’s clear that those countries will know about the Ivorian current energy practices and show a great interest in the country’s related resources and opportunities.

For that purpose, in the literature review chapter, I described how some writers deal with the issues of land, resources, and decision-making as regards bioenergy policies. I also enumerated successful experiences in selected countries and number of projects in progress or aborted in Côte d’Ivoire.

2.2.3 Economic Development

My last specific objective is to define the role of bioenergy in economic development. As it’s seen, it increases the economy of some developed and emerging countries. Among others, the US is the first global biodiesel producer while Brazil ranks first regarding bioethanol (Lopes 2009; Hazell and Pachauri 2006).

My argument is that the industrialization process of countries like Côte d'Ivoire can rely on energy resources from agriculture. So, bioenergy projects have potential for developing economy since industrialized nations are known as developed ones.

In sum, if the Ivorian government is convinced that food security and energy security are complementary, that cooperating with other countries is helpful, and that bioenergy industries participate in developing economy, it will surely revise its national energy plans. As a result, most people will access clean and affordable energy and economic activities will grow.

III. METHODOLOGY

1. RESEARCH METHOD

In accordance with the three hypotheses respectively linked to land use, resources, as well as policy partnership, the research method I selected is the causal method in order to determine the cause-effect relationships in my argumentation. In the introduction, I mentioned as hypotheses: using sustainably land, diversifying bioenergy sources, and developing a strong policymaking so as to preserve food security while developing bioenergies. The causal method actually shows how land use prevents land competition, the relationship between resource diversification and sustainability, and the roles of all the stakeholders in mitigating risks. In each case, the relationship is established between both variables.

As we learned from the Person's Correlation, for the causal relation to happen, one variable impacts the other variable (UWE 2007). Altogether, the hypotheses explain the conditions under which bioenergy can be advantageous to Côte d'Ivoire. Experiments realized by other countries mentioned in the literature review below strengthen my argumentation.

Contrary to the causal research method, other methods could not help develop properly the hypotheses and find out the efficient ways and means to produce bioenergies. As an example, the descriptive research method is associated with collecting information, describing the reality, but without analyzing its causes, nor designing conclusions (Hale 2011).

Nevertheless, since the descriptive research methods include observation, case study, and survey (Hale 2011), it's important to inform that this thesis methodology also took into account the descriptive method through case study which consisted in revealing experiences from selected countries that are Mali, Brazil, Korea, and others. Therefore, both the causal method and the descriptive method were adequate.

2. TYPES OF DATA

On the one hand, I focused on quantitative data to examine land and bioenergy sources. On the other hand, qualitative data were more suitable to analyze government initiatives, PPP, and development assistance by international organizations in selected countries and Côte d'Ivoire. Also, I gathered data from the secondary source though I recognize the originality of primary data (survey, observation, experimentation, interview, etc.). I did so for two reasons. The main reason is the sociopolitical instability following the 2002 armed conflict that divided Côte d'Ivoire into two parts: the North occupied by rebels and the South by the government. Today, the situation is better, but the conflict's impact is still perceptible. In rural areas, especially in rebel zones, farmers were displaced with their families and agricultural activities were affected in such a way that illegal networks were created to export crops (Global Witness 2007).

Today, displaced farmers and other rural people are returning to their places and reorganizing. However, it's not yet time to get recent and accurate primary data from them for being in a state of shock. Instead, available data on the Ivorian agriculture, in addition to data from other countries, were useful to support my argumentation.

The other reason why I focused on secondary research data is linked to the disadvantages of primary data. In addition to addressing a large volume of people in order to gather excessive data, sometimes based on feelings, emotions, personal views, etc., primary research data techniques could be costly and time-consuming (http://ag.arizona.edu/arec/wemc/nichemarkets/7_PrimaryData.pdf).

On the contrary, secondary data were helpful because of the diversity of information on energies and the universality of the issue. The sources include energy books and papers, environmental reports, seminars, websites, government studies, institutional publications, etc. As regards bioenergy ingredients – land, resource, policy partnership –, I completed data I got on Côte d'Ivoire with those on other countries. That would have been complicated to achieve in the case of primary research data process.

3. DATA ANALYSIS METHOD

Upon gathering data, I sometimes compared those on Côte d'Ivoire to those on selected countries and I found out the conditions under which Côte d'Ivoire could achieve as well as the others bioenergy projects. The comparative method took into account both statistical and non-statistical data.

4. LIMITS OF THE METHODOLOGY

To sum up, the methodology I opted for is composed of:

i. Cause-effect relationships and case study as research methods;

ii. Quantitative, qualitative, and secondary data;

iii. Comparative method for data analysis.

However, it has limits. Concerning the research methods, I argue that applying policies undertaken by other countries could make Côte d'Ivoire perform well in the bioenergy sector, but, in the same conditions, there is no evidence that the same causes will produce the same effects. In other words, the cause-effect relationship is not necessarily universal. Therefore, when analyzing comparatively data I got on Côte d'Ivoire to those on Brazil, Korea, Mali, or other countries, I found that Côte d'Ivoire has potential for achieving bioenergy projects, but how can I make it sure? Also, regarding data, as I mentioned, due to sociopolitical trouble, there are limited recent data on the country's agricultural production.

Such a situation could complicate the consideration of agricultural waste for energy projects. Moreover, I am aware that the use of secondary data is very delicate. Not only some of data I exploited were produced for other purposes different from my subject, but also, there is the risk of gathering some biased secondary data because those data are moving from hand to hand.

5. CONCLUDING REMARK

Considering the advantages and disadvantages of the study method I selected, I found that it helped me state the problem, develop the hypotheses, analyze data, and draw conclusions. It's clear that any methodology has its pros and cons and is likely to improve depending on research requirements.

IV. LITERATURE REVIEW

Regarding energy, one can look at diverse writings both at the national and international levels. Many reports, theses, journal papers, and other papers are available on energy patterns with a focus on the growing trends for alternative energies considered as outstanding solutions to the global energy crisis due to great concerns about fossil energies. In this chapter, I evoked how some writings underlined the need to produce bioenergies as well as the attitudes to be adopted by the governments. From the global to the domestic trends, the literature review analyzed the negative and positive impacts of key issues like land, resources, and policymaking.

1. LAND

1.1 Negative Aspect of Land Use for Bioenergy Production

The human pressure on land for activities like urbanization, infrastructure development, and agriculture including food and energy crops is likely to generate a negative impact on land so that sustainability could drop back (Wamukonya, Masumbuko, Gowa, and Asamoah 2009). Bioenergies contribute to land competition, threatening thus the socioeconomic and environmental fundamentals of sustainable development. Indeed, "by 2030, bioenergy requirement for arable land will increase at 36%" (Wamukonya, Masumbuko, Gowa, and Asamoah 2009). Consequently, one could understand that food insecurity is expected to keep on taking place in the long run.

The land use changes also threaten pastoral lifestyles with the reduction of grasslands designated to feed domesticated and wild herbivores (UN-Energy 2007). In this context, the Intergovernmental Panel on Climate Change (IPCC) underlined the rise in the global land area dedicated to bioenergies by the 2050's and a scenario in this sense indicated the use of

385 million hectares, “one quarter of the present planted agricultural area, with three-quarters of this area in developing countries” (Hazell and Pachauri 2006). The main focus is the poor in rural areas, where energy plantations are developed, as those people planting a particular piece of land at a fixed time, may lose their land and suffer more poverty and food insecurity (Hazell and Pachauri 2006).

The concerns regarding land in connection with bioenergies also have to do with environment. Despite its main purpose of mitigating global warming due to carbon dioxide released by some energy sources such as fossil energies and traditional biomass sources, bioenergy production has some drawbacks on the ecosystem and the living environment. One of them is the excessive use of fertilizers in agricultural practices. As bioenergy production increases, the need for fertilizers increases and that can harm “areas of high conservation value” (Wamukonya, Masumbuko, Gowa, and Asamoah 2009). It’s also argued that converting land into energy crops without adequate measures has often proven worse than fossil fuels due to the net amount of carbon released in soils (Wamukonya, Masumbuko, Gowa, and Asamoah 2009).

Moreover, in bioenergy activities, there is no way to neutralize carbon since the channel “also requires fossil fuels for growing, transporting, and processing the feedstock and for refining and distributing the biofuel” (Hazell and Pachauri 2006). Other issues discussed by the literature are the risk of erosion upon removing too much biomass from the soil as well as the reduction of water resources and other biodiversity components (Hazell and Pachauri 2006).

The hydrological impact is more severe when the energy crops are planned to grow rapidly because while natural plants and certain food crops grow slowly with less water requirement, the active human intervention in developing energy crops increases the need for water (Hazell and Pachauri 2006).

1.2 Positive Aspect of Land Use for Bioenergy Production

The literature suggested some alternatives to tackle the land problems for bioenergy development. A Sustainable land management by identifying adequate areas actually prevents competition when producing bioenergies. In other words, the best option to avoid land competition is to use "degraded or marginal lands", but there are still technical, socioeconomic, and political concerns regarding degraded lands (Wamukonya, Masumbuko, Gowa, and Asamoah 2009). Despite those challenges, in this chapter, I indicated how "successful plantations have already been established on such lands in some developing countries" (Hazell and Pachauri 2006). Moreover, it's useful to know that energy crops occupy only 2.3% of the current global agricultural lands (Wamukonya, Masumbuko, Gowa, and Asamoah 2009).

From the environmental perspective, renewable energies are an outstanding solution to the continuous increase in the earth's temperature. In this context, the 450 scenario elaborated by the International Energy Agency (IEA) is a strategy to protect the Earth by "limiting the increase in temperature to 2°C", but the failure of the Copenhagen Accord showed the difficulty to achieve the goal without real commitments to the world energy production and consumption patterns (UNFCCC 2009 and Birol 2010).

Among polluting activities, in rural areas, using petroleum diesel for agricultural machinery, slash-and-burn-farming, and others, can reduce air quality and generate health problems **(**UN-Energy 2007). Another source of pollution is the excessive use of traditional biomass resources like charcoal and firewood even in urban areas. The literature mentioned "2.4 billion people relying on traditional biomass for their energy needs and 1.6 billion not having any access to electricity" (UN-Energy 2007). Reference is made to poor countries where biomass is easily available to people for their basic needs relative to cooking and heating. In addition to polluting the living environment and the atmosphere, the production of firewood and charcoal is “associated with degradation of forest and woodland resources and soil erosion” (Hazell and Pachauri 2006). In Kenya, for example, people involved in producing charcoal get “only 1kg of charcoal for every 6 kg of wood harvested” and “in one year, an urban household cooking exclusively with charcoal uses between 240 kg and 600 kg of charcoal, produced using between 1.5 ton and 3.5 tons of wood” (Hazell and Pachauri 2006).

As a result, alternative energies, mostly bioenergies, are adequate to save the Earth and improve human condition. To this end, enhancing degraded lands “would also improve soil quality, sequester carbon, and restore habitats” (Wamukonya, Masumbuko, Gowa, and Asamoah 2009). In developing countries, where the dependence on fossil fuels and traditional biomass is higher, classified degraded lands are estimated at “about 2 billion hectares” (Hazell and Pachauri 2006).

The decline in the GHGs emissions is also expected as a huge benefit from bioenergies. Among other advantages (UN-Energy 2007; Wamukonya, Masumbuko, Gowa, and Asamoah 2009):

i. They participate in implementing sustainable agricultural techniques by saving energy, varying plants, and reducing chemicals;

ii. They are useful in transportation, electricity, and Combined Heat Power (CHP);

iii. Households can increase forest and other natural resources conservation, and avoid indoor and air pollution by using modern bioenergies like biogas instead of burning wood and organic waste.

As the global bioenergy development focuses on mitigating climate change mainly caused by fossil fuels, land use changes, and agriculture **(**UN-Energy 2007), there are expectations such as “Decline at twice in carbon emissions from 1990-2008 to 2008-2020 and about four times in 2020-2035; Increase in low-carbon technology at more than three-quarters of global power by 2035; Increase at 39% in new sales for plug-in hybrids and electric vehicles by 2035" (Birol 2010).

2. BIOENERGY SOURCES

2.1 Negative Uses of Resources for Bioenergy Production

The technologies used in bioenergy development take into account combustion, gasification, and fermentation, and rely on diverse sources that are "traditional crops (sugarcane, maize, oilseeds), crop residues and waste (maize Stover, wheat straw, rice hulls, cotton waste), energy-dedicated crops (grasses and trees), dung, and the organic component of urban waste" (Hazell and Pachauri 2006). However, from an input to another, the outcomes may be different. From the negative view, for example, it's stated that converting oilseeds into biodiesel and maize and sugar beets into ethanol is not competitive with oil price, nor better regarding CO_2 emissions. Considering other examples like waste and the scale of plantations in bioenergy projects, not only the soil is likely to be impoverished and exposed to erosion when too much biomass waste is removed, but also large-scale feedstock plantations compete over water with food crops, degrade sites of high value conservation with excessive use of fertilizers, and harm biodiversity (Hazell and Pachauri 2006).

Furthermore, the result of a scenario in which the global amount of fossil fuel consumed daily is translated into bioenergy is an increase by "15 and 5 times of, respectively, the current world plantings of sugarcane and maize". It means the excessive need for those crops is a potential source of land competition (UN-Energy 2007). Consequently, the prices of some main food crops, like sugar, maize, rapeseed oil, palm oil, and soybean, also used as biofuel feedstock, have already increased due to their shift toward energy-dedicated crops (UN-Energy 2007). In developing countries, due to the weak utilization of crops for energy purpose, there is so far no fundamental data to size their benefits for the poor (Hazell and Pachauri 2006).

2.2 Positive Uses of Resources for Bioenergy Production

For bioenergy sources to be cost-effective, producing them should take into account conditions like economic viability, suitability, productivity, inputs, flexibility, resistance potential, competiveness, opportunity costs, and so forth. As examples, ethanol from sugarcane is cheaper than oil and emits less carbon and using degraded soils for bioenergy crops contributes to environmental restoration (UN-Energy 2007).

Furthermore, though bioenergy production could generate land competition and an increase in food prices, "yet the poor would gain from cheaper energy" (Hazell and Pachauri 2006). Indeed, the higher food price will benefit farmers in developing countries who will produce more and there will be more agricultural waste as bioenergy feedstock, leading to jobs and incomes (Hazell and Pachauri 2006; UN-Energy 2007). However, second-generation technologies converting trees, grasses, and waste into energy, should be prioritized in order to reduce dependence on land (UN-Energy 2007).

In populated agricultural nations, especially in rural areas, where lands are mainly used for food, it's clear that agricultural activities generate a large amount of residues. Therefore, much energy can be obtained from those residues. Besides, collecting and converting agricultural and biomass waste into energy generate the creation of facilities in order to increase rural economic activities. Among others, some crop waste like "sugarcane bagasse, sisal waste, coffee husks, rice husks, maize cobs, and banana leaves", which are produced in processing factories, have a higher cost-effectiveness (Hazell and Pachauri 2006).

Moving from traditional biomass energy to modern bioenergy may be easier and advantageous to poor countries where almost 2-3 billion people get their energies services from firewood, charcoal, manure, and agricultural residues (Hazell and Pachauri 2006; UN-

Energy 2007). It's all about modernizing those sources and getting the net benefits for rural populations, the environment, agriculture, and economy (Hazell and Pachauri 2006). In addition to using waste for energy, developing energy-dedicated crops in rotation with food crops on the same lands also "improves productivity and disease and pest resistance while diversifying income opportunities for producers", and specifically jatropha contributes to restore degraded lands (UN-Energy 2007). The opportunity is the creation of "new markets for farmers" (Hazell and Pachauri 2006).

Environmentally, ethanol and biodiesel in transportation pollute less than fossil fuels. Also, biogas from human and animal waste reduces bad odors in residential areas and near waste disposal, and preserve air quality (UN-Energy 2007). Moreover, not only biogas from biowaste reduces the amount of organic waste containing "methane, a GHG 21 times more potent than carbon dioxide", but also biochar derived from biofuel "helps store carbon in the soil while also reducing soil emissions of nitrous oxide or methane and providing valuable fertilizer" and such fertilizers help develop the conservation agriculture technique which sequesters more carbon (UN-Energy 2007).

In sum, diverse resources are available so that, from 10% of the global energy supplies, bioenergy applications are expected to increase due to the growing and better trends for diverse unused residues and energy crops (Hazell and Pachauri 2006).

3. POLICYMAKING

3.1 Negative Aspect of Policymaking for Bioenergy Production

The policy framework should be the driving force in bioenergy projects. Otherwise, such projects become costly both to food security and environment, and the topical "food, feed, or fuel debate" remains without sustainable decisions (UN-ENERGY 2007). As reported, about 854 million people, predominantly in developing countries, suffered from hunger from 2001 to 2003 (UN-ENERGY 2007).

Additionally, due to business opportunities in bioenergy activities, as stakeholders including decision-makers, private sector, financial institutions, and individuals get involved, small farmers are likely to lose their lands or lands they rent (Hazell and Pachauri 2006). In fact, land competition is expected to be competition between not only food and energy-dedicated crops, but also competition between landowners and renters, leading to concentration of ownership (UN-ENERGY 2007).

Another policy issue has to do with subsidies and tax reductions. The main purpose of reducing taxes for liquid biofuels is to promote the use of these bioenergy sources rather than conventional oil, limiting GHGs emissions. However, in accordance with experiences from the US, Brazil, and Thailand, it's reported that it's sometimes "inefficient to subsidize cleaner fuels", mainly when subsidies are higher than the benefits of reducing GHGs emissions through ethanol (UN-ENERGY 2007).

Another constraint is the weak or non-enforcement of international energy agreements. The Copenhagen Accord, among others, failed to achieve the 2°C goal as the main polluters didn't reduce their emission targets as promised (Birol 2010).

3.2 Positive Aspect of Policymaking for Bioenergy Production

For bioenergy activities to produce good results, sustainable policies taking into account energy, environment, agriculture, and trade need to be undertaken in various ways at the country, interstate, and international levels (UN-ENERGY 2007). Analyzing the country side, the first thing to do is to increase education and public awareness campaigns relative to energy and food securities. Accordingly, subsidizing producers on degraded lands could be an option and there are available guidelines on bioenergy projects "including the availability of rural infrastructure, credit, and land tenure" (UN-Energy 2007). In other words, some papers underlined the need to assess before selecting the suitable “technologies, policies, and investment strategies to pursue” in order to perform well both in agriculture and energy (UN-energy 2007). Also, key factors like feedstock, market, and objectives contribute to develop energy policies and attract investments and initiatives (UN-Energy 2007).

However, decision-makings should not only take into account the landless peasants as well as the poor, in general, by including them in energy projects and facilitating their access to food and energy, but also focus on small scale projects, which could be cost-effective and generate jobs and incomes in rural areas, as it happens in the US and Brazil, the two largest ethanol producers, where small farmers and “small rural cooperatives” participate in training programs aimed at giving them technical advice and building their capacity (UN-Energy 2007).

In addition, the tax policy properly developed to promote bioenergies could prove successful since their advantages and costs may vary from a country to another, each one analyzing its context in collaboration with international assistance and cooperation (UN-ENERGY 2007 and Birol 2010). For this purpose, human and infrastructure capacities are fundamental to mitigate risks relative to food availability, access, stability, and utilization, and consider competitiveness when adopting bioenergy policies (UN-ENERGY 2007 and Birol 2010). Also, due to the weakness of developing country’s currencies, it’s clear that importing conventional oil increases the cost of foreign exchanges transactions as the global foreign exchange market’s currency is the dollar (UN-ENERGY 2007). Therefore, bioenergies could reduce the dependence on conventional oil and reduce foreign exchange needs. Differently, at the same time, on the same foreign exchange market, with the same currency, exporting bioenergy is economically profitable to developing countries since the business generates enormous incomes when governments play key roles by enforcing regulations to support bioenergy sources with commercial value (UN-Energy 2007).

In summary, with government incentives as demonstrated in Brazil, the European Union (EU), and the US (UN-Energy 2007):

i. Bioenergies can compete on the market and reduce fossil oils prices;

ii. Countries mostly depending on the oil market can diversify their supply;

iii. Farmers can increase incomes by extending the market to bioenergies.

In order to share knowledge and experiences, some nations work in association and this interstate strategy includes dialogues between the public and the private sectors, local communities, and others from different countries (Wamukonya, Masumbuko, Gowa, and Asamoah 2009). As an example, the Pan-African Non-Petroleum Producers Association (PANPPA) aims to promote biofuel industry in Africa (UN-Energy 2007). Also, South-South cooperation between Cameroon, Ghana, Guinea-Bissau, Mali, and Mexico exists for biodiesel production while Brazil, India, France, the UK, Haiti, Malawi, Mozambique, Nigeria, Senegal, and South Africa work in a South-South-North cooperation context to develop ethanol (UN-Energy 2007). The benefits of bilateral and trilateral partnerships are visible in countries like Nepal where the Dutch-Nepalese Biogas Support Program is meeting the energy needs of 3% of people through 120, 000 biogas plants, and Brazil where Germany "financed the production of 100,000 additional ethanol-driven cars" (UN-Energy 2007).

For any kind of cooperation to be efficient, the stakeholders should take advantage of the PPP since it's achieving Research and Development (R&D) regarding bioenergy so that adopting bioenergy policies could attract investments and technology transfer (UN-Energy 2007). In Philippines, different German institutions cooperate with the Leyte State University to install an efficient cooking stove and plant oils sold at a cheaper price in order to save time and money (UN-Energy 2007).

In addition to the country and the interstate levels, international policymaking helps mitigate risks and get higher returns when investing in bioenergies because, at that level, governments, the private sector, and international organizations, mostly those of the UN System, cooperate with the purpose of establishing adequate regulations and standards as regards lands, sources, markets, taxes, etc. (Wamukonya, Masumbuko, Gowa, and Asamoah 2009). Within this framework, not only the UN System experts in energy play a key role by assisting energy stakeholders, both in the public and private sectors, in implementing their energy plans, but also International Financial Institutions (IFIs) are likely to assist them through microcredit for small-scale and large-scale bioenergy projects in developing countries (UN-Energy 2007).

As far as the private sector is concerned, the investments of Multinational Corporations (MNCs) in bioenergies are strong when the sector is incentivized by governments. Loans from IFIs also help States mitigate risks and increase benefits. In sum, the private sector provides management skills and a great part of the financial resources, the public sector represented by the government frames the business environment by adequate regulations, and donor communities, as well as IFIs, contribute financially (UN-Energy 2007). Other international organizations like the UN-Energy, UNESCO, and FAO contribute by establishing management tools and guidelines aimed at supporting agro-industries in rural areas (UN-Energy 2007).

Among other instruments, bioenergy development projects could rely on the Global Bioenergy Partnership (GBEP), International Bioenergy Platform (IBEP), UNCTAD, and Global Village Energy Partnership (GVEP) so that both food and energy securities could get preserved without harming the environment (UN-Energy 2007). As well, the FAO, UNEP, UNIDO, UNCTAD, and WTO are planning bioenergy certification standards and, specifically, the UNEP, through its Rural Energy Enterprise Development (REED) programs, encourages clean energy initiatives and activities in Africa, Brazil, and China (UN-Energy 2007).

Nevertheless, one should also analyze the bioenergy enterprise from the market side. In other words, what can be done at the international level to make bioenergies, precisely biofuels, competitive with conventional oil prices? As an answer, while the WTO is planning to implement free trade in agricultural commodities with the intention of expanding biofuels, companies are analyzing bioenergy market opportunities worldwide in accordance with a decrease in oil production (UN-Energy 2007). Investments are expected to increase, as bioenergies accesses international markets, and Central American as well as Sub-Saharan African countries are likely to produce more due to lower production costs based on resource availability, climatic conditions, and other opportunities necessary to develop bioenergy industry and markets (UN-Energy 2007).

In brief, bioenergies are so delicate that their development can generate benefits when the issues of land, resources, and policymaking are well considered, but fail to achieve the expected goals as those issues are not managed in a suitable way. Discussing experiences from other countries will surely help learn more on the subject.

4. BIOENERGY EXPERIENCES IN SELECTED COUNTRIES

4.1 MALI (UN-Energy 2007 and FAO 2009)

4.1.1 Opportunities

Implemented in the Garalo commune a rural electrification project aims to supply power produced from jatropha seed, on a small-scale plantation, to more than 10,000 people over 19,800 inhabitants, from different ethnic groups. 300 farmers deal with the jatropha cultivation and the opportunities Mali has for the project are its extreme poverty, the cost of the increasing global oil prices, the decline in cotton price, etc.

In Mali, only 1% of the rural population accesses modern energy services like electricity and Liquefied Petroleum Gas (LPG). This issue, the abovementioned opportunities, and the interest of international business companies in jatropha made it easier to the country to redevelop this energy crop since it has a related experience. Other attractive factors are the likely role of jatropha residues as fertilizer, its ability to protect the soil against erosion, its weak GHG emissions, and the use of fewer inputs (water, fertilizer, arable lands, etc.) compared to other crops. Additionally, as only 3.76% of the total surface of Mali, 1.2 million km^2, is covered by arable lands, there is an opportunity to grow jatropha on degraded lands (Sangho, Labaste, and Ravry 2010).

4.1.2 Government Incentives, Private Initiatives, and PPP

The Garalo Project (GP) is supported both by the public and private sectors. From the public side, the national energy policy integrates renewable energies, specifically jatropha, as a suitable means to meet energy needs while reducing dependence on conventional oil and facing environmental concerns. Accordingly, the Malian Domestic Energy and Rural Electrification Development Agency (AMADER) provides a large grant to support the energy tariff and keep the power plant sustainable. At the municipal level, authorities support the social and business model of the project through by-laws allowing rural communities to access ownership of the jatropha production and devote the local production to the power plant.

From the private side, domestic and international institutions intervene at all the steps. The Garalo Jatropha Producers' Cooperative (CPP) and the power company, ACCESS, deal with the supply. While CPP manages the technical, commercial, and financial aspects, from the jatropha seeds to the vegetable oil sold to ACCESS, as well as the residues used as fertilizer, ACCESS produces and sells electricity. Other institutions play other roles. For example, Mali-Folk Center Nyetaa (MFC Nyetaa) coordinates, mediates, raises funds, implements jatropha nurseries and the power plant, distributes jatropha plants in villages, and trains. It’s relevant to mention that ACCESS is a MFC subsidiary with a commercial status, while "MFC represents Denmark's Folk Center for Renewable Energy and is supported by global partners including the UNEP, UNDP, and the GVEP" (UN-Energy 2007), as well as the Fuel from Agriculture in Communal Technology (FACT) foundation. In the supply chain, to make it easier to people to access power at a sustainable price, an Electricity Consumer Association (ECA) plays a role of interface between consumers and ACCESS.

Besides the governmental action and private initiatives, the PPP is also critical in developing the GP and the Malian jatropha industry in general. On the one hand, the AMADER and FACT Foundation collaborate to provide the project with a large grant. On the other hand, since the 1990's, the GTZ assists the Malian government in developing diverse renewable energy projects.

4.1.3 Achievements

The GP is full of achievements relative to the following livelihoods outcomes.

Human Capital

The farmers acquired new techniques in producing and commercializing jatropha. They also know about sustainable land management, all the jatropha process from seeds to electricity supply, as well as income generation. Moreover, small electricity-related jobs (repairs, shops, connection, etc.) have been created.

Natural Capital

The concept of land use change is most fundamental with the move from cotton that is in decline to jatropha, the new opportunity, adding value to the land. In addition, the jatropha cultivation does not require much water.

Social Capital

In the villages of Garalo, the initiative increased the social relations by making people work more together to profit from the land. Famers now possess property rights over the land.

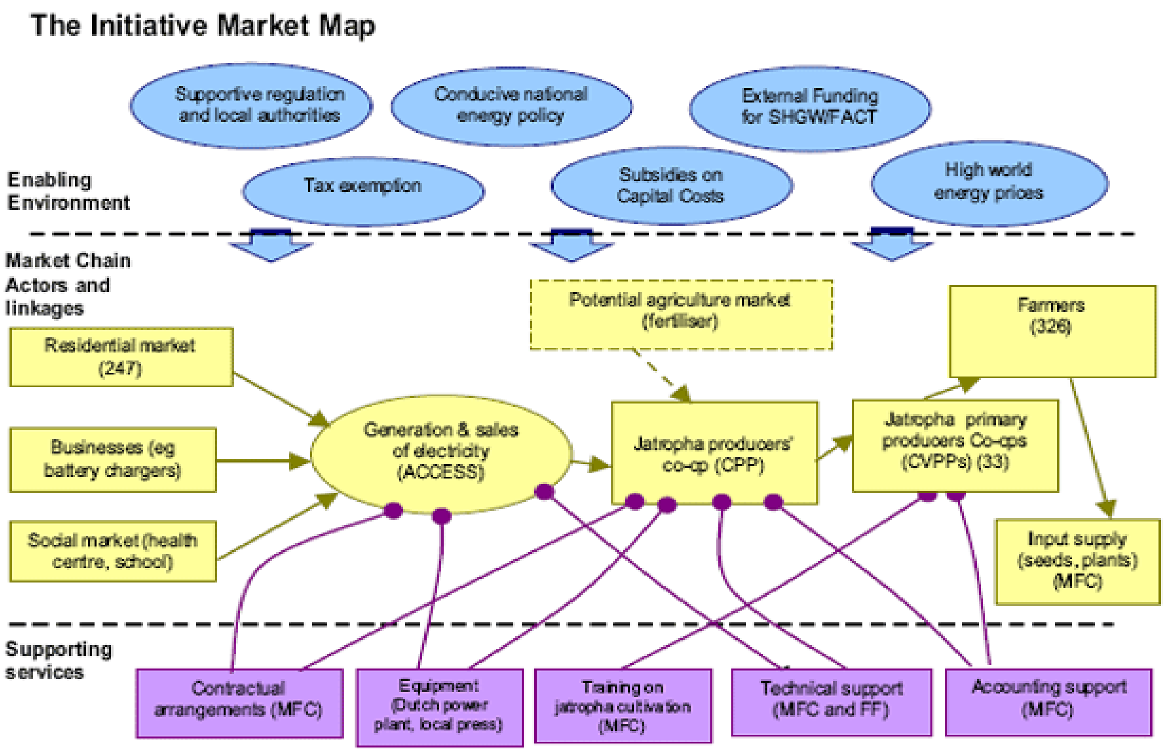
Also, the project's product, modern energy, is affordable to the villages that enjoy socio-cultural activities (music, dance, etc.) and security with street lighting. The ECA fights to preserve the sustainability of the social capital.

Physical Capital

An integrated management of agriculture and energy infrastructure is visible through the GP. This is a value added to Garalo's infrastructure as the villages are now electrified. Before, there were insufficient and poor social services and a lack of income-generating activities. Consequently, electricity changed the villages' life. In addition to the power plant, the mechanical press and the associated institutions and services processing jatropha seeds participate in improving the Garalo's infrastructure.

Financial Capital

Increased funding made a local market available to farmers with a guarantee of incomes and access to cheaper modern energy caused the promotion of new income-generating activities, leading to a decline in the prices of some basic products.



Source (Figure 1): Mali Jatropha Electrification (FAO 2009)

4.1.4 Plans for the Future

In the future, depending on the GP achievements, the initiative will be extended by the implementation of other units in other rural areas due to the land availability. Another plan is to produce biogas from the oil cake, the solid residue left after the jatropha seed. Moreover, in the long run, it's expected that the national energy policy considers the opportunity to substitute renewable energies generated locally for diesel oil in order to import less fossil fuel.

4.1.5 Challenges

What will happen to the GP if the global oil price declines? Managing sustainably the project is also thinking about such likelihood. Another issue is the unpaid bills by certain consumers because if the number of those consumers keeps on growing, it will affect the cost-effectiveness of the project. Furthermore, though the current jatropha seeds' supply in Garalo is well balanced, at the national level, the demand is higher than the supply. This situation is a threat to the communal market. Also, concerning the status of the farmers and the land, so far the issue of ownership is not yet overcome as some of them still use the land as tenants. This practice is in contrast with the Malian legislation that attributes the land to whom plants it with trees. Being jatropha a perennial tree, it makes it difficult to the landowners to rent their lands to immigrants who could become owners according to the customary law. Consequently, excluding immigrants from access to the land could weaken not only the social capital of the GP, but also the entire production process since the human capital also would be affected.

4.1.6 Lessons

The net benefits gained by Mali through the GP present, among others, the following lessons to learn:

i. Implementing a national energy strategy, in collaboration with the civil society and the private sector, as a key factor to achieve renewable energy projects;
ii. Using degraded lands for energy projects to increase the land utility while preventing food insecurity;
iii. Selecting bioenergy sources in accordance with criteria such as availability, productivity, cost-effectiveness, competitiveness, etc.;
iv. Considering poverty as an opportunity, rather than a weakness, to adopt renewable energy policies;
v. Adopting regulations and mechanisms to make renewable energies affordable to lower-income people and protect consumers' rights.

4.2 BRAZIL (Hazell and Pachauri 2006; Costa Ivan@cebi2000.com.br)

4.2.1 Opportunities

For bioenergy production and use, Brazil has opportunities like an intense solar radiation, a plentiful rainfall, excellent agricultural areas, appropriate climatic conditions, a rich biodiversity, large areas of low density population, labor availability, and experience. Moreover, though the country is the second global leader in biofuels, after the US, it's insufficiently exploiting its biomass residues and other residues for energy.

4.2.2 Government Incentives

The Brazilian bioenergy success has more to do with commitment of the government that adopted in 1975 the "ProÁlcool" policy, the Brazilian Alcohol Program, as a response to oil crisis. The government actually provided a vision of the relevant initiatives on biomass-based ethanol production. At the federal and state levels, technical standards, high technologies, financial advantages, and appropriate market conditions were implemented. Among other things, the government promoted pure ethanol fuel vehicles, guaranteed ethanol fuel prices and the ethanol market by blending all gasoline with ethanol, reduced tax on ethanol vehicles, provided ethanol producers with financial support in order to increase production, etc.

Indeed, by the 1980s and the 1990s, when the petroleum markets stabilized, Brazil kept on running its bioethanol industry. In 1997, independent power producers from sugarcane waste and other sources were allowed to sell electricity to the grid. Today, there are no more direct subsidies, but the PPP is making ethanol competitive on the market by increasing the sugarcane industry through loans and credits.

In addition to ethanol, the country officially adopted the biodiesel program in December 2004 in order to diversify the national energy matrix. In 2005, a law permitted a 2% addition of biodiesel to the petroleum diesel. By 2008, the 2% became mandatory.

To stimulate the implementation of the biodiesel program, the national development bank (BNDES) opened a special line for supporting projects up around 90%.

4.2.3 Achievements

Public policy support, PPP, and private investments play a strong role in the Brazilian bioenergy industry so that the results are encouraging. Since 2004, Brazil was the global Biofuel market leader before being overtaken by the US. On the domestic market, among the 19 million vehicles running, about 16 million use gasohol (mixture of gasoline and ethanol) and 3 million, pure ethanol. Economically, by substituting ethanol for gasoline, the nation saved around US$ 43.5 billion from 1976 to 2000. Also, as a marketable mechanism, the

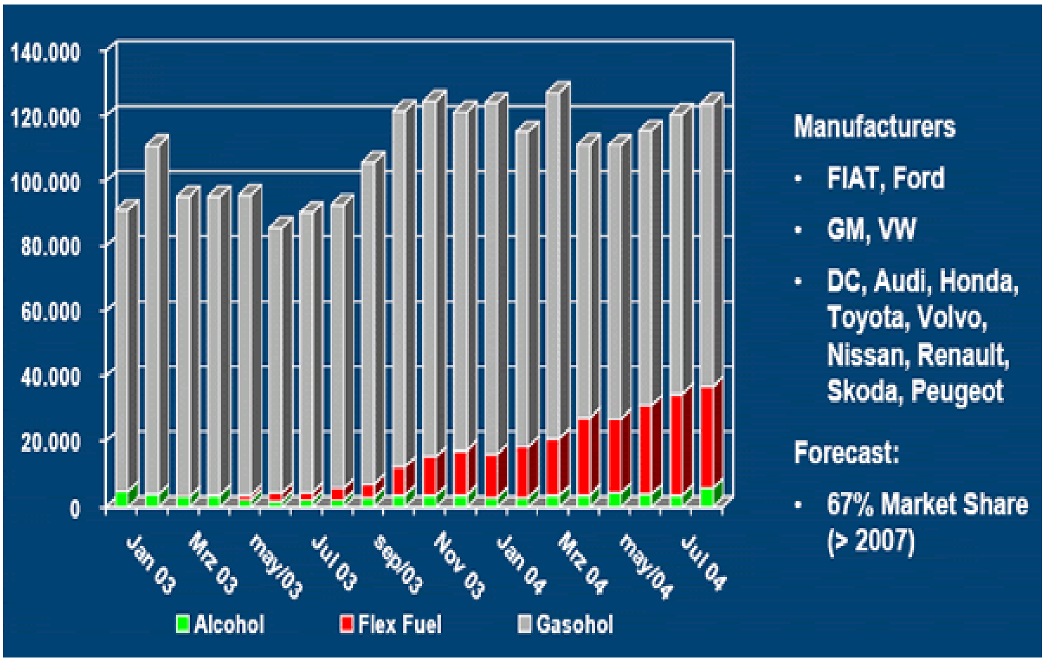
Brazilian ethanol is a tool for GHGs reduction, green growth, and urban management. The utilization of gasohol and the elimination of lead in gasoline improved air quality in large cities like São Paulo and Rio de Janeiro. As an example, adding 10% ethanol to gasoline reduces CO by more than 25%.

In terms of sustainable development, the Brazilian success is an evidence that ethanol properly integrated this concept by creating jobs, preserving a clean urban environment, and promoting clean renewable energies. Compared to oil and coal, ethanol creates many more jobs and requires much less investment. For example, there were, in 2001, one million direct and 300,000 indirect jobs in ethanol production, mostly in rural areas for unskilled workers. Also, almost 30% of sugarcane productions belong to small farmers, representing a source of income generation. Besides, great investments in the refineries increased the production of ethanol and generated the production of electricity from the sugar bagasse. The 1997's legislation on electricity supply increased the share of the sugarcane residue. Considering the amplitude of the program, to avoid land competition and preserve food security, the sugar plantations only cover 8.6% of the total land cultivated with major crops and they are rotated with food crops such as rice, peanuts, tomatoes, maize, soy, and beans.

In the automobile sector, Brazilian automakers are manufacturing Flexible Fuel Vehicles (FFVs), running on ethanol-blended gasoline (E85) or pure ethanol (E100). Biodiesel, the other type of biofuel, is also improving the bioenergy activities. In 2004, the production by source was as follows: castor oil plants – 1200 l/ha; oil palm nuts – 5000 l/ha; soya – 400 l/ha, babassu nuts – 1600 l/ha; macauba nuts – 4000 l/ha.

However, before the official launching of the biodiesel program in 2004, biodiesel oil achieved 38 billion liters in 2003, with 29 billion dedicated to transports. The imposition of the 2% addition of biodiesel to the mineral diesel actually increased the internal market during the three following years at about 800 million liters per year.

Figure 2: Sales of Flex-Fuel Cars on the Brazilian Market



Source: Bioenergy - The Brazilian Success Experience (Ivan@cebi2000.com.br)

4.2.4 Plans for the Future

To address the growing global demand for ethanol, by 2013, Brazil plans to add 3 million on the current 5.7 million hectares of sugar cultivation. Moreover, the government, Petrobras, a local oil company, and other stakeholders are co-investing in production, pipelines, railways and port facilities. Personally, Petrobras is investing to increase the export capacity of ethanol from 2.5 billion to 9 billion liters per year.

As the world leader in ethanol production, Brazil expects the same success in biodiesel. After 2013, the 2% addition of biodiesel in gasoline is planned to rise to 5% (B5). Also, the million jobs in the ethanol sector are expected to reach 1,204,000.

4.2.5 Challenges

The main challenge faced by the country in producing biofuels is the forest management. The planned expansion of sugarcane plantations is likely to increase deforestation because as plantations grow, cattle are dislocated from pastureland and integrate new areas within the forests. Accordingly, to tackle this issue, the government develops reforestation programs, but, again, environmental NGOs are worried about the establishment of large-scale exotic species plantations that are most of the time harmful to the local biodiversity (Ceccon and Miramontes 2007).

4.2.6 Lessons

The Brazilian success in bioenergy production includes the following lessons:

i. Making the automobile industry construct cars running with only biofuels or biofuels mixed with gasoline;
ii. Subsidizing biofuel projects to promote competition with conventional petroleum products;
iii. Allowing independent renewable electricity producers to access market among traditional utilities;
iv. Supporting private ownership of sugar mills;
v. Promoting bioenergy activities in rural areas so as to increase employment.

4.3 KOREA (Ministry of Environment 2010; YUN, CHO, and HIPPEL 2011)

4.3.1 Opportunities

At first sight, Korea does not seem to be a country where bioenergy activities could be successful due to some of its geographical features. Among other things, its land mass is about 100,000 km^2, 70% of which is mountainous. Regarding natural resources, specifically biomass, Korea is not well-endowed as most of its mountainous trees are manmade forests. Moreover, agriculture’s contribution to the GDP was only 2.6% by 2010 while the industrial sector accounted for 39.3% and services 58.2 (http://en.wikipedia.org/wiki/South_Korea).

However, analyzing diverse opportunities, the country undertook bioenergy development. First, its development policies consider green growth as a tool to promote sustainable consumption and production. As a matter of fact, in August 2008, in his Green Growth Declaration, the President underlined related advantages like “low carbon”, “new national development paradigm”, “new growth engines and jobs through green technologies and clean energy”. Second, despite the weak amount of natural resources, there are other fields in Korea to create the bioenergy potential. Some examples are livestock excretions, food waste, marine waste, waste wood, pruned branches, agricultural and marine byproducts, non-edible agricultural crops, etc.

Another factor to make bioenergy successful in Korea is R&D with its key role in the country’s rapid economic growth. Applying R&D to bioenergy industries actually helps achieve quality standards, cost-effectiveness, jobs creation, incomes generation, and others (Hazell and Pachauri 2006). Besides those opportunities, Environmental education in Korea includes waste sorting, green areas and parks creation, and the “Reduce, Reuse, Recycle” principle (3R). Such practices improve waste management and energy savings policies which make available bioenergy resources.

4.3.2 Government Incentives

The Korean government’s support for promoting alternative energies, and mainly bioenergy, can be evaluated on four aspects. First, Korea increased its “Waste resource-to-Energy” policy by improving the institutional aspect. With the purpose of preserving energy security, the government performed various actions in order to implement motivating factors including “Standards for Fluff” Refuse Derived Fuel (RDF) “Testing Methods, Process, etc., for Energy Recovery Standards”, “Biogas Produced from Organic Waste as City Gas” and “Animal Residues as New Renewable Energy”.

Second, in addition to being an opportunity, R&D is one of the government's incentives to promote alternative energies countrywide. R&D plays a critical role in bioenergy development from making available suitable technologies to analyzing market opportunities. Technology takes place within the "whole cycle from raw materials to energy consumption" and the "integrated application of diverse techniques and raw materials". Likewise, research sustains bioenergy activities by selecting suitable sources, analyzing costs and benefits, creating market opportunities, etc.

Third, Korea implemented a "Master Plan for Waste Resource and Biomass-to-Energy". The plan aims to achieve "Energy Infrastructure and Measures", "Low Carbon Green Village", and "Institutional Foundation".

The fourth aspect is the policy partnership. At this level, the Ministry Of Environment (MOE), the Ministry for Food, Agriculture, Forestry, and Fisheries (MIFAFF), other ministries and institutions work in collaboration to implement the "Waste Resource and Biomass-to-Energy" Master Plan, examine measures, and discuss support as well as cooperation issues.

Also, policy partnership is about working with the private sector in a "Stronger Private-Public Governance System". It consists in setting up a "Private-Public Committee by region", an "Expert Forum", and an "Active Regional Networking" in order to collect public views and disseminate information to attract public interest in "Waste Resource and Biomass-to-Energy policies".

4.3.3 Achievements

Through the government's commitment to the "Waste Resource & Biomass-to-Energy Policies", Korea achieved various goals like "facility extension and secured budgets" and "accomplishments from biomass-to-energy measures". "Facility Extension and Secured

Budgets" consist of 13 RDF plants (2,460 tons/day), 2 RDF-Dedicated Boilers (700 tons/day), and 1 Waste Heat Recovery Plant (750 tons/day).

Regarding "accomplishments from biomass-to-energy measures", four sources are examined. The first one is the utilization of livestock excretions as energy source. For this purpose, from 5 communal plants in 2007, the MIFAFF achieved 56 plants in 2010. As well, the MOE undertook the construction of "10 Combined (purification and compost and liquid fertilizer utilization) Public Treatment Plants", "2 Resource-Circulation (biogas and liquid fertilizer utilization) Public Treatment Plants", etc.

Source (Figure 3): Waste Resource & Biomass-to-Energy Policies for Low Carbon Green Growth (MOE 2010)

The second accomplishment is about "forest biomass-to-energy" through "afforestation and biomass collection" and "wood pellet production and consumption extension". While the former is associated with implementing an "integrated afforestation system in 25 places", the latter is about 10 "wood pellet plants" and "3500 home pellet boilers" by 2010 in "Rural Community Centers and Recreation Forests".

Third, in the context of "agricultural biomass-to-energy", on the one hand, Korea performed a "platform technology R&D" including an "integrated excretion-to-resource process from 2007" and "new research projects" on agricultural byproducts from 2010. On the other hand, the country implemented a "canola pilot project for biodiesel production", 4,500 hectares, "from October 2007 to Jun 2010".

Fourth, "marine biomass-to-energy" is part of the Korea's achievements in bioenergy production. That case takes into account two aspects: "Sea forests in coastal areas" and "Marine biomass technology R&D". The first aspect comprises "180 hectares of sea forests" and "artificial marine plants" while the second one underlines R&D in order to search for cost-effective and outstanding varieties.

4.3.4 Plans for the Future

The future of "waste resource & biomass-to-energy policies" in Korea promises outstanding performance in resource production, energy infrastructure, and energy supply. By 2013, 90% of the available animal excretions are planned for energy. By 2020, 0.5 million hectares farm and 2.3 billion liter ethanol are estimated. Also, by 2020, 12% of wood pellets (5 million tons) are expected to be utilized as a direct result of:

i. 50,000 hectares of rotation forest, 7,000 hectares of sea forest, and marine resource security by 2013;

ii. 1.27 million hectares of afforestation (10% of the country surface area) and 6.5 million m^2 biomass by 2020.

As far as the energy infrastructure is concerned, in addition to increasing RDF plants, recovery and resources facilities, the country is planning the creation of 14 environment energy towns in 8 regions and an Environment Post-Graduate University by 2113, as well as 600 low carbon green villages by 2020.

Therefore, “New Renewable Energy Supply Target” is expected to be 3.78% by 2013 and 4.16% by 2020. Waste and biomass contribution to the target could be 83.9%.

4.3.5 Challenges

The Korean “Waste Resource & Biomass-to-Energy Policies” are facing some challenges. As an example, for not being an agricultural country, it may be difficult to Korea to get sufficient resources so as to achieve the 83.9% of waste resource and biomass contribution to alternative energies. Also, the sustainability of such a project could be undermined by the country’s surface area. Korea is actually around 100,000 km^2, 70% of which is mountainous, with about 50,000,000 people. Consequently, the afforestation of 10% of the territory for bioenergy purpose, as planned for 2020, represents a great challenge in the national context of land use targets.

4.3.6 Lessons

From the Korea’s success in bioenergy development, the following lessons should attract attention:

i. Making it possible to undertake “Waste & Biomass Resource-to-Energy Policies” with limited available resources;

ii. Underlining and utilizing R&D as a sustainable tool to promote technology and achieve development projects in the energy sector;

iii. Implementing a national energy plan, in collaboration with the private sector and the civil society, as a key factor to achieve renewable energy projects;

iv. Selecting bioenergy sources in accordance with criteria such as availability, productivity, cost-effectiveness, competitiveness, etc.;

v. Adopting regulations and mechanisms to preserve energy security, food security, and the environment while promoting renewable energies.

5. BIOENERGY INITIATIVES IN COTE D'IVOIRE

Though the Ivorian government is not undertaking legal actions or a real involvement in bioenergy activities, there are, as follows, related initiatives and projects.

5.1 Jatropha Plantations to Energy

Jatropha is a tried-and-tested energy tree in developing African countries like Mali, Senegal, Burkina Faso, etc. As already known, the opportunities offered by jatropha are impressive. Consequently, in Côte d'Ivoire, some organizations and individuals are cultivating the tree, mostly in rural areas. For example, the Ivory Coast Renewable Energies Development Agency (ADERCI), a private agency, assisted 70,000 farmers in planting 100,000 hectares of jatropha and castor seed on degraded lands, in the center of the country, as an additional crop to cocoa and coffee (African Agriculture 2008). Oil from both sources is expected to be sold to the Ivorian Refinery Company (SIR) and the Côte d'Ivoire's Petroleum Activities Firm (PETROCI) for diesel. The expectations are high since 5,000 hectares of each of both crops can generate annually between 15 and 23 million liters of biodiesel (African Agriculture 2008).

In addition to the center, in the eastern part of the country, previously dominated by cocoa and coffee plantations, many farmers are diversifying their activities with jatropha on abandoned lands (African Agriculture 2008).

5.2 Urban Solid Waste to Energy

I focused on "Abidjan Municipal Solid Waste-To-Energy Project" to examine the opportunity to develop biogas in Côte d'Ivoire from urban solid waste (CDM 2006).

Regarding the conversion of urban waste into energy, as described in the project paper, it consisted in implementing a solid waste treatment plant in order to produce annually biogas from 200,000 tons of municipal solid waste and that biogas should be converted into 25 GWh to be used as follows: 4.5 GWh for onsite consumption and 20.5 GWh for sale to the Ivorian Electricity Operation Firm (SOPIE), a public company (CDM 2006). The project was expected to create at least 210 jobs in addition to declining CO_2 emission and addressing other environmental issues (CDM 2006). Though the project is aborted, I pointed out some of its advantages in the "Data Analysis" chapter below.

5.3 Agro-Industrial Waste and Biomass to Energy

It's reported that some private agro-industries or wood industries used in the past or keep on using waste from their activities to produce electricity for onsite consumption. Some of them are: two sugar companies producing 50 MW of electricity from bagasse; vegetable oil mills getting 75 MW from palm nut fiber, shell, and cottonseed shell; one wood industry producing 1.5 MW from solid wood waste; and one coconut mill getting 1 MW from coconut shell (MMPE 2010).

In the "Data Analysis" chapter, I selected one sugar mill to examine the details surrounding energy production from sugar bagasse and other related waste.

5.4 Animal Excrement to Energy

In the central northern and western parts of the country, a project titled "Project of Power Production from the Biogas supplied by Animals' Excrement" consisted in getting biogas from about 20,000 bovines and ovines on a state-owned area of 30,800 ha to produce electricity and heat (ADERCI 2009). It was expected that one part of the electricity would fuel the area's facilities and the surplus should be sold to the national electricity grid while the heat should fuel the digester (ADERCI 2009). Among other advantages, the small scale

CDM project would annually reduce CO_2 emissions by 320,000 tons, create economic activities and job opportunities, decrease rural exodus, and stimulate rural development (ADERCI 2009). However, the project that was expected to start by March 2009 was also aborted.

Finally, these projects and many others show the extent to which, individually and collectively, people are willing to develop bioenergy activities in Côte d’Ivoire, but the government’s commitment is really weak.

V. HYPOTHESES DEVELOPMENT

On the pretext of preserving food security, the Ivorian government is not framing the different bioenergy initiatives countrywide with a national policy or regulations. Therefore, the three hypotheses I developed in this chapter establish the relationship between bioenergies and food security, showing how and why the former can take place without harming the latter. Indeed, I argue that bioenergies can help protect food security while providing environmental and socioeconomic advantages.

First Hypothesis: **Sustainable Land Use for Bioenergy Development**

The hypothesis is that using degraded or marginal lands to develop energy crops prevents land competition. From the government side, there is a fear that farmers could substitute energy crops for food crops on arable lands. On the contrary, degraded lands are useless for agriculture because of deterioration in their quality mostly caused by inadequate exploitation. However, some energy crops like jatropha have proven likely to grow on that kind of land (UN-Energy 2007 and FAO 2009). So, food security is not harmed for the type of land considered for energy crops is out of competition. Instead, I assumed that food crops contribute to food insecurity through unsustainable agricultural practices. Conversely, it's clear that growing energy trees on degraded lands participates in food security by restoring the biodiversity and the soil quality as the restored lands can be reused for planting food crops.

Moreover, one can analyze bioenergies and food security in relation to climate change to understand well the real causes of food insecurity and the importance of bioenergies. The trio (bioenergy, climate change, and food security) represents a challenge to the global community and environmental organizations worldwide (FAO 2008). By changing land use from food crops to energy-dedicated crops, one is worried about the cost to food security and other factors. Nevertheless, while developing bioenergies on arable lands could generate food crisis, climate change is already doing so by decreasing agricultural productivity through land biophysical deformation and it's known that climate change originates from factors such as unsustainable agricultural methods and excessive use of fossil energies. As a solution, bioenergies, among other alternative energies, are required to mitigate climate change and environmental degradation because they emit less carbon than fossil energies (Lopes 2009). Therefore, bioenergies can help secure food by preserving land quality.

Second Hypothesis: **Adequate Selection of Resources for Bioenergy Development**

I argue that when the sources are carefully selected to develop bioenergy programs, there is nothing to worry about food security. Bioenergy activities are likely to take advantage of diverse sources including "traditional crops (sugarcane, maize, oilseeds), crop residues and waste (maize stover, wheat straw, rice hulls, cotton waste), energy-dedicated crops (grasses and trees), dung, and the organic component of urban waste" (Hazell and Pachauri 2006). Though some food crops are used for energy purpose, to preserve food security, the priority should be given to inputs like agricultural byproducts, biomass waste, food and animal waste, as well as other waste.

In this context, waste-to-energy carbon-offset under the Kyoto Protocol's CDM underlines the need to address GHGs emissions in two ways: reducing waste to mitigate pollution worldwide and producing suitable energies from waste in order to decrease the dependence on conventional energies that are the main responsible for global warming (UNFCCC 1997). Since Côte d'Ivoire ratified the Kyoto Protocol and is aware of the negative effects of pollution on the atmosphere, it should examine the opportunity to convert into energy the amount of waste produced countrywide. This would improve waste management, meet energy needs, and prevent food insecurity.

For example, Côte d'Ivoire can produce biogas from urban solid and liquid waste including household waste, mud from urban and industrial wastewater treatment plants, agro-industrial waste from food processing industries, and biomass, as well as animal waste, in rural areas. For bioethanol production, the juice of cashew apple and cocoa, abandoned by farmers in the production areas during the harvest periods, the non-exported production of pineapple and mango, some sugarcane residues, and others are useful resources. Regarding pineapple and mango, the idea will not be to classify automatically those food crops as waste, but there is a huge quantity unutilized after production. In fact, due to quality standards on international markets, all the crops cannot be exported and the remaining stock is not completely consumed by people. Instead, it contributes to increase waste through the country's local markets. In such cases, do bioenergy projects threaten food security? No, they don't. On the contrary, not only they help reduce the amount of waste, but also waste move from uselessness to business opportunities, creating consequently employment and welfare.

Besides waste as energy source, one can look at the crops and profit from those that are appropriate to energy. It's true that in addition to sugarcane residue, its juice is also a feedstock for producing bioenergies in Brazil (Hazell and Pachauri 2006, Lopes 2009, and Ivan@cebi2000.com.br). It's also true that the US produces ethanol from corn and is debating on how to use rice for the same purpose (RFA 2011). Other food crops are used for energy elsewhere. Rice, corn, sugar, and other crops are actually basic foodstuffs in Côte d'Ivoire. In the long run, maybe they could serve as energy feedstock without damaging food security in the country.

However, in the meantime, let's examine crops that can be cost-effective by adding value to the energy services. So far, jatropha has a great potential for two reasons: it's a tried-and-tested source with advantages; there are initiatives about the tree in Côte d'Ivoire and to make them successful, the national commitment is required.

Third Hypothesis: **Key Role of Policymaking in Bioenergy Development**

An appropriate policymaking in bioenergy development helps the poor access both food and energy. Before enumerating some benefits of this policymaking, it would be interesting to underline the role of the government in building it. Any development activities, projects, or initiatives need a legal and secure environment. For example, in the business sector, domestic and private investments flow when governments provide incentives like investment tax credit, tax holidays, infrastructure, and regulations. Also, in the social domain, most of the development aid programs aimed at reducing poverty are formed under conditions like good governance, democracy, security, and equity.

Applying this argumentation to my hypothesis, I argue that to achieve decision-making in the energy sector, the public side should create the suitable conditions. Once created, the PPP, regional cooperation, international cooperation, and development assistance will take place so as to promote bioenergy projects and provide the poor with opportunities to access both food and energy. By referring to the poor, I do not ban the business side of bioenergies, but they are the victims of food insecurity worldwide.

The first benefit of a sustainable policymaking is risk mitigation. For instance, as the public sector, business organizations, and the civil society get associated, the likelihood of failing is smaller than will be otherwise. Cooperation with all the stakeholders in drawing a comprehensive bioenergy strategy may help establish a balance between food and energy because the poor as well as the rich don't need only food, but also energy. The "food vs. fuel debate" is a very topical subject that produces diverse writings and opinions, underlying the necessity of finding out appropriate ways to produce and use both (Penwarden 2007 and

Lewis 2008). In general, some risks associated with bioenergy projects are competition over agricultural lands, crops substitution, deforestation, environmental threats, investments loss, and social issues. By establishing a strong PPP, which is a kind of joint venture, it's easy to mitigate the costs, in case of failure, or to convert the costs into benefits when success takes place. As a matter of fact, from every side – economy, environment, and society – where risks could appear, the PPP could rely on domestic and international competences.

Regarding economic risks linked to land, financial investment, and other capital investments, private financial institutions help reduce them. The promise of bioenergy attracts investments and initiatives from individuals and, stimulated by state incentives, the private sector, at the international level, is investing in the sector. If necessary, to mitigate risks, IFIs assist large bioenergy projects (UN-Energy 2007).

Environmentally, the risk has to do with global warming and other environmental concerns due to land use change (Wamukonya, Masumbuko, Gowa, and Asamoah 2009). Accordingly, working in partnership is of huge interest to achieve a sustainable land management. The participatory land management includes experts from the government, domestic environmental NGOs, international environmental organizations like the UNEP, Global Environment Facility (GEF), UNFCCC, and UN-Energy.

Socially speaking, the focus is mainly the poor who are net food buyers so that promoting energy rather than food could be costly to them. In fact, it's not clear that access to energy is cheaper to the poor through the promotion of bioenergies (Hazell and Pachauri 2006). Also, due to land competition, small farmers who are not landowners end out of farming activities and become poorer and poorer (FAO 2009). However, if the public powers implement regulations and develop partnership, this will generate debates and R&D on poverty reduction in the process of producing bioenergies. As R&D activities associate domestic institutions with international ones like the FAO, UNEP, International Food Policy

Research Institute (IFPRI), and others, the chances of performing well in bioenergy development are higher.

In sum, an appropriate policymaking will help secure food and access modern, cheaper, and non-polluting energies with fewer costs by:

i. Getting a flow of local and international investments, as well as assistance, in the sector of bioenergies;
ii. Emphasizing successful experiences and lessons from other countries;
iii. Selecting from developed countries suitable technologies in harmony with the recipient country's opportunities such as types of land, bioenergy sources, climatic conditions, etc.;
iv. Developing knowledge acquisition and sharing.

VI. DATA ANALYSIS AND FINDINGS

1. LAND AS ENERGY SOURCE

1.1. Analysis of Data on Land

Côte d'Ivoire is more than three times larger than South Korea with about 322,462 km². As far as agriculture is concerned, 21.8% of the country's land is arable and the land patterns as well as recorded rainfall are suitable to develop diverse crops like cocoa, cashew, coffee, cotton, rubber, food crops, energy crops, etc. (Aregheore 2009 and IFAD 2010). In fact, its location in a tropical zone provides it with rain forests in the south where annual rainfall is at least 1,700 mm while the savannah regions receive between 1,000 mm and 1,500 mm (CBD 2009).

Among other resources, the forest is naturally composed of commercial timber, firewood, wood charcoal, medicinal plants, food plants, ornamental plants, and plants appropriate to other uses. The Convention on Biological Diversity (CBD) report mentions around 1,500 species utilized for medicinal purposes and 800 species for other purposes. Moreover, there is no arid land.

On the contrary, though there is no reported data on degraded lands, it's well known that some human practices keep on impacting on land quality (CBD 2009). In Côte d'Ivoire, agricultural, logging, and mining activities mostly contribute to deforestation, generating in this way desertification and soil degradation (IMF 2009). Deforestation exposes soil to erosion and rays of sunlight, making it progressively inadequate for agriculture (CBD 2009).

According to the CBD report, before 1960, date of the country's independence from France, the colonial power, the dense forests covered 46% of the land mass, with 12 million ha. By 2007, this area was estimated at 2.802 million ha corresponding to a loss over 75% (IMF 2009). Such a decline happened due to diverse factors.

Regarding agriculture, the report mentions that the planted areas were progressively 6% of the territory in 1965, 11% in 1975, 23% in 1989, and about 40-50% nowadays. Altogether, agriculture covered 7,500,000 ha by 1989; 3,340,000 ha of which were dedicated to export crops (CBD 2009 and IMF 2009).

In addition to agriculture, logging activities also impacted on the natural forest areas. Contrary to agriculture, there is no reported data on timber exploitation from the natural forest. Instead, there are statistical information on logging projects recently developed by wood industries. I actually talked about electricity production from solid wood waste in the "Literature Review" chapter above.

As far as the mining sector is concerned, gold, diamond, iron, nickel, manganese, bauxite, and others are explored and exploited on the Ivorian land, contributing to its degradation (IMF 2009):

i. SODEMI, a state-run organization, is exploiting more than 3,000,000 tons of manganese in Grand-Lahou, near Abidjan, with an annual average production of 100,000 tons;

ii. The private sector, associations, and individuals are involved in mining activities through artisanal methods;

iii. The mining resources include 3,000 million tons of iron, 390 million tons of nickel, 1,200 million tons of bauxite, 3 million tons of manganese, 100,000 carats of diamond, a golden area, the largest in West Africa, of over 100,000 km^2, etc.

As a reminder, energy needs are also a great cause of soil and forest degradation, with around 77.5% of households using charcoal or wood as fuel in 2008.

1.2. Findings

1.1 Côte d'Ivoire's land is full of features such as availability, diversity, and high recorded rainfall appropriate to crops development;

1.2 Biomass sources, mostly forest waste, used by rural people for energy purpose, are more advantageous when converted into clean energy;

1.3 Since jatropha grows on degraded lands in Mali where only 3.76% of the land mass (45,120 km^2/1.2 million km^2) is arable, Côte d'Ivoire can consider its degraded lands to grow jatropha or other energy crops.

2 AGRICULTURE AS ENERGY SOURCE

In the following lines, by talking about agriculture for producing energies, I don't mean that agricultural crops should be dedicated to energy production. The issue of food security is so delicate that using raw agricultural products in the context of bioenergies requires accurate studies. Instead, I focus on agricultural byproducts not only as energy sources, but also as an economic added value in the agricultural sector.

However, though Côte d'Ivoire is a global leader in agriculture, I could not find sufficient statistical data on agricultural waste in general. On the contrary, there are available data regarding crops production, cultivated areas, etc. Therefore, I estimated those data to figure out the potential for accessing agricultural byproducts in order to develop energy projects. I selected four crops for this study.

2.1 Analysis of Data on Agricultural Crops and Residues

2.1.1 Cocoa

Côte d'Ivoire is the first global cocoa producer with "around 40% of the world cocoa production, 35% of the total value of Ivorian exports" (Global Witness 2007). It occupies 48%

of the cultivated areas (CBD 2009). As indicated in the table 1 below, the country alone produced 1,222,000 tons of cocoa beans by 2009 while the world production was 3,515,000 tons. Not only this performance is more than the third of the global production, but also it overtakes individually America (456 tons; 13%), all Asia and Oceania (575 tons; 16.4%), and both of them together (1,031,000 tons; 29.4%).

Table 1: World Production of Cocoa Beans (thousands tons)

	2007/2008	%	2008/2009	%
Africa	**2,687**	**72.0**	**2484**	**70.7**
Cameroon	185	5.0	210	6.0
Côte d'Ivoire	1,382	37.0	1,222	34.8
Ghana	729	19.5	662	18.8
Nigeria	220	5.9	240	6.8
Others	171	4.6	150	4.3
America	**453**	**12.1**	**456**	**13.0**
Brazil	171	4.6	157	4.5
Ecuador	111	3.0	112	3.2
Others	171	4.6	187	5.3
Asia and Oceania	**591**	**15.8**	**575**	**16.4**
Indonesia	485	13.0	475	13.5
Papua New Guinea	52	1.4	52	1.5
Others	54	1.4	48	1.4
World total	**3,731**	**100**	**3,515**	**100**

Source: ICCO, www.icco.org/statistics/production.aspx

The interest in cocoa for bioenergy development is motivated by its juice. In the country, at the end of the harvests, the cocoa pulp is removed from the cocoanuts and stored in containers or under banana tree leaves or under plastic covers. The process is the fermentation that allows to avoid cocoa bean's germination and to get the chocolate's aroma (Dembele, Coulibaly, Traoré, Mamadou, Silue, and Touré 2009).

In accordance with Côte d'Ivoire's production capacity, even without data on cocoa waste, one can assume that the process of fermentation results in a great quantity of cocoa juice with an alcoholic taste. In rural areas, the juice is sometimes used in the form of beverage, but the large part is wasted while it could contribute to improve farmers' revenues (Anvoh, Guéhi, Beugré, Kinimo, and Gnakri 2010). Among other things, the fermented cocoa juice could be a source of ethanol production, participating consequently in the option for clean and affordable energies.

Moreover, regarding the industrial aspect, Côte d'Ivoire processes 17% of its cocoa beans before exportation (Global Witness 2007). It's clear that a considerable amount of byproducts result from the processed cocoa.

2.1.2 Cotton

Cottonseed oil, like other vegetable oils or animal fats, is considered as a clean energy source through its conversion into biodiesel by transesterification, which consists in mixing cottonseed with methanol and solid acid catalysts to produce a fuel considered "biodegradable, renewable, non-toxic" and more eco-friendly when compared to conventional oils (CHEN, PENG, WANG, and WANG 2007).

In Côte d'Ivoire, one could pay attention to cottonseed for biodiesel production because cotton occupies 7% of the cultivated areas and ranks third major crop, after cocoa and coffee, with a total ginning capacity of 530,000 tons by 2010 (CBD 2009 and World Bank 2009). In the table 2 below, since 1997, its production didn't follow a constant evolution. From 1997 to 2000, the statistics were in increasing order regarding the cultivated areas, cottonseed production, and fiber production. On the contrary, the yield (kg/ha), the ginning yield (%), and the cottonseed price per kilogram didn't follow the same order along the same period. From 1998 to 1999, both yields decreased and increased again in the period 1999-2000 while cottonseed price remained constant in 1998-1999 before decreasing in 1999-2000.

Table 2: Evolution of Cotton Production (Tons) since 10 years						
Year	**Cultivated Area (ha)**	**Cottonseed Production**	**Yield Kg/ha**	**Ginning Yield (%)**	**Cotton Fiber Production**	**Cottonseed Price (FCFA/kg) 1 FCFA = US$ 0,002**
1997/1998	244,313	337,097	1,380	43.58	146,906	200
1998/1999	271,371	365,003	1,345	42.89	156,533	200
1999/2000	291,457	402,367	1,381	44.06	177,284	183.32
2000/2001	248,478	287,000	1,155	42.69	122,518	216.07
2001/2002	282,678	396,236	1,402	43.20	171,159	190
2002/2003	269,730	396,417	1,470	43.37	171,928	180
2003/2004	206,387	180,144	872	43.39	78,102	200
2004/2005	263,486	323,141	1,225	43.35	140,080	185
2005/2006	271,248	267,843	987	43.54	116,319	140
2006/2007	198,954	145,648	732	43.59	63,477	145
2007/2008		114,288				150

Sources: Ministry of Agriculture (MINAGRI); Interprofessional Cotton Association (INTERCOTON) http://www.coton-acp.org/docs/strategies/CCdM_080619_Coton.pdf

Observing the period 2000-2003, one can see that cotton (seed and fiber) production, the yield (kg/ha), and the ginning yield achieved an increase while the cultivated areas increased in 2001-2002 and decreased in 2002-2003, and the cottonseed price alone decreased during the period 2000-2003. However, the cultivated areas alone increased over the period 2003-2006. In 2006-2007, though the ginning yield and the cottonseed price increased slightly, there was a general decline.

The table 2 shows instability in the Ivorian cotton sector, but it remains one of the main agricultural commodities playing a critical role in the economy. As indicated in the table 3 below, the value of cotton exports is greater in Burkina Faso and Mali than in Côte d'Ivoire. However, among the six main cotton producers of the region, the country ranks fourth regarding the value of cotton exports ($ 146 million), cotton production (139,000 tons), and first for the cotton yields per hectare.

Table 3: West and Central Africa Cotton-related Statistics (extract)						
	Benin	**Burkina Faso**	**Cameroon**	**Chad**	**Côte d'Ivoire**	**Mali**
Value of cotton export ($ Million)	168	201	111	64	146	253
Cotton's export share (%)	36.9	76.6	5.7	19.7	2.9	30.0
Cotton's contribution to GDP (%)	4.9	5.0	0.8	2.5	1.0	6.2
Cottons' production (000 tons, lint	152	177	99	59	139	225
Cotton area (000 hectares)	331	408	200	277	253	510
Cotton yields (kg/ha, lint)	459	435	498	213	532	439
Grower price (CFAF/kg, seed cotton	202	190	186	162	190	193
Average cotton plot (hectare)	1.0	1.9	0.7	1.4	1.3	2.6
Households in cotton production	325	210	300	200	200	300

Sources: FAO (FAOSTAT); World Bank (World Development Indicators); IMF (International Financial Statistics; various country sources, and author's calculations http://siteresources.worldbank.org/INTTRADERESEARCH/Resources/544824-1146153362267/Benin_0708.pdf

The most interesting, in accordance with the potential of the cotton sector for producing bioenergies, is the ginning yield's evolution during the periods mentioned in the table 2. Although cotton production was generally instable from 1997 to 2007, with remarkable increases and declines, the ginning yield remained between 42.69%-44.06%. Consequently, it could be assumed that cottonseeds can contribute to develop biodiesel industry in Côte d'Ivoire due to the constant availability of the resource. Getting biodiesel from cottonseed oil would add economic value to the cotton sector and even reduce dependence on conventional energies.

As an example, for running agricultural machines and transporting the crops, biodiesel produced inside the sector would play both the roles of substitute and alternative fuel. Moreover, the textile industry would also benefit from power produced from biodiesel since its activities require it. Therefore, why not reduce dependence on conventional power since biodiesel derived from cottonseed oil can produce it and even supply the national electricity grid?

Table 4 : Destination of the Cottonseed (Tons)			
	2004/2005	**2005/2006**	**2006/2007**
Sales to TRITURAF	78,200	42,000	10,000
Exports	38,100	45,000	35,000
Plants, Losses, and Donations	12,800	13,000	12,300
Other Sales	20,900	18,000	13,500
Total	150,000	118,000	70,800

Source: World Bank (http://www.worldbank.org/afr/wps/wp130b.pdf)

The table 4 shows some data on cottonseed's destination during the period 2004-2007. The Ivorian Oilseed Crushing and Vegetable Oil Refining Facility (TRITURAF) was one of the main customers of the cotton companies that used cottonseed and other vegetable oils to produce cooking oil, soap, oil cake for cattle feeding, etc. Today, the facility went bankrupt due to the 2002 sociopolitical and military crisis that lasted ten years. However, except the cottonseeds sold to the TRITURAF and the planted ones, some of the remaining parts (exports, donations and other sales) indicated in the table 4 could be devoted to biodiesel projects. More attention would also help reduce the amount of cottonseed losses so as to maximize biodiesel production.

2.1.3 Cashew

Like cotton, cashew production occupies 7% of the Ivorian total cultivated areas and is an export crop that has been developed in some cotton zones due to decline in cotton production and thanks to revenues from cotton (CBD 2009). With a production of 330,000 tons, Cote d'Ivoire is the second global cashew nuts producer, behind India, and the first exporter (AFP 2009). In 2008, it exported 310,000 tons of its raw cashew nuts transforming less than 1% (N'CHO 2009).

In general, cashew nuts are processed and utilized for diverse applications with medical and culinary values (http://www.nutrition-and-you.com/cashew_nut.html). In addition to the nut, cashew apple is an opportunity to add economic value to the sector. My interest in cashew production in Côte d'Ivoire is actually motivated by the energy potential of its apple. Instead, a large amount of the apple is wasted in African countries like Côte d'Ivoire, Nigeria, Ghana, and others (Topper 2002).

However, it's important to note that cashew apple is less wasted elsewhere. As an example, Ghana converted it into alcoholic drink and achieved up to 42,000 liters (60,000 bottles of 0.7 liters) in 2002 for the internal and regional markets, and was planning to conquer the international market. Another example is Nigeria where raw cashew apple and its juice are sold on the markets (Topper 2002).

Contrary to both countries, Côte d'Ivoire is not recovering its cashew apple. Almost all the resource is abandoned in harvest areas and ferments uselessly. It would be efficient to gather the apples in adequate conditions and collect their fermented juice in order to develop an ethanol industry, which could actively serve as energy source (Rural Hub 2006). It's reported that 1 ton of cashew apple produces 30 liters of ethanol through a calculation where:

235,000 tons of cashew nuts (Côte d'Ivoire's total production in 2005-2006) = 2,350,000 tons of cashew apples = 70,500 m^3 of ethanol (equivalent to 30 liters of ethanol/ton) (Rural Hub 2008).

Applying the same calculation to the 2009 total production, which is more recent, the result is as follows:

330,000 tons of cashew nuts (Côte d'Ivoire's total production in 2009) x 2,350,000 tons/235,000 = 3,300,000 tons of cashew apples;

Where 3,300,000 tons of cashew apples x 70,500 m^3 of ethanol/2,350,000 tons = 99,000 m^3 of ethanol (30 liters of ethanol/ton).

As shown by data, the amount of cashew apples derived from the 2009 production could produce 99,000 m^3 of ethanol. So, there is an opportunity to develop ethanol in the Ivorian cashew sector, but, so far, there is no related national policy.

The following steps show how cashew apple could be converted into ethanol:

Pilot Project Processing Cashew Apple Juice into Ethanol – Theoretical process (Rural Hub 2006)

1. *Apples collection and washing;*
2. *Juice extraction (and possible de-tanning);*
3. *Juice fermentation into a 10 alcoholic degree liquid (wine);*
4. *Filtering the fermented juice;*
5. *First distillation of the wine into alcoholic mixture;*
6. *Water addition and rinsing;*
7. *Second distillation, alcohol separation and pure ethanol collection.*

The process is estimated at USD 100,000 – 200,000 and needs to be fully monitored by specialists in alcohol production (Rural Hub 2006).

2.1.4 Sugarcane Residues

In Côte d'Ivoire, sugarcane cultivation is managed by two main companies, each with two units, producing more than 1,430,000 tons – Sucaf (860,861 tons) and Sucrivoire (569,322 tons) – and the total raw sugar produced in 2005-2006 was 147,279 tons (Rural Hub 2008). By analyzing the difference between the amount of sugarcane produced (1,430,000 tons) and the derived raw sugar (147,279 tons), it appears that the sugarcane sector generates a lot of waste. The bagasse and the molasses are the well-known residues remaining after processing sugarcane and both are important energy sources as seen in Brazil where ethanol production from sugarcane plantations yielded considerable incomes and jobs ranking Brazil the first global ethanol producer (Hazell and Pachauri 2006, Lopes 2009, and Ivan@cebi2000.com.br).

In the Ivorian context, I considered data on S-Z, one of the Sucrivoire's units, located in Zuénoula city, in the Northwest of the country, to bring out the key role of sugarcane residues in energy production for onsite consumption. A quick look at the table 5 below shows that energy issues are critical at S-Z since the sugar unit doesn't limit itself to energy consumption, but also produces it, and specially electricity. In the table 5A, electricity consumption (2,180 TOE) is greater than half of S-Z total energy consumption (4,285 TOE). Moreover, the next table (table 5B) underlines the high contribution of S-Z to its own electricity supply (1,720 TOE/2,180 TOE or 78.91%) compared to the CIE's contribution (460 TOE/2,180 TOE or 21.09 %).

Table 5: Energy Consumption, Supply, and Production at S-Z

Table 5A: Energy Consumption			Table 5B: Electricity Supply			Table 5C: Electricity Production		
Energy Type	**Capacity (TOE)**	**Proportion (%)**	**Source**	**Capacity**	**Proportion (%)**	**Source**	**Capacity (TOE)**	**Proportion (%)**
Total Energy	**4,285**	**99.64**	**Total**	**2180**	**100**	**Total**	**1,720**	**100**
Electricity	2,180	50.51	**From CIE**	460	21.09	**From Bagasse**	1,677	97.50
Fossil Energy	2,105	49.13	**From S-Z**	1,720	78.91	**From Diesel Oil**	43	02.50

<u>Source</u> : S-Z ; Optimisation Energétique d'une Unité Agricole Intégrée : Cas S-Z (BAYILI 2010)

As seen in the table 5C, 97.50% of the total electricity produced is from the sugarcane bagasse while only 02.50% is from a fossil resource (diesel oil).

Table 6: Projection of Energy Consumption and Electricity Supply at S-Z

Table 6A: Projection of Energy Consumption			Table 6B: Projection of Electricity Supply		
Energy type	**Capacity (TOE)**	**Proportion (%)**	**Source**	**Capacity (TOE)**	**Proportion (%)**
Total Energy	**3,709**	**100**	**Total Electricity**	**2,180**	**100**
Electricity	2,180	59	**From CIE**	00	00
Fossil Energy	1,529	41	**From S-Z**	2,180	100

<u>Source</u> : S-Z ; Optimisation Energétique d'une Unité Agricole Intégrée : Cas S-Z (BAYILI 2010)

In addition to developing electricity from the bagasse, S-Z is planning to increase its energy efficiency through both reducing its total consumption and meeting its full electricity need from inside, ending its dependence on the CIE's contribution (Table 6). From 4,285 TOE (Table 5A), the total energy consumption is expected to decline at 3,709 TOE (Table 6A). Although there is no information on the projection period, the table 6A shows that the decrease in energy consumption at S-Z will take place from the side of fossil energies that will shift from 2,105 TOE (Table 5A) to 1,529 TOE (Table 6A). In the same vein, in the table 6B, the whole electricity supply (2,180 TOE) is expected to result from S-Z itself.

Table 7: Exploitable Energy Resources at S-Z

Resource	Annual Average	Energy Type	Data source
Solar Irradiation	5kw/h/m^2/d	Photovoltaic or Thermodynamic Solar	Agronomic Study Department (S-Z)
Marahoué River	To be studied	Hydro-electric Power Station	No information
Arable Land	10,000 ha	Energy Plantations	Managing Board (S-Z)
Non-Exploited Bagasse	1,220 tons	Electricity and Biofuel	Managing Board (S-Z)
Foam	20,347 tons	Biofuel	Managing Board (S-Z)
Molasses	20,347 tons	Biofuel	Managing Board (S-Z)

Source : S-Z ; Optimisation Energétique d'une Unité Agricole Intégrée : Cas S-Z (BAYILI 2010)

The table 7 gives more details on S-Z's energy potential. However, sugarcane residues (non-exploited bagasse, foam, and molasses) are the focus of energy development in the sector. It's clear that S-Z is likely to get its full energy independence in the future. In the table, the 1,220 tons of non-exploited bagasse are actually energy available for storage. Instead, after each harvest, they are abandoned due to conservation concern (BAYILI 2010) and surrounding rural people only use a little part of it as fuel (Developing Renewables 2006). Also, since so far S-Z only develops electricity from bagasse, it could extend energy production to ethanol from other available waste like foam (20,347 tons) and molasses (34,347 tons).

2.2 Findings

i. Due to Côte d'Ivoire's international celebrity in agriculture, there are sufficient available agricultural byproducts for energy development;

ii. The limited or lack of data on agricultural residues makes it difficult to estimate the real amount of those residues;

iii. Generally, the crop residues remain abandoned in the harvest areas or somewhere else and only contribute to pollute the environment;

iv. The case of S-Z, with sugarcane residues, is an evidence that the agricultural sector can acquire its energy independence;

v. The remaining bagasse abandoned by S-Z, as well as residues from the other three sugar units, could produce additional energy for the country if there were a related state policy;

vi. Since cottonseed is used to produce staple commodities, including cooking oil, soap, oil cake for cattle feeding, and others, its consideration for biodiesel production could generate competition;

vii. Producing ethanol from cashew apple cannot create competition for the resource as it's uselessly abandoned in harvest areas.

3 ANIMAL EXCREMENT AS ENERGY SOURCE

Animal production, consisting of livestock and poultry, is a minor economic activity, representing only 4.5% of the agricultural GDP and 2% of the total GDP, but it's important to consider animal excrements as an opportunity to develop alternative energy programs in Côte d'Ivoire (CBD 2009).

Table 8: Trend of the Main Animal Production for the Period 2002 - 2007 (number of heads)						
Species	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Cattle	1,392,787	1,420,642	1,449,054	1,478,035	1,507,596	1,337,000
Sheep	1,477,458	1,507,007	1,537,147	1,567,890	1,599,248	1,162,000
Goats	1,160,860	1,184,077	1,207,759	1,231,914	1,256,552	945,000
Total Pork	**307,517**	**312,999**	**318,589**	**324,290**	**330,104**	**323,470**
Modern Pork	57,924	59,662	61,452	63,296	65,195	54,855
Traditional Pork	249,593	253,337	257,137	260,994	264,909	268,615
Total Poultry	**30,560,787**	**29,817,890**	**26,481,574**	**31,231,951**	**31,893,134**	**32,371,894**
Layers	2,190,000	1,910,000	2,290,000	1,410,000	1,588,000	1,366,400
Broilers	5,600,000	4,750,000	640,000	5,870,000	5,946,000	6,256,000
Traditional Chicken	22,770,787	23,157,890	23,551,574	23,951,951	24,359,134	24,749,494
Total Animals	**34,899,409**	**34,242,615**	**30,994,123**	**30,834,080**	**36,586,634**	**36,139,364**

Source: DPP/MIPARH; Poverty Reduction Strategy Paper (IMF 2009)

3.1 Analysis of Data on Animal Production in Relation to Excrement

The table 8 above shows diverse species produced in the Ivorian animal sector from 2002 to 2007. By gathering the species, the total amount of heads is 203,696,225 with an annual average of about 34,000,000 heads along the period 2002-2007.

Without available data on the amount of excrement produced, but knowing that each head produces excrement daily, it's clear that the sector is full of waste opportunities for energy. Such experiences from other countries are well known. Korea achieved related communal plants in 2010 and plans by 2013 to convert 90% of animal excrement into energy (MOE 2010). In China, GE Energy is planning to produce power and heat with biogas derived from chicken farm manure. “The farm owns three million chickens, producing 220 tons of manure and 170 tons of wastewater each day”, with a likely annual “reduction of around 95,000 tons of CO_2 “(Ottewell 2012).

By comparing data on the Chinese chicken farm to the 2007 Ivorian traditional chicken production (see table 8), the Ivorian case provides the following data:

24,749,494 chickens x 220 tons of manure/3,000,000 chickens = 1,818 tons of manure (excluding waste water);

Where 1,818 tons of manure x 95,000 tons of CO_2/220 tons of manure = 785,000 tons of CO_2.

As the 24,794,494 Ivorian traditional chickens produce 1,818 tons of manure daily, if that amount were to be converted into biogas so as to develop power and heat, or for cooking, the annual CO_2 reduction in 2007 would be 785,000 tons. As well, if the Ivorian total animal production were to be included in the scenario, the energy potential of animal waste would get higher. Instead, animal waste are utilized by rural people as fertilizer and raw fuel (Akanza and Yoro 2003; Developing Renewables 2006) and there are data neither on the amount produced nor on the amount used as fertilizer or fuel. Moreover, using them as fuel may emit GHGs. Of course, it's a good idea to fertilize more lands with animal waste because increased soil fertility contributes to implement and preserve food security. However, since the agricultural sector doesn't use the total amount of animal excrement, it would also be suitable to think about energy projects.

3.2 Findings

i. Producing alternative energies from animal excrement is a successful experience in other countries;

ii. There are available waste opportunities in the Ivorian animal sector for bioenergy development;

iii. Animal excrement as fertilizer adds economic value to the agricultural sector, but not the full amount of excrement is utilized for that purpose. So, the remaining stock can serve as clean energy source;

iv. Using animal excrements as raw fuel is a potential source of pollution;

v. There is no database on waste from the Ivorian animal sector.

4 URBAN WASTE AS ENERGY SOURCE

Here, the focus is Abidjan, the economic capital of Côte d'Ivoire, the most populated among the French-speaking African cities with around 6,000,000 people, and a key sociocultural and economic meeting point in Africa (IMF 2009 and http://fr.wikipedia.org/wiki/Abidjan). Abidjan is facing a growing urbanization so that waste management is a delicate matter that needs to be tackled with more attention. Accordingly, I am interested in pointing out the energy potential inside those waste.

4.1 Analysis of Energy Opportunity from Abidjan Municipal Waste

As of September 2002, Abidjan had around 3 million inhabitants, but from that date to 2009, due to the sociopolitical and military crisis, population increased to about 6 million since the conflict caused migratory movements from upcountry towns to the capital city (IMF 2009). The environmental impact of the overpopulation is perceptible not only on air quality, but also on household refuse management. On the one hand, it's reported that industries' emissions are estimated at "70 tons of sulphur dioxide (SO_2), 21 tons of nitrogen oxide (NOx), and 12 of tons toxic dust" while traffic emits "6 tons of SO_2, 22 tons of NOx and 15 tons of toxic dusts" per day. On the other hand, household refuse increased from 2,500 tons in 2002 to 3,500 tons in 2009 (IMF 2009).

Along the period 2002-2009, the increase in household refuse is known, but there is no available data on the amount of substances emitted in the atmosphere by 2002. Data reported above refer to 2009. However, if one considered that air pollution in Abidjan rose at the same rhythm as household refuse, the following calculations would help find out the amount of substances emitted by 2002:

The total substances emitted by 2009 are: 70 tons of sulphur dioxide (SO_2) + 21 tons of nitrogen oxide (NO_x) + 12 tons of toxic dust (from industries) + 6 tons of SO_2 + 22 tons of NO_x + 15 tons of toxic dust (from traffic) = 146 tons of pollutant substances.

Considering the same rhythm of increase, if the amount of household refuse increased from 2,500 tons in 2002 to 3,500 tons in 2009 and the total amount of substances emitted in the atmosphere in 2009 is 146 tons, therefore the total amount of those substances emitted in 2002 is as follow:

146 tons x 2,500 tons/3,500 tons = 104 tons of pollutant substances (in 2002).

In sum, during seven years, from 2002 to 2009, in Abidjan, household refuse rose by 1000 tons (3,500 tons – 2,500 tons) while pollutant substances rose by 42 tons (146 tons – 104 tons). However, appropriate measures are not being undertaken to reduce atmospheric pollution and household waste, and the current waste collection rate is 46% instead of at least 90% as recommended (IMF 2009).

Among various solutions, it would be interesting to exploit Abidjan municipal waste for energy purpose in order to create jobs, reduce waste, develop clean energy, etc. The tables 9, 10, and 11 below actually refer to a CDM project titled "Abidjan Municipal Solid Waste-To-Energy Project" and aimed to treating annually 200,000 tons of municipal waste so as to produce biogas, and then 20.50 GWh of electricity from that biogas (CDM 2006). The project was expected to extend on 25 years while the first crediting period would extend from April 1st, 2009 to March 31st, 2016 (CDM 2006).

Though the project is aborted, data provided by the tables help understand its opportunities and profits.

Table 9: Waste Composition of Abidjan Municipal Solid Waste	
Waste Type/d	**Proportion (%)**
Pulp, paper, and cardboard	1.26
Textiles	0.59
Wood and wood products	0.00
Garden, yard, and park waste	24.40
Food and food waste	58.57
Glass, plastic, metal, and other inert waste	15.18
Total	**100**

Source: Abidjan Municipal Solid Waste-To-Energy Project (CDM 2006)

The table 9 shows the types of Abidjan solid waste considered for biogas production after collection and dumping. Food and food waste represent 58.57% or more than half the total waste. Besides energy projects, the large amount of food inside the Abidjan waste attracts more attention in accordance with food security. It indicates that food conservation is so inefficient that some food is wasted. Therefore, there is compensation by getting biogas from wasted food, but conserving food is a priority to preserve food security. Instead of food, biogas from food residues is more efficient.

Table 10: Quantity of Waste Before and After Sorting (Tons)		
Year	**Quantity Before Sorting**	**Quantity After Sorting**
2009 (from April 1st)	58,800	41,200
2010	174,300	122,000
2011	200,000	140,000
2012	200,000	140,000
2013	200,000	140,000
2014	200,000	140,000
2015	200,000	140,000
2016 (to March 31st)	50,000	35,000
Total	**1,283,100**	**898,200**

Source: Abidjan Municipal Solid Waste-To-Energy Project (CDM 2006)

In the same vein, the table 10 reminds the 3R policy: Reduce, Reuse, and Recycle. To produce less waste, it's important to use fewer products. Moreover, the table shows that once produced, waste need to be sorted and divided into two groups from which profits are likely to arise. In fact, during the first crediting period (April 1st, 2009 – March 31st, 2016), the expected total amount of waste before sorting is 1,283,100 tons and this amount shifts to 898,200 tons after sorting. The difference (1,283,100 tons – 898,200 tons) is 384,900 tons. Not only the 384,900 tons subtracted from the total amount (1,283,100 tons) of municipal waste before sorting comprise reusable and recyclable materials, but also the remaining 898,200 tons after sorting enter the "Abidjan Municipal Solid Waste-To-Energy Project" (CDM 2006).

It's known that the major objective of developing clean energies is to reduce GHGs emissions in order to preserve the environment and sustainability. Concerning the "Abidjan Municipal Solid Waste-To-Energy Project", the table 11 below indicates the expected total reduction of CO_2 (502,318 tons) upon the first crediting period if the project took place. The table also shows approximately what would be the current (2011) total reduction of CO_2 emission. This total along the period April 1st 2009 – 2011 would be (7,186 + 39,001 + 59,485) 105,672 tons if the project to took place.

Table 11: Estimated Amount of Emission Reductions over the Chosen Crediting Period

Year	**Annual estimation of emission reductions** (tons CO_2e)
2009 (starting date: April 31st)	7,186
2010	39,001
2011	59,485
2012	72,316
2013	81,633
2014	88,488
2015	93,604
2016 (end of first crediting period: March 31st)	60,605
Total estimated reduction (tons CO_2e)	**502,318**
Total number of crediting years	**7 years** (renewable)
Annual average over the crediting period of estimated reductions (tons CO_2e)	**71,760**

Source: Abidjan Municipal Solid Waste-To-Energy Project (CDM 2006)

Considering other data, one can check the impact of the expected current reduction on the country's total CO_2 emission. As a matter of fact, the amount of CO_2 released per each

Ivorian in 2011 could be estimated at 0.33 ton (http://perspective.usherbrooke.ca/bilan/tend/CIV/fr/EN.ATM.CO2E.PC.html) while the population was estimated at 20,153,000 the same year (http://fr.wikipedia.org/wiki/C%C3%B4te_d%27Ivoire). Therefore, the total emission of CO_2 in 2011 was (20,153,000 habitants x 0.33) 6,650,490 tons. As a result, by 2011, the "Abidjan Municipal Solid Waste-To-Energy Project" would cause the country total emission to fall to (6,650,490 – 105,672) 6,544,818 tons.

4.2 Findings

i. The "Abidjan Municipal Solid Waste-To-Energy Project" is still feasible due to PPP as well as financial and technical support;

ii. Such a project helps establish the balance between the overpopulation and waste production citywide while creating jobs;

iii. The expected total reduction of CO_2 over the first crediting period would contribute to improve air quality inside the city, mitigating thus the effects of global warming.

5 SUMMARY OF RESEARCH FINDINGS

As a summary, my research findings regarding bioenergy development in Côte d'Ivoire take into account three issues including lands, resources, and decision-making.

First, I found that the risk of land competition is avoidable since in addition to arable lands, there are degraded lands due to unsustainable agricultural practices and other factors. As learned from the Malian case study, some energy crops like jatropha grow on degraded lands. Consequently, there should be no fears for food security. However, though those lands exist, there is so far no database on their amount.

Second, to produce bioenergy as cost-effectively as possible, Côte d’Ivoire has diverse sources like forest waste, agricultural byproducts, and animal waste. Indeed, some private companies are already engaged in producing energy from such residues. Nevertheless, apart from data on agricultural and animal productions, I found that no study was undertaken to establish databases on waste from those sectors.

Third, it results from the study that given the resource diversity and private initiatives countrywide, the only ingredient missing to improve the energy services by producing bioenergies is public decision-making.

In this context, the study showed through experiences from selected countries how public commitment associated with PPP as well as regional cooperation and international cooperation led to sustainable energy policies including fossil energies, bioenergies, and other alternative energies.

VII. DISCUSSION

The analysis of data has indicated that there will be outstanding results if bioenergy projects are developed in Cote d'Ivoire. However, not everything is positive upon analyzing the collected data. Various aspects of this study still remain controversial and require more attention in order to increase the reader's understanding. Among other things, the following issues seem to be not yet sufficiently elucidated:

1. Food Security

The main worry about bioenergy development, and specifically in Africa, is food security due to the likely use of land for energy crops (Hazell and Pachauri 2006; UN-Energy 2007). As a solution, degraded lands are considered adequate for energy crops like jatropha. Yet, due to the lack of related knowledge, one could imagine that some landowners or renters will mistake degraded lands for other lands still fertile. Also, others may intentionally use arable lands for energy crops.

Another argument against bioenergy policies could be the risk of changing the agricultural trend through the substitution of energy crops for food crops. In fact, if the government showed interest and provided incentives to bioenergy development, that could cause farmers, energy developers, and other stakeholders to use not only more lands for energy crops, but also raw food crops for energy projects. Such a policy is likely to result in unsustainable agricultural practices and increase food insecurity.

Moreover, some people may argue that, instead of energy, certain agricultural waste could be useful for other purposes. As an example, it would surely be more cost-effective and an economic value addition to the agricultural sector to produce alcoholic drinks and juice from the fermented cocoa juice and cashew apple (Rural Hub 2006).

In addition to the abovementioned risks, another problem could be competition over soil nutrients, by using a large amount of biomass waste, and animal excrement for energy projects. Those elements are useful to preserve the soil fertility and using them for energy impoverishes the soil and threatens agriculture.

Last, but by no means least, it should be reminded that the poor in rural areas are net food buyers and they meet their energy needs with forest residues, firewood, charcoal, and other raw energy sources that they get either for free or cheaper (Hazell and Pachauri 2006). Therefore, if their raw energy sources were to be converted into clean energy and if they were to pay for that clean energy, their limited purchasing power could be ruined and they would more difficultly access food. The remark is that there is no guarantee of cheaper energy for the poor through bioenergy development.

However, contrary to the opinion that bioenergies would represent a threat for food security, I would like to underline that the risk can be mitigated. Regarding land, though some farmers are not experienced enough to distinguish degraded lands from arable ones, there are research agencies such as the ANADER and the CNRA, specialized in agricultural development and training, to assist them in distinguishing lands. Accordingly, the argument of confusing lands does not matter and the use of arable lands for energy plantations could be subjected to a sustainable policy.

About the likelihood of changing the agricultural trend by promoting energy crops instead of food crops, the argument is not solid for two reasons. First, not all the farmers will give up food crops for energy ones since food production allows some of them to get sufficient financial resources and a good social position. Second, food security is not preserved only with food crops, but also with financial resources. So, if energy crops substitute for food crops on some agricultural lands, food will remain secured as the financial resources produced from the energy crops will help import food.

In addition, there is no evidence that using agricultural waste like cocoa juice and cashew apple for other purposes rather than energy is better. Since so far those resources are wasted, converting them into energy could help meet energy constraints.

Concerning soil nutrients, if removing biomass waste to produce clean energy can impoverish soils and harm food security, the risk of impoverishing soil already exists because rural people mostly satisfy their energy needs by removing forest waste. Furthermore, it's not risky to develop energy from animal excrement since not the total production of animal waste is utilized as fertilizer and traditional fuel.

Talking about the purchasing power of the poor who are net food buyers, rather than decreasing, it's likely that it increases as bioenergy projects generate jobs and incomes inside rural areas. Consequently, even paying for clean energy, the rural people can have more access to food.

2. Feasibility Study

Besides concern about food security, it's likely that some people will evoke the lack of conditions under which bioenergy industries can grow in Côte d'Ivoire. The first condition may be data gathering while there is almost no data countrywide on bioenergy sources like forest residues, agricultural waste, degraded lands, and animal excrement because of the lack of state interest.

The evaluation of the investment requirements, including R&D, bioenergy inputs, human resources, equipment, infrastructure, training, timing, and so on, is also a fundamental condition before getting involved in bioenergy projects. That condition happens not to be fulfilled in Côte d'Ivoire. The failure of the "Abidjan Municipal Solid Waste-To-Energy Project" may be considered in this context as an illustration since a feasibility study was driven, but the project didn't take place. In sum, the argument will be that producing bioenergies in Côte d'Ivoire is not an efficient project.

Another condition, could argue people, is the competiveness on the energy market. In fact, energy production and distribution in the country is dominated by MNCs that mainly focus on fossil sources. Therefore, to which extent potential bioenergy developers could hold competition against conventional energy developers in terms of investment capacity and price competitiveness? It's even imaginable that the latters will try to stick a spoke in the wheels of the formers in order to preserve monopoly.

In my opinion, it's true that the conditions under which bioenergy activities take place are not yet totally fulfilled in Côte d'Ivoire, but there is potential for implementing bioenergy industries. The lack of data or the limited data on bioenergy sources does not mean that the sources are inexistent. Its rank of first global cocoa producer actually makes the country have a considerable amount of waste that is the fermented cocoa juice. As well, we learned from data that 1220 tons of sugar bagasse are wasted in S-Z due conservation concern (BAYILI 2010). As a result, the lack of a comprehensive database should not represent an obstacle to bioenergy development.

The investment requirements should not represent an obstacle either because undertaking bioenergy activities in the country will not consist in investing enormous resources in the beginning. Experimental phases or pilot projects will be a priority to mitigate risks. All beginnings are difficult and even failures convey lessons to learn.

As far as competition between conventional energy producers and bioenergy producers is concerned, it cannot constitute a problem as it happens. It can rather improve the country's energy and economic situations by stimulating competitive prices, reducing dependence on conventional energies, mitigating air pollution, creating jobs, etc. Competition can even stimulate interest of fossil energy producers in bioenergies and increase related investments so that fossil energy sources could be preserved.

3. Comparison with other Countries

With the intention of encouraging the Ivorian government to adopt bioenergy policies, I collected data on other countries where governments succeeded in developing bioenergy industries. I mostly focused on Mali, Brazil, and Korea. However, I recognize that my idea of making comparisons will not be approved unanimously. First, some will consider that no comparison is possible between Mali and Côte d'Ivoire because Mali is almost four times larger than Côte d'Ivoire with a large amount of degraded lands to grow jatropha tree. Mali land mass is 1.2 million km^2 and only 3.76% of this territory is arable while Côte d'Ivoire's land area is 322,462 km^2, with 21.8% of arable lands (UN-Energy 2007, FAO 2009, and CBD 2009).

The comparison shows that there is no risk of food insecurity in Mali when growing jatropha tree due to the availability of degraded lands. Moreover, it could be argued that in Mali jatropha projects substituted for cotton cultivation that was in decline.

Second, regarding the comparison with Brazil, the nonpartisans of bioenergy in Côte d'Ivoire could find that, in addition to being the fifth global biggest country with 8,514,877 km^2, Brazil is an emerging country, the first global bioethanol producer, and relatively experienced with a developed local bioenergy market mostly supported by the automobile industry (Hazell and Pachauri 2006; Ivan@cebi2000.com.br; http://en.wikipedia.org/wiki/Brazil). On the contrary, will argue people, none of those potentialities is available in the Ivorian context. Above all, it's important to examine the market issue before undertaking bioenergy projects.

Concerning the comparison to Korea, the counterargument will be that Korea is a developed country while Côte d'Ivoire is a poor one. In fact, Korea achieved such a rapid and formidable economic growth that it is among the G20 countries with an accurate experience in R&D, green growth as well as waste management policies.

Beside the gaps between the selected countries and Côte d'Ivoire, it could be stated that in the same conditions, the same causes don't necessarily produce the same effects. In other words, it means even if Côte d'Ivoire had the same prerequisites as other countries, it wouldn't necessarily perform well in bioenergy development.

As a response, my point is that the reference to other countries does not mean Côte d'Ivoire has the same full potentialities as them. It's all about finding out how the country can achieve bioenergy production by getting some of the opportunities the selected countries have. First, like Mali, the Ivorian government can take advantage of the degraded lands to plan jatropha cultivation though those lands may be in small amount. In addition, Mali cooperates with the civil society, the private sector, and international organizations to mitigate risks. Côte d'Ivoire could also do so.

Second, compared to Brazil, Côte d'Ivoire has no automobile industry to promote the local consumption of biofuels, but can rely on the global bioenergy market due to increased demand in order to add value to its economy (Jussi Heinimö 2006). As well, as in Mali, jatropha oil and other vegetable oils can improve the local electricity market. Moreover, electricity production from the sugarcane bagasse at S-Z is proof that there is potential for developing a local market for some bioenergy sources in the country.

Third, it's true that contrary to Korea Côte d'Ivoire is very behind in the domain of R&D so that it could not soon reach Korea's level in bioenergies. Nevertheless, there are some institutions, the roles of which are linked to alternative energy promotion, biomass and forests management, agronomic research, soil study, etc. Some of them are the MMPE, the

CNRA, the ANADER, the Tropical Geography Institute (IGT), the Ivorian Office of Parks and Reserves (OIPR), the New Energy Research Institute (IREN), and the ADERCI. Why not involve them in research on the country's bioenergy potential? The real problem is the lack of commitment from the government.

4. Other Alternative Energies

Since I mentioned bioenergies as a way to improve Côte d'Ivoire's energy situation while adding value to the economy, some may ask me why I didn't suggest other alternative energies like wind and solar. Their argument could be that the country is well-endowed with sun and wind and that there are a few solar and wind energy plants that are malfunctioning (Wamukonya, Masumbuko, Gowa, and Asamoah 2009; Reep 2010). Therefore, one question could be: why not think about restoring and preserving the current alternative energy plants before undertaking bioenergy projects?

My response to the question will be as simple as possible. I of course know about the solar and wind resources as well as the related energy projects and activities, but one should also note the existing bioenergy projects and activities such as the jatropha plantations I mentioned in the literature review chapter and the production of electricity from sugar bagasse at S-Z. In fact, it's possible to restore the existing solar and wind energy plants and go through bioenergy development at the same time.

Moreover, I would like to remind that agriculture is the main economic activity of Côte d'Ivoire and exploiting waste from this sector for energy purpose will add value to the economy, create job opportunities, improve the energy situation, and contribute to environmental conservation by making sustainable the fossil sources and mitigating climate change effects, and so will the domestic waste and other bioenergy sources.

In sum, I recognize that my argument about bioenergy development in Côte d’Ivoire is debatable, but the country’s potentialities should encourage the government in the sense of decision-making.

VIII. CONCLUSIONS AND RECOMMENDATIONS

As stated in the introduction, the study is aimed at exploring and communicating the Côte d'Ivoire's bioenergy opportunities in order to stimulate policymaking which will result in improving people welfare ecologically and socioeconomically while accessing energy. To this end, I focused on cause-effect relationships and case study as research methods and I sometimes used the comparative method for data analysis. Those methods were appropriate because they allowed me to gather and analyze diverse data (quantitative, qualitative, and secondary) regarding bioenergies worldwide.

My purpose is to deal with energy issues in the country so that most people, mostly low-income and middle-income persons, could access modern and non-polluting energies for their basic needs. By stating and developing the purpose, I expect to reach my main objective which is to lead the government to integrate bioenergies in its energy plans. Specifically, in accordance with fears of risks surrounding bioenergy production, I showed how food security and energy security are complementary, how PPP and cooperation helped other countries implement sustainable energy policies, and how bioenergies contribute to economic development through industrialization.

In summary, my research has two aspects. On the one hand, it has emphasized the opportunity to produce bioenergies in the country through the availability of sources like degraded lands, agricultural waste, animal excrement, and municipal waste. Based on experiences from other countries, the findings have also indicated that policymaking is the most critical way to undertake and make adequate bioenergy plans.

On the other hand, the research have found that some aspects are not discussed enough to encourage policymaking in favour of bioenergies. Among others, food security seems to be still threatened; the prerequisites for such projects like data gathering, investment costs, and timing are not fully examined; the reference to selected countries only brings out weak similarities; and the option for bioenergies rather than other alternative energy sources is not necessarily the best.

Regarding those research weaknesses, I explained how food security can be preserved in bioenergy production, enumerated existing prerequisites, highlighted similarity factors between Côte d'Ivoire and the selected countries, and showed that the country can develop both bioenergies and other alternative energies like solar and wind. In addition, it's important to note that due to the extent of energy issues, and specifically bioenergies worldwide, this study could not meet all the related requirements.

However, some conclusions from the findings have shown why bioenergy policy is very weak or even absent in Côte d'Ivoire. Above all, it should be concluded that there is a contrast between the statement of policy regarding energy and the reality at the governmental level. The literature indicates that the Ivorian government feels concerned with energy security with the purpose of making available affordable and clean energies for all, but the statement is not followed by concrete decision-making on the ground (FAO 2009). From the study, another conclusion is that the fewer bioenergy projects and activities managed by the private sector and individuals fail to achieve the expected goals because they are not incentivized by the government. Also, it should be known that the lack of sustainable waste management strategies is an obstacle to bioenergy policies. Otherwise, the "Abidjan Municipal Solid Waste-To-Energy Project" (CBD 2006) would not remain a mere theory on paper up to now and, in general, the "Waste Resource & Biomass-to-Energy Policies for Low Carbon Green Growth" (MOE 2010) would attract more attention due to the availability of resources countrywide.

As a concluding remark, I have to add that the weak national interest in bioenergies slows the industrialization process of the country. In fact, since the 1960s, its economy is mainly based on agricultural exports and a weak industrialization rate (http://www.mongabay.com/reference/country_studies/ivory-coast/ECONOMY.html).

Altogether, the argument that food security is likely to decrease, due to the risk of land competition, as bioenergies are adopted, should not stop the movement towards practical actions. The study has indicated the ways to mitigate risks and the need to preserve both food security and energy security.

With reference to the study findings and conclusions, I will now make recommendations to the Ivorian government so that it could perform well in the domain of bioenergies if it decides to consider them.

Regarding food security, it should undertake accurate land studies through institutions like the CNRA, IGT, ANADER, and others to determine the types of lands available and implement sustainable forest policies. The same institutions need to be equipped and organized to lead advanced agricultural R&D. The government should also think about increasing the land law as well as the landed property right by facing the current land conflicts mostly stimulated by the 2002 armed conflict (IRIN 2010).

In addition to food security, the conditions for bioenergy development also need state attention. It's a question of doing feasibility studies before engaging in huge projects. Are there sufficient resources for bioenergy production? Does the country have the appropriate skills, technology, and infrastructure? What will be the right timing? What will be the social, environmental, and economic gains from such projects? The main objective of the feasibility studies is to answer those questions.

Also, the national energy policy should be revised in order to match the energy policy statement with the real situation on the ground. The aim of this is to establish a balanced exploitation and use of both conventional and alternative energies sources in order to reduce dependence on fossil fuels and develop clean and affordable energies for all. The government should take advantage of the new national energy code underway in the MMPE (BABATUNDE 2012) to show more interest in alternative energy sources (IMF 2009). Moreover, the legal framework could be an ideal opportunity for the State to think about buying the waste surplus in private companies like sugar factories and others where energy is produced from waste.

Talking about waste in general, the country's waste management strategies should improve through the option for waste-to-energy policy. The first thing to do in this context is to promote at the individual, domestic, company, and state levels the 3R strategy in order to lower the country's carbon footprint. Another important thing to do is to improve the waste management cycle through five steps: Prevention, Preparing for reuse, Recycling, other Recovery, and Disposal (EU 2010). At present, due to the deficiency of waste management in the country's urban areas, and specifically in Abidjan, not only garbage is littering the streets, but also it is illegally dumped close to residence areas. Therefore, it would be profitable to create new appropriate landfills and plan biogas production. As well, the government should motivate the revival of the "Abidjan Municipal Solid Waste-To-Energy Project" (CDM 2006). There is also an urgent need to establish and monitor databases on waste from all activities.

Moreover, the industrialization process that is delaying since the period of independence should be examined with more attention because industrialization is the basis of development nowadays. Promoting alternative energy industries, and specially bioenergies, would actually participate in accelerating that process due to the country's bioenergy potential. As the government shows interest in bioenergy industries for industrial development, the private sector will grow with the emergence of bioenergy SMEs/SMIs that will create job opportunities and reduce consequently poverty. As usual, the development of this kind of project will require pilot projects.

Lastly, I strongly recommend that the government increase cooperation inside and outside so as to implement an effective participatory management of energy and food issues. Inside, all the stakeholders should get involved in the "food vs. fuel" debate in order to highlight the sustainable ways to manage both issues. Regarding outside cooperation, at the regional level, Côte d'Ivoire keeps on attending conferences and workshops on agriculture, food, and energy. As an example, I personally represented the country at the "Regional Workshop for Africa on Ways and Means to Promote the Sustainable Production and Use of Biofuels", from 8 to 10 December, 2009, in Accra, Ghana (CBD 2009). Therefore, the government should consider the recommendations from such meetings and also learn from other African countries. As far as international cooperation is concerned, it would be advantageous not only to enforce the agreements on energy and climate change ratified by the country, but also to profit from the technical and financial support provided by international organizations. From the international level, it's also important to attract FDI for alternative energies as it happens in the sector of conventional energies.

As mentioned above, this paper could not cover all the research requirements. It only contributed to seek ways to preserve food security in Côte d'Ivoire while improving access to energy by making available sustainable bioenergy sources. However, the paper paved the way to further study on energy issues in general in the country. I focused on bioenergies, but it should be noted that the weakness of the national energy policy covers many of the alternative sources; I mean biomass, solar, wind, waste, etc. It also appears that the energy sector, based on fossil sources, hydroelectric power, and geothermal power, is dominated by a small number of MNCs.

Therefore, the roles of further studies could consist in indicating the relationship between energy monopoly and the lack of policy toward clean and affordable energies in the country, as well as doing feasibility studies for bioenergy projects. Furthermore, as the study focused on secondary research data, further studies could be conducted to gather data from original sources and accomplish statistical analysis on the issue.

Finally, this research paper has indicated that the development of bioenergies in Côte d’Ivoire does not represent a consequent threat to food security. Instead, being energy a development factor, bioenergies help agriculture and other business sectors acquire their energy independence, which participate in increasing food security. The question is what kind of policy is adopted and how it’s implemented.

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APPENDICES

APPENDICES

Appendix 1: **Mali Jatropha Electrification**

Balance of Rights, Responsibilities and Revenues of Actors

	Rights	Responsibilities	Revenues
Small farmers	- Use of land for farming or usufructuary rights in some cases - Sales of Jatropha seeds	- "Caretakers" of the land - Plantation, Jatropha seeds collection and delivery to the co-operative	- Cash from selling Jatropha seeds to CPP - Income from other farm products generated from intercropping system (Peanut, Fonio, etc.)
Jatropha production village committees (CVPP)	- Collect seeds at village level and deliver to the co-operative (CPP)	- Seeds collection storage and delivery to the co-operative in Garalo.	- Income from selling seeds to the Pressing co-operative (CPP)
Co-operative of Jatropha producers (CPP)	- Buy the seeds from the farmers (CVPP)	- Press the seeds and sell the oil to the power company (ACCESS)	- Income from Jatropha oil and potential income from seed cake selling
AMADER (Rural electrification agency)	- Promotion of Rural electrification in Mali	- Ensuring that subsidy is used according to regulation	- Grant from World Bank, other donors and State
ACCESS (Power company)	- Electricity sales	- Electricity production and distribution	- AMADER's subsidy - Electricity sales
Electricity consumer association (ECA)	- Interact with ACCESS and local authorities	- Look after electricity subscribers	- None
MFC	- None	- Project follow-up and quality control	- Grants, project implementation

Source: Mali Jatropha Electrification

Appendix 2: **Energy Price in Côte d'Ivoire**

1. **High-Voltage Tariffs (KWH)**			
Price of Kwh in FCFA TTC	**Short-time Utilisation**	**General Utilisation**	**Long-time Utilisation**
Annual Bonus per Subscribed Kwh	46. 658. 33	63.120	79.563
Price of Kwh during full Hours	49.14	32.59	29.16
Price of Kwh during Peak Hours	90.01	36.91	32.59
Price of Kwh during Off-peak Hours	27.71	27.72	27.71
Annual Electrification Fee per Subscribed Kwh	1.700	1.700	1.700
Monthly Radio and Television License	1000	1000	1000

Source: CEPICI, MMPE, CIE (Jun 2005), Optimisation Energétique d'une Unité Agricole Intégrée : Cas S-Z (BAYILI 2010)

2. **Hydrocarbons Tariffs**	
Type	**Cost**
Premium Unleaded Gasoline	615 CFA/liter
Lamp Oil	470 FCFA/liter
Diesel Oil	545 CFA/liter
Distillate Diesel Oil (DDO)	491.71FCFA/Kg
Fuel Oil	307. 28FCFA/Kg

Source : GPP (September 2006), Optimisation Energétique d'une Unité Agricole Intégrée : Cas S-Z (BAYILI 2010)

Note
Full Hours: From 7:30 am to 7:30 pm and from 11 pm to midnight
Peak Hours; From 7:30 pm to 11 pm
Off-peak Hours: From midnight to 7:30 am
1 FCFA =US$ 0.002.

Appendix 3 Côte d'Ivoire's Energy targets and Indicators

Côte d'Ivoire's Energy Targets and Indicators			
Indicators	**Level in 2008 (%)**	**Target in 2013**	**Target in 2015**
Proportion of Electrified Localities	31	43	50
Proportion of Households with Access to Electricity	17	35	55
Proportion of Households with Access to Modern Cooking Systems	20	40	60
Proportion of the Share of New and Renewable energies in the national Energy Consumption	0	3	5

Source: Poverty Reduction Strategy Paper – Côte d'Ivoire (IMF 2009)