

October, 2008

Sustainable Bioenergy Development in UEMOA Member Countries

Foreword

In the arid and semi-arid regions of Africa that encompass most countries of the West African Economic and Monetary Union (UEMOA)—Bénin, Burkina Faso, Côte d'Ivoire, Guinée Bissau, Mali, Niger, Sénégal, and Togo—the challenges of land degradation and desertification, compounded by the lack of access to energy and effects of climate change, are alarming. The Intergovernmental Panel on Climate Change predicts that Africa will be among the regions of the world most affected by climate change, and land degradation remains a substantial threat to Africa's ability to realize its potential in meeting the Millennium Development Goals (MDGs).

The current crises in the energy and agricultural sectors have brought into focus the daunting challenges facing the UEMOA region. The region's heavy dependence on oil imports is absorbing most of its export earnings, while the sharp increase in food prices has exacerbated the already fragile food security situation. Access to modern energy sources in UEMOA countries is limited; rural electrification remains below five percent. Despite the rapid urbanization that has taken place in all the UEMOA countries, the transition of urban dwellers to modern fuels remains slow. Traditional biomass still accounts for more than seventy percent of end-use energy consumption in the region, putting further pressure on the environment and impacting negatively on human health. The ability of small farmers to improve their livelihoods in the face of these energy constraints has been further compromised by the surge in both energy and grain prices globally over the last two years.

Land degradation and desertification influence agricultural production, food security, and energy security on a continent that remains a net food and energy importer. Responding to these threats and maintaining economic growth requires a strengthening of policies and institutions in ways that improve and protect agricultural capacity, and the adoption of coherent strategies to broaden energy access and address climate change, land use, and food security.

Managing these challenges requires action on several fronts. Fighting rural poverty and improving food and energy security will require not only an increase in agricultural production and industrial productivity, but also a diversification and expansion of the rural economy through the creation of new products and markets. Sustainable energy security requires diversifying supplies and developing alternative energy options within countries. Addressing climate change certainly involves reducing emissions of greenhouse gases and developing adaptation capacities, but for the arid and semi-arid regions the most pressing concern is reversing the trend of desertification and land degradation. By integrating and strengthening both their agriculture and energy policies, the UEMOA countries should enhance agricultural productivity and food security, increase rural energy access, and build capacity to adapt to climate change impacts.

West African countries have a range of opportunities for addressing many of their social, economic, and environmental development needs by incorporating modern bioenergy and sustainable energy services into their energy sectors. The UEMOA countries have the potential to

grow both food and energy crops, to develop non-food sources of biomass for energy use, and to adapt biomass energy technologies to modern efficient uses while improving rural incomes and farm productivity.

I am pleased to note that this report was commissioned by the Hub for Rural Development in West and Central Africa in order to better assess the potential of bioenergy and reduce the policy uncertainty faced by governments in the region. This is in accordance with the Hub's mission of offering policy and analytical services to governments, regional organizations, and organizations of producers to formulate and implement rural development policies, with a view to advancing the sustainable development of bioenergy.

This report, led by the UN Foundation, in partnership with the International Centre for Trade and Sustainable Development and the Energy and Security Group, identifies opportunities, assesses constraints, identifies trade-offs, and outlines key policy issues for promoting sustainable production and use of bioenergy in the eight member countries of UEMOA. It also provides appropriate data to guide governments and international organizations as they consider smallholder production schemes to broaden the use of bioenergy as part of a comprehensive agriculture sector strategy, while reducing poverty and arresting environmental degradation.

The Millennium Development Goals serve as important near term targets for countries to measure their progress on sustainable development. Achieving these goals is critical for Africa—and for the West African countries studied in this report. Success in meeting these goals and addressing climate change and its potential consequences demands well-integrated agriculture and energy policies if progress is to be sustained and strengthened. It is my hope that, in addition to shaping energy policy in the UEMOA region and bringing all stakeholders and partners, including UN Energy Africa, on board, this assessment will provide a new view of the potential of agriculture to help bring millions of Africans out of the dark and out of poverty.



Kandeh K. Yumkella

Director-General

United Nations Industrial Development Organization

Letter from the Rural Hub

The philosopher Ortega y Gasset said that all the possible changes could be classified into two main categories: the first relates to the fact that something changes in the world, and the second to when the world changes. The aim of this report is not “to change something” in West Africa but rather to deeply change West Africa.

This report’s objective is to provide West African Economic and Monetary Union (UEMOA) policymakers a framework within which to promote and implement public policies aimed at reducing rural poverty by broadening access to bioenergy. The report is the result of a close collaboration between the International Centre for Trade and Sustainable Development, the United Nations Foundation, and the Rural Hub. Also, this analysis could not have been possible without the valuable and effective contribution of the Energy and Security Group, which did its utmost to make the report technically useful for policymakers.

By making the most thorough analysis possible of the “energy–agriculture” issues, drawing on existing data and analysis, and setting up the basis for bold, well-thought-out public policies related to biofuels in the region, the report offers concrete proposals for action to public, national, and regional decisionmakers.

The scope of the issue is enormous. How we address the challenge of energy security, which is the other side of food security, will determine the future of our populations and the credibility of our politicians and institutions.

We know how fragile the process of defining and implementing public policies is in West Africa. This topic has been well studied by the academic world and multilateral institutions. One of the unanimous conclusions relates to the shortage of available, reliable economic and agricultural data due to inadequate public information systems. While bearing in mind these limitations, the report aims to provide a rational, objective effort to define the substantial potential that exists, ways of producing bioenergy that would be economically useful and technically feasible, and the principles that would shape an optimal regulatory framework.

The implementation of strategies for using energy for development in our region will necessarily imply an evolution in public governance, which will see a committed leadership join forces with a strong, engaged civil society through producers’ organizations making their voices heard and defending their interests.

Our development cannot be achieved without innovation and creativity at all levels: the report is a pledge to this. Under the leadership of the UEMOA, the Rural Hub will commit to ensure that the implementation of these recommendations is conducted realistically, progressively, and in a sustained way.

The need for well-balanced public policies in this domain has been reaffirmed by the UEMOA, which has built a coherent regional strategy with respect to bioenergy. The UEMOA now intends to create the same dynamic at the national level. The report seeks to support this process.



Dr. Ibrahim Assane Mayaki

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This report was commissioned by Ibrahim Assane Mayaki, Executive Director of the Hub for Rural Development in West and Central Africa (Senegal); undertaken by Moustapha Kamal Gueye of the International Centre for Trade and Sustainable Development (ICTSD-Geneva, Switzerland) and Judith Siegel of the Energy and Security Group (USA); and coordinated by the UN Foundation (USA).

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List of Acronyms

AAPB.....	African Association for the Promotion of Biofuels
AfDB	African Development Bank
AGRA.....	Alliance for a Green Revolution in Africa
AMADER	The Program for Rural Electrification
ANCR.....	National Association of Rural Councilors (Senegal)
APL.....	Agricultural Policy Law (Mali)
AREED	Africa Rural Energy Enterprise Development
AU	African Union
bbI.....	Barrels
BEDP.....	Bagasse Energy Development Programme
BEET	Bioenergy Evaluation Tool
BERP	Biomass Energy Regional Program
BIO-DME.....	Biomethanol Biodimethyl-ether
BIOCARMA	National Agency for Bioenergy (Mali)
BOAD	West Africa Development Bank
BTL.....	Biomass-to-liquids
CDCF	Community Development Carbon Fund
CDM.....	Clean Development Mechanism
CER.....	Certified Emission Reduction
CFA	Central African Franc
CGIAR.....	Consultative Group on International Agricultural Research
CHCP	Combined Heat, Cooling, and Power
CHP.....	Combined Heat and Power
CIAT	International Center for Tropical Agriculture
CIF.....	Climate Investment Funds

CILSS.....	Inter-State Committee to Combat Drought in the Sahel
CIRAD.....	French Agricultural Research Center for International Development
CNEDD....	National Council of the Environment for Sustainable Development (Niger)
CNG.....	Compressed Natural Gas
CO ₂	Carbon Dioxide
COMPETE.....	Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems – Africa
CSS.....	Senegalese Sugar Company
DGIS.....	Directorate General of International Cooperation of the Government of the Netherlands
EBID.....	ECOWAS Bank for Investment and Development
ECOWAS.....	Economic Community of West African States
EIB.....	European Investment Bank
EIP.....	School Instrument of Peace (Nigerian NGO)
ERDF.....	ECOWAS Regional Development Fund
ERIB.....	ECOWAS Regional Investment Bank
ESG.....	Energy and Security Group
ESMAP.....	Energy Sector Management Assistance Program
ETBE.....	Ethyl Tertiary Butyl Ether
EU.....	European Union
EUBIA.....	European Biomass Industry Association
EUEI.....	The European Union Energy Initiative
FAME/FAEE.....	Fatty Acid Methyl/Ethyl Ester
FAO.....	Food and Agriculture Organization (United Nations)
FCFA.....	Franc de la Coopération Financière en Afrique Centrale
FINESSE.....	Financing Energy Services for Small-Scale Energy Users
FMO.....	Netherlands Development Finance Facility

f.o.b.....	Free on Board ¹
FT	Fischer-Tropsch Diesel
GBEP.....	Global Bioenergy Partnership
GDP	Gross Domestic Product
GEEREF	Global Energy Efficiency and Renewable Energy Fund
GEF	Global Environment Facility
GHG.....	Greenhouse Gas
GTZ ..	The Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Cooperative)
GVEP.....	Global Village Energy Partnership
ha	Hectare
IBEP.....	International Bioenergy Platform
IBI	International Bioenergy Initiative
IBRD.....	International Bank for Reconstruction and Development
ICTSD.....	International Centre for Trade and Sustainable Development
IDA.....	The International Development Association
IEA.....	International Energy Agency
IFAD	International Fund for Agricultural Development
IFC.....	International Finance Corporation
IFDC.....	International Center for Soil Fertility and Agricultural Development
IMF	International Monetary Fund
JI.....	Joint Implementation
KfW	Kreditanstalt für Wiederaufbau
kg	Kilograms
km ²	Square Kilometers
km ³	Cubic Kilometers

¹ Commonly used when shipping goods, “free on board” indicates who pays loading and transportation costs, and/or the point at which the responsibility of the goods transfers from shipper to buyer.

LPG	Liquefied Petroleum Gas
m ²	Square Meters
m ³	Cubic Meters
MDG	Millennium Development Goals
MFP	Multifunctional Platform Project
MIGA	Multilateral Investment Guarantee Agency
MJ	Megajoule
MW	Megawatt
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental Organization
OMVS	Organisation pour la Mise en Valeur du Fleuve Sénégal
OSS	Sahara and Sahel Observatory
PCF	Prototype Carbon Fund
PPO	Pure Plant Oil
PPP	Public Private Partnerships
REEEP	Renewable Energy and Energy Efficiency Partnership
REVA	Return to Agriculture (Senegal)
RME	Rapeseed methyl ester
RPS	Renewable Portfolio Standard
SBC	Systems Benefit Charge
SME	Small and Medium Enterprise
SONABHY	National Oil Company, Burkina Faso
SOSUCO	National Sugar Company of Burkina Faso
SVO	Straight Vegetable Oil
tCO ₂ e	Tonnes Carbon Dioxide Equivalent
UEMOA	West African Economic and Monetary Union
UN	United Nations

UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNF	United Nations Foundation
UNFCCC.....	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
VAT	Value Added Tax
VER.....	Verified Emissions Reductions
WARDA.....	West Africa Rice Development Agency
WEC	World Energy Council

1. Introduction

Energy is essential to development. Countries with access to abundant and affordable modern energy have significantly larger gross domestic product (GDP), higher per capita income levels, longer life expectancies, increased literacy rates, and greater educational attainment. Without electricity and other modern energy services, it will be impossible to raise rural productivity, alleviate poverty, and achieve the United Nations Millennium Development Goals (MDGs).

In September 2007, the West African Economic and Monetary Union (UEMOA) joined with the Rural Hub of Western and Central Africa in commissioning a report from the United Nations Foundation (UNF), the International Centre for Trade and Sustainable Development (ICTSD), and the Energy and Security Group (ESG) to explore opportunities for bioenergy in the region. *The goal of this report was to assess the agriculture sector's potential for bioenergy production and identify constraints in UEMOA member countries, recognizing the equally vital need for food security in the region.*

The UEMOA region faces an urgent need to better understand its potential, weigh the various options, and define a clear strategy for bioenergy development to ensure that member countries pursue a path that helps, not harms, their economic and social advancement.

Globally, 80% of total primary energy supply depends on fossil fuels—coal, gas, and oil. In the poorest countries in Africa, traditional biomass and diesel are often the only energy options, although some do have access to hydropower. Even in oil-rich African countries most people remain energy poor. Rising costs of fossil fuels compromise the ability of many developing countries to broaden access to energy, even as the use of such fuels worsens global climate change. Developing countries—especially in equatorial zones—are uniquely vulnerable to climate change, which will change weather patterns and disrupt agriculture.

The eight UEMOA countries—Benin, Burkina Faso, Côte d'Ivoire, Guinea Bissau, Mali, Niger, Senegal, and Togo—possess a rich resource base that can be sustained by a combination of good policies and practices to expand the production of and access to food, fuel, and fiber. Undertaking these strategies to improve agriculture and forest productivity, protect watersheds, and produce bioenergy should also strengthen their ability to adapt to climate change.

Box 1-1: Economic and Monetary Union of West Africa (UEMOA) Overview

The UEMOA is an organization of eight states in West Africa established to promote economic integration among countries that share a common currency. The UEMOA was created by a treaty signed at Dakar, Senegal, on January 10, 1994, by the Heads of State and Government of Benin, Burkina Faso, Côte d'Ivoire, Mali, Niger, Senegal, and Togo. On May 2, 1997, Guinea Bissau became its eighth member state.

The UEMOA is a customs and monetary union among eight members of the Economic Community of West African States (ECOWAS). Its objectives are:

- Greater economic competitiveness, through open and competitive markets, along with the rationalization and harmonization of the legal environment.
- The convergence of macroeconomic policies and indicators.
- The creation of a common market.
- The coordination of sectoral policies.
- The harmonization of fiscal policies.

The UEMOA has supported member countries in achieving macroeconomic convergence criteria; developed an effective surveillance mechanism; adopted a customs union and common external tariff (early 2000); harmonized indirect taxation regulations; and initiated regional structural and sectoral policies. A September 2002 International Monetary Fund (IMF) survey cited the UEMOA as “the furthest along the path toward integration” of all the regional groupings in Africa.

ECOWAS and the UEMOA have developed a common program of action on trade liberalization and macroeconomic policy convergence. They have also agreed on common rules of origin to enhance trade, and ECOWAS has agreed to adopt the UEMOA's customs declaration forms and compensation mechanisms.

UEMOA is the acronym used among French-speaking countries. In some English sources the acronym WAEMU is used for the Union instead. This report follows the French standard.

Traditional wood biomass, which comprises 73% of primary energy in the region, must be adapted to create more efficient and cleaner fuels. Poor forestry practices must be reversed, as they undermine sustainable forest management and reforestation programs. Waste streams and agricultural residues can add to these resources. Locally grown bioenergy crops, sustainably produced, can also be transformed into modern fuels—expanding energy access, creating more employment opportunities, and generating higher incomes. With the correct policies and choices, the use of bioenergy can also reduce greenhouse gas emissions as energy consumption expands.

As work evolved on this report, the already fragile economic outlook in these countries was further influenced by the rapid acceleration of food and fuel prices since January 2008. All but one of the UEMOA member countries (Côte d'Ivoire) are dependent on oil imports for their electricity and

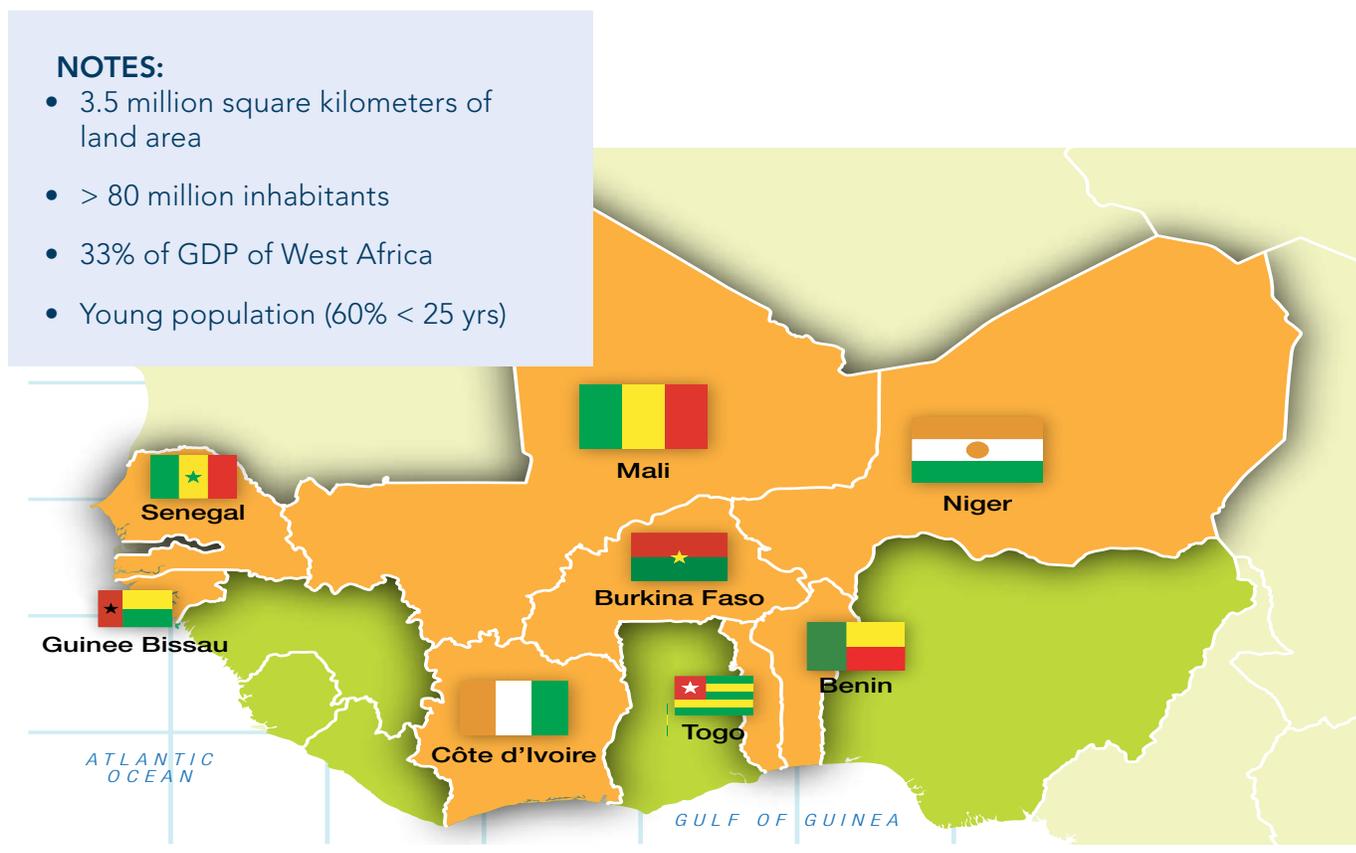
transportation needs. Moreover, all eight countries must import staple foods to meet nutritional requirements. Rapidly rising fuel costs and sharp increases in the price of staple crops (e.g., wheat and rice) have led to a deterioration in the balance of payments outlook. Given the synergies between agriculture and bioenergy, global food and energy circumstances have heightened this report's importance and timeliness.

The report concludes that, notwithstanding many challenges that require careful consideration, UEMOA member countries have the natural resources, the land availability, and the demand to improve agriculture productivity and develop bioenergy successfully in the context of a comprehensive sustainable agriculture and forest conservation strategy.

1.1 DEVELOPING A BIOENERGY STRATEGY

In response to this situation, the UEMOA joined with the Rural Hub, which supports rural development in Western and Central Africa, to commission a bioenergy report led by UNF with ICTSD and ESG. This report's purpose is to provide an initial assessment of the opportunities for and constraints to developing sustainable bioenergy production in West Africa, recognizing the need for food security. Participating countries included the eight French-speaking UEMOA members: Benin, Burkina Faso, Côte d'Ivoire, Guinea Bissau, Mali, Niger, Senegal, and Togo (see Figure 1-1).

Figure 1-1: Countries of the UEMOA



The report's objectives are threefold:

- Define strategies for sustainable agricultural and energy policies that would enable countries to improve their current/planned bioenergy policies (national, regional, local) and integrate them into broader development programs, with a focus on the rural economy. The challenge here is to manage available resources in a sustainable, productive manner.
- Establish an analytical base to inform bioenergy policy development in light of the social, environmental, and economic conditions of UEMOA member countries.
- Strengthen public and private institutions' ability to facilitate the implementation of coherent, pragmatic policies and regulations that promote bioenergy.

1.2 AUDIENCE

A broad-based audience is anticipated for this report. It will include:

- The UEMOA and its eight member countries. An overview of the UEMOA is found in Box 1-1.
- Other countries within the sub-Saharan region.
- Bilateral and multilateral organizations active in the UEMOA member countries.
- Local investors and financiers.
- Private sector companies, small and medium enterprises (SMEs), local businesses, and producer organizations.
- Non-governmental organizations (NGOs) and others active in the design, development, and implementation of agricultural–bioenergy initiatives in the UEMOA region.
- Members of civil society.

1.3 WHAT TO LOOK FOR IN THE REPORT

This report tackles the range of issues and information to be considered by the UEMOA member countries, and the region overall, in determining whether and how to move down a sustainable bioenergy path. It is intended to serve as a guide to decisionmakers—public, private, donors, and NGOs—in exploring the potential bioenergy contribution to helping lift these countries from poverty to prosperity. While not a panacea for all energy and agricultural needs of the region, bioenergy could make a potentially considerable contribution. Successful models and lessons learned from countries across the world can help guide the process, hasten the impacts, and increase the likelihood of success.

The sponsors of this report are driven by an interest to work with this incredibly resilient region—battered by an array of man-made and natural disasters—in making a difference in the lives and livelihoods of its people. Though the challenges may be great, inaction is not an option.

The report addresses the following:

- Provides country profiles of the eight UEMOA countries, including economic, social, demographic, and bioenergy data.
- Profiles the agricultural sector in the UEMOA, with an emphasis on rural development and food security.
- Discusses the important linkages between the energy, forestry, and agricultural sectors.
- Explains bioenergy conversion technologies—across the commercialization spectrum—from mature, to pilot, to research and development.
- Delineates the range of bioenergy feedstocks possible for the UEMOA, including activities underway and in planning.
- Summarizes opportunities and challenges to sustainable bioenergy development in the region.
- Discusses policy and regulatory issues related to bioenergy development.
- Addresses finance considerations for the successful development of a bioenergy market in the region.
- Outlines a critical three-year action plan for moving forward in the region, authored by the UEMOA.
- Offers conclusions and recommendations.

Chapters two through seven provide foundational information about the region and the issues. Chapters eight through eleven look forward to the implications and provide recommendations.

While data in the region can be incomplete for a variety of reasons, this report looks to the broad trends to draw conclusions. Each chapter provides a vital base of information needed for the UEMOA, and all are critical to success. The interdependency of these activities and how they are addressed—particularly as they relate to issues of energy, agriculture, food security, and environment—set this report apart.

2. UEMOA Member Country Overviews

An overview of UEMOA member countries, highlighting each country's geography, demographics, economics, key crops, energy situation, and bioenergy status is provided as country background for the remainder of this report.¹

BENIN AT A GLANCE:



Population: 8,294,941 (2008)

Urban population: 46.1%

Rural population: 53.9%

Human Development Index:² 0.437 (2005)

Electricity Access: 23%

GDP per capita: \$1,500 (2007)

Major Agricultural Crops: Cotton, maize, cassava (tapioca), yams, beans, palm oil, peanuts, cashews; livestock

% of Land under Cultivation: 2.3% (2005)

Oil production: 0 bbl/day (2007)

Oil consumption: 9,232 bbl/day (2007)

Oil imports: 16,830 bbl/day (2007)

2.1 BENIN

2.1.1 COUNTRY OVERVIEW

Benin comprises a narrow strip of 110,620 square kilometers (km²) of land area between Togo and Niger, of which about 24% is arable land. Permanent crops account for only a little over 27% of this land use. The area of irrigated land was 120 km² in 2003 and total renewable water resources 26 cubic kilometers (km³) in 2001. The total population is 8.2 million people, with a growth rate of 2.6% (2008 est.) and 37% of its population living below the poverty line (2007 est.).

¹ Data sources for this chapter are primarily CIA, 2008 and UEMOA Country Studies (to be published).

² The Human Development Index combines normalized measures of life expectancy, literacy, educational attainment, and per capita GDP for countries worldwide, on a scale of 0 to 1.

The country is endowed with small offshore oil deposits, limestone, marble, and timber. Benin's main agricultural products include cotton, maize, cassava, yams, beans, palm oil, peanuts, and cashews. Its main industries are textiles, food processing, construction materials, and cement. Agriculture accounts for one-third of the country's GDP, with industry accounting for 15%, and services over half of GDP. Growth in GDP has averaged 5% over the past seven years, with a per capita GDP of US\$1,500 (2007 est.). Benin remains underdeveloped and dependent on subsistence agriculture, cotton production, and regional trade. Export commodities include cotton, cashews, shea butter, textiles, palm products, and seafood. Imports include foodstuffs, capital goods, and petroleum products. Benin's largest trading partner is China, accounting for one-fifth of export earnings and 47% of imports. Insufficient electrical supply continues to adversely affect Benin's economic growth, though the government has recently taken steps to increase domestic power production. The country consumes 587 kWh of electricity, producing 105 million kWh and importing 595 kWh (2005). Completely dependent on trade for its oil, Benin imports approximately 9,232 bbl/day (2007).

2.1.2 BIOENERGY FEEDSTOCKS—POLICIES AND PROGRAMS

A number of agricultural crops can serve as feedstocks for bioenergy production. These include cassava, cashew nuts, maize, and sugarcane for ethanol production, and cotton seeds, groundnuts, palm oil, soy, jatropha, and ricin for biodiesel. Overall, the evaluation of the various feedstock options, the potential for production growth, and competing demand for human and animal consumption tend to point to cassava as a significant potential crop for ethanol production. Benin is the largest producer of cassava in the UEMOA region, with approximately 2.5 million tonnes of cassava produced in 2006. Production, though, has been on the decline after peaking in 2003. Using 5% of that potential for ethanol production could generate around 20,000 cubic meters (m³) of ethanol. There are small ethanol production units employing cassava as feedstock.

Due to its comparatively limited demand for water and soil quality, sweet sorghum is also a suitable feedstock in Benin. The advantage of sorghum over other crops is that it produces two harvests per year. Estimates indicate that with less than 20,000 ha of production, sweet sorghum delivers similar ethanol yield as cassava—42,000 and 43,923 liters respectively. Currently, annual cashew production is around 40,000 tonnes, with a cashew fruit production of 160,000 tonnes per annum. This fruit is generally just thrown away (considered waste). An ongoing project seeks to assess the technical potential of ethanol production from cashew fruit.

The main oilseeds produced in Benin are cotton, groundnuts, palm trees, and soy. Estimates of current production and consumption do not seem to offer significant potential for non-human/animal use of most of these crops. Recent development of palm oil in the southern part of the country—host to 50% of agricultural production—has given rise to concerns by environmental groups about potential displacement of grain production. On the other hand, there are initiatives for jatropha-based oil and biodiesel produced from other agricultural crops.

BURKINA FASO AT A GLANCE:



Population: 15,264,735 (2008)

Urban population: 21.3%

Rural population: 78.7%

Human Development Index: 0.370 (2005)

Electricity Access: 7%

GDP per capita: \$1,300 (2007)

Major Agricultural Crops: cotton, peanuts, shea nuts, sesame, sorghum, millet, maize, rice; livestock

% of Land under Cultivation: 0.22% (2005)

Oil production: 0 bbl/day (2007)

Oil consumption: 8,300 bbl/day (2005)

Oil imports: 8,158 bbl/day

2.2 BURKINA FASO

2.2.1 COUNTRY OVERVIEW

This landlocked country has 273,800 km² of total land area, of which about 18% is arable land and 0.22% is employed for permanent crops. The irrigated areas cover 250 km² (2003) and total renewable water resources are 17.5 km³ (2001). Though 90% of Burkina Faso's 15 million citizens are farmers, agriculture accounts for only 30% of GDP, with industry accounting for 19%, and services 51%. Approximately 46% of the population is below the poverty line.

Cotton is the main cash crop, but the susceptibility of cotton to severe weather patterns such as drought amplifies farmers' plight. GDP growth in 2007 is estimated to be 4%, well below the 10-year average of 6%. This is due mainly to higher energy costs, imported foodstuffs, and low cotton prices. Beyond cotton, agricultural products include peanuts, shea nuts, sesame, sorghum, millet, maize, rice, and livestock. Industries include cotton lint, beverages, agricultural processing, soap, cigarettes, textiles, and gold. Burkina Faso's largest trading partner is China, accounting for 41% of exports. Imports come primarily from Côte d'Ivoire (26%), France (23%), and Togo (7%).

Burkina Faso relies on imported petroleum for most of its electricity needs, estimated at 8,158 bbl/day.

2.2.2 BIOENERGY FEEDSTOCKS—POLICIES AND PROGRAMS

Woody biomass accounts for 95% of biomass energy consumption. Petroleum products constitute 13% and electricity 2% of final energy consumption. Local bioenergy development could improve the diversity of energy supply. Certain initiatives are already underway. Nevertheless, at present, there is no national bioenergy policy.

While several agricultural crops appear to be potential feedstocks for ethanol and biodiesel production, only a few have been assessed from a technical and economic perspective. Sugarcane appears to be the most suitable crop for ethanol production. The national sugar company (SN SOSUCO) has approximately 5,000 ha that could be used for this purpose. Theoretically, this land could produce 20,000 m³ of ethanol each year. Since 2003, cotton production has increased after a long period of decline. Total production ranges from 500,000 to 700,000 tonnes of cotton seeds. Further, there is an ongoing project to produce cotton oil with the national company SN SOSUCO in collaboration with the group DAGRIS. The unit is expected to have a productive capacity of 10,000 tonnes of oilseeds. In 2006, the Ministry of Trade and Enterprise Development started a collaborative effort with the national oil company (SONABHY) to produce biodiesel from cotton oilseeds. *Jatropha* plantations have been initiated in several parts of the country and are likely to expand following interest generated by research on high-yield seeds from institutions such as the French Agricultural Research Center for International Development (CIRAD) and national agricultural research institutions.

CÔTE D'IVOIRE AT A GLANCE:



Population: 18,373,060 (2008)

Urban population: 49.5%

Rural population: 50.5%

Human Development Index: 0.432 (2005)

Electricity Access: 51%

GDP per capita: \$1,700 (2007)

Major Agricultural Crops: coffee, cocoa beans, bananas, palm kernels, maize, rice, cassava (tapioca), sweet potatoes, sugar, cotton, rubber; timber

% of Land under Cultivation: 11% (2005)

Oil production: 57,700 bbl/day (2005)

Oil consumption: 27,000 bbl/day (2005)

Oil imports: 76,730 bbl/day (Côte d'Ivoire is a major refiner) (2004)

Oil exports: 85,780 bbl/day (2004)

2.3 CÔTE D'IVOIRE

2.3.1 COUNTRY OVERVIEW

Bordering the North Atlantic Ocean between Ghana and Liberia, Côte d'Ivoire has a total land area of 318,000 km². Ten percent of that land is arable; 11% is comprised of permanent crops. Irrigated areas cover 730 km² (2003) and total renewable water resources are 81 km³ (2001).

The total population exceeds 18 million, with an annual growth rate of approximately 2% (2008 est.). Forty-two percent of the population is below the poverty line. The country is the world's largest producer and exporter of cocoa beans and a significant producer and exporter of coffee and palm oil. Côte d'Ivoire is also rich in petroleum, natural gas, diamonds, manganese, iron ore, cobalt, bauxite, copper, gold, nickel, tantalum, silica sand, clay, and hydropower. Other agricultural and forestry products include bananas, maize, rice, cassava, sweet potatoes, sugar, cotton, rubber, and timber. Most of the population (68%) is engaged in the agriculture sector, which accounts for 27% of GDP. Industry accounts for 22% of GDP and services 50%. GDP grew by 1.6% in 2007, but per capita income has declined by 15% since 1999. Major exports include cocoa, coffee, timber, petroleum, cotton, bananas, pineapples, palm oil, and fish. More than half of Côte d'Ivoire's imports (fuel, capital equipment, and food) are supplied by Nigeria and France.

Since 2006, oil and gas production have been one of the most important economic activities as Côte d'Ivoire has one of the largest refineries in the UEMOA region. Earnings from oil and refined products were \$1.3 billion in 2006, while cocoa-related revenues were \$1 billion during the same period. Côte d'Ivoire's offshore oil and gas production has resulted in substantial crude oil exports and provides sufficient natural gas to fuel electricity exports to Ghana, Togo, Benin, Mali, and Burkina Faso. In 2005, Côte d'Ivoire produced 57,700 bbl/day and consumed 27,000 bbl/day. The country is self-sufficient in oil. In 2005, the country produced 5.305 billion kWh, consumed 2.9 billion kWh, and exported 1.397 billion kWh of electricity.

2.3.2 BIOENERGY FEEDSTOCKS—POLICIES AND PROGRAMS

Côte d'Ivoire has the largest percentage of electrification in the UEMOA region—85% in urban areas. The agricultural sector provides several opportunities for bioenergy production. Côte d'Ivoire has the largest potential for palm oil since its production exceeded 300,000 tonnes in 2006. Although the country produced about 2.25 million tonnes of cassava in 2006, no ethanol production from cassava has occurred. Approximately 500,000 tonnes of biomass is produced each year from agro-industrial enterprises, half of which is used to produce electricity.

Sugarcane production, concentrated in the country's northern part, is approximately 1,320,000 tonnes. It involves two major companies: Sucaf (860,861 tonnes) and Sucrivoire (569,322 tonnes). In 2005–2006, total raw sugar production was 147,279 tonnes. There is much interest in industrial-scale production of ethanol from sugarcane, maize, and other crops in Côte d'Ivoire. An American company has committed to investing US\$1 billion to produce 3.5 billion liters of ethanol from sugar and maize over a five-year period.

Although cashew production is important and has potential, no production is underway yet. The total production of 235,000 tonnes of cashew nuts, translating into 2,350,000 tonnes of cashew fruit, could potentially generate 30 liters of ethanol per tonne of cashew fruit, for a total of 70,500 m³ of ethanol. Jatropa plantations have been initiated only recently.

GUINEA BISSAU AT A GLANCE:



Population: 1,503,182 (2008)

Urban population: 26.1%

Rural population: 73.9%

Human Development Index: 0.374 (2005)

Electricity Access: 11.5%

GDP per capita: \$500 (2007)

Major Agricultural Crops: rice, maize, beans, cassava (tapioca), cashew nuts, peanuts, palm kernels, cotton; timber; fish

% of Land under Cultivation: 6.9% (2005)

Oil production: 0 bbl/day (2005)

Oil consumption: 2,480 bbl/day (2005)

Oil imports: 2,463 bbl/day (2004)

2.4 GUINEA BISSAU

2.4.1 COUNTRY OVERVIEW

Guinea Bissau has a total land area of 36,120 km² and borders the North Atlantic Ocean between Guinea and Senegal. It is rich in fish, timber, phosphates, bauxite, clay, granite, limestone, and unexploited deposits of petroleum. The country produces rice, maize, beans, cassava, cashew nuts, peanuts, palm kernels, and cotton. It also has large timber and fisheries industries. Arable land accounts for 8.3% of total land; 6.9% is devoted to permanent crops. Agriculture accounts for 62% of GDP, but employs 82% of the population. Guinea Bissau exports fish and seafood along with small amounts of peanuts, palm kernels, and timber. Imports include foodstuffs, machinery, transport equipment, and petroleum products. Because of high costs, the development of petroleum, phosphate, and other mineral resources is not a prospect for the near future. Since offshore oil prospecting has not yet yielded commercially viable crude deposits, the country remains dependent on oil imports at the rate of 2,463 bbl/day (2004). Electricity production (60 million kWh) fulfills domestic consumption requirements (55.8 million kWh).

2.4.2 BIOENERGY FEEDSTOCKS—POLICIES AND PROGRAMS

Guinea Bissau's energy profile is dominated by traditional biomass, which represents 90% of energy consumption. Petroleum products account for 8% of energy consumption and electricity accounts for the remaining 2%. Recent trends in the energy profile indicate a slight reduction in

the use of woody biomass to its 90% level from 97% in 1990 due to the increased use of natural gas. Development of biomass conversion into modern energy applications is limited.

Agricultural production benefits from suitable conditions with respect to rainfall—1,200 to 2,600 mm more per year than most other UEMOA member countries. Cashew is the most prominent agricultural crop in Guinea Bissau, generating more than US\$60 million of the country's export income from an annual production of 80,000 to 90,000 tonnes. Cashews offer the highest potential for bioenergy production in the form of ethanol from cashew fruits and electricity from cashew nuts. The total annual production is estimated to reach 600,000 tonnes, of which only 30% is transformed into juice to produce wine and spirits. If the remaining 70% (usually lost) were to be employed for the production of ethanol, the potential production of ethanol would be approximately 8,400 to 12,700 m³ per year. However, a major drawback is that the season lasts only three months each year, from April to June.

Beyond ethanol production, there may be significant potential for electricity generation from cashew nuts. An ongoing initiative with support from the UEMOA Commission seeks to assess that potential.

In addition, timber harvesting yields some 67,000 m³ of wood residues annually. This resource currently provides 12,000 tonnes of charcoal to meet the demand for cooking fuel. New applications to process these resources (pellets) and burning the cleaner fuel in more efficient stoves could improve the energy balance as outlined in the introduction. These residues could also be used in electricity generation.

In Guinea Bissau, effective forest management will be crucial. One possible policy shift is the reduction of charcoal in favor of more efficient and less polluting fuel options. Such an effort could also improve the quality of life for many rural people and replace charcoal production with alternative cooking fuel production.

MALI AT A GLANCE:



Population: 12,324,029 (2008)

Urban population: 33.4%

Rural population: 66.6%

Human Development Index: 0.380 (2005)

Electricity Access: 17%

GDP per capita: \$1,000 (2007)

Major Agricultural Crops: cotton, millet, rice, maize, vegetables, peanuts; cattle, sheep, goats

% of Land under Cultivation: 0.33% (2005)

Oil production: 0 bbl/day (2007)

Oil consumption: 5,600 bbl/day (2006)

Oil imports: 5,600 bbl/day (2006)

2.5 MALI

2.5.1 COUNTRY OVERVIEW

With 1.22 million km² of land, Mali borders southwest Algeria and is among the world's poorest countries. This is because the country is landlocked and approximately 65% of the land area is desert or semi-desert.

Only about 4% of its land is arable, with 0.03% under permanent cultivation. Irrigated areas cover more than 2,360 km² (2003), and the total renewable water resources are 100 km³ (2001). The total population exceeds 12 million (July 2008 est.). The growth rate is 2.7% (2008 est.), and 36% of the population lives below the poverty line (2005 est.). Key environmental problems include deforestation, soil erosion, desertification, inadequate supplies of potable water, and poaching. Economic activity is largely confined to an area irrigated by the Niger. Eighty percent of the labor force either farms or fishes, which accounts for 45% of GDP. Industrial activity is concentrated on processing farm commodities. Mineral resources include gold, phosphates, kaolin, salt, limestone, uranium, gypsum, and granite. Bauxite, iron ore, manganese, tin, and copper deposits have been discovered but have not been exploited. The country is vulnerable to fluctuations in world prices for cotton, its main export, and gold. In terms of electricity production, Mali is producing and consuming 804 million kWh (2006). The country is entirely dependent on oil imports, amounting to 5,600 bbl/day (2006 est.). Mali has a considerable trade deficit, with exports estimated at \$294 million free on board (f.o.b.), and imports of \$2.4 billion f.o.b. (2006).

2.5.2 BIOENERGY FEEDSTOCKS—POLICIES AND PROGRAMS

Mali has adapted its 2006 agriculture legislation with the specific objective of energy production from agricultural crops.

Jatropha has been a centerpiece of the country's experience with bioenergy and a focus of government efforts. Several pilot projects have been initiated over the past several years with jatropha oil being used to run agricultural machinery and for rural electrification. To date, the national potential for jatropha has not been evaluated. However, partial assessments indicate the availability, as do experiments conducted to evaluate potential seed and oil production. It is estimated that Mali has more than 20,000 km of jatropha hedge. Seed production is estimated to be two kilograms per linear meter, resulting in a natural potential of about 34,000 tonnes per year. If jatropha plantations were to be developed on available agricultural land, approximately four million hectares could be utilized. Using one-quarter of this area with a production assumed to be at three kilograms in the fifth year of growth, Mali would obtain a raw production of at least 7.8 million tonnes of seeds, equivalent to 1.95 million liters of diesel in the form of jatropha oil in one year. Furthermore, the potential for jatropha's development remains considerable, since areas not suitable for crops could be planted with jatropha.

Ethanol development is also underway with two sugar-producing units that belong to SUKALA-S.A. (Dougabougou and Siribala). Sugarcane production is 400,000 tonnes per year, and molasses between 8,000 and 10,000 tonnes per year. Approximately 50% of molasses is dedicated to ethanol production; the remainder is sold for animal feed or to the agro-food industry. The company produces 2.3 million liters of ethanol per year. Ethanol is sold to the pharmaceutical industry and to the agro-food and beverage industries in Mali. Large quantities (about one million liters per year) are exported to Burkina Faso. Production of cane could be doubled or tripled with the implementation of new sugar projects on 12,000 ha financed by the American-Brazilian consortium. The vast potential of agricultural residues and forest resources for modern energy generation (e.g., biogas, electricity) remains underutilized. Despite Mali's huge cotton production, the recent surge in the demand for cottonseed oil for human consumption seems to undermine any potential for energy use. Meanwhile, declining world prices have tended to encourage farmers to move to other crops, resulting in a decline in national cotton production. In Mali, the regulatory framework for bioenergy is defined in the national energy policy, the national strategy for renewable energies, and the national strategy for the development of biofuels. These initiatives will be implemented by the National Agency for Bioenergy (BIOCARMA), which is currently being developed and is expected to be operational in the summer of 2008.

NIGER AT A GLANCE:



Population: 13,272,679 (2008)

Urban population: 23.2%

Rural population: 76.8%

Human Development Index: 0.374 (2005)

Electricity Access: 7%

GDP per capita: \$700 (2007)

Major Agricultural Crops: cowpeas, cotton, peanuts, millet, sorghum, cassava (tapioca), rice; cattle, sheep, goats, camels, donkeys, horses, poultry

% of Land under Cultivation: 0.01% (2005)

Oil production: 0 bbl/day (2005)

Oil consumption: 5,450 bbl/day (2005)

Oil imports: 5,412 bbl/day (2004)

2.6 NIGER

2.6.1 COUNTRY OVERVIEW

Niger is landlocked and mostly desert (the northernmost four-fifths). Of its 1.27 million km² of land, 11% is arable, 0.01% is used for permanent crops, and only 730 km² are irrigated. Niger has renewable water resources of 33.7 km³ (2003). The total population exceeds 13 million (July 2008 est.), with 63% of the population living below the poverty line (2007 est.). Key environmental challenges include overgrazing, soil erosion, deforestation, desertification, and loss of wildlife populations.

The economy centers on subsistence crops, livestock, and some of the world's largest uranium deposits. The agriculture sector comprises 39% of GDP, but employs 90% of the labor force. Agriculture products include cowpeas, cotton, peanuts, millet, sorghum, cassava, rice, cattle, sheep, goats, camels, donkeys, horses, and poultry. Drought cycles, desertification, and population growth have hit the economy hard.

Niger has a current account deficit of \$321 million (2007 est.), with exports of uranium ore, livestock, cowpeas and onions comprising \$428 million f.o.b., while imports of foodstuffs, machinery, vehicles and parts, petroleum, and cereals comprise \$800 million f.o.b. (2006).

Growth in the future could be sustained by exploitation of oil, gold, coal, and other mineral resources. Electricity consumption is 437.7 million Kwh, with 220 million kWh being supplied through imports (2005). Oil consumption is supplied almost entirely by imports, which amount to 5,412 bbl/day (2004).

2.6.2 BIOENERGY FEEDSTOCKS—POLICIES AND PROGRAMS

Woody biomass remains the primary source of energy, providing 95% of energy needs for the vast majority of the population. There is a significant forest area estimated at 16,000 ha, which represents 2% of total land cover. Valuable forest resources are under threat due to increasing deforestation and the advance of desertification. The national strategy for rural development adopted in 2003 seeks to promote the development of renewable sources of energy, including biogas, vegetable oils, ethanol, and biodiesel.

A dozen agro-forest species have been identified in Niger as potential energy plants and crops, including natural plants such as balanites, jatropha, neem, and ricin. Export crops include cotton, groundnuts, maize, and cassava. However, the country's initiatives have focused on species that seem to be adapted to the Sahel's ecological conditions, in particular the potential to develop jatropha and other oil plants.

Studies of land use have indicated that 953,401 ha could be made available for planting jatropha bushes, taking into account protected zones and forest reserves that total 313,599 ha. The Sahelo-Sudanic zone is considered the most suitable area for jatropha development.

Niger has demonstrated the most interest in neem for biofuels development. In June 2005, a demonstration of the use of neem oil in a diesel motor pump took place at the National Council of the Environment for Sustainable Development (CNEDD). The mix was 0.5 liters of diesel and 0.5 liters of neem oil. As an experiment, a Nigerian NGO—the School Instrument of Peace (EIP)—initiated the use of neem oil to operate some motor pumps and grain mills in their participating villages of Seno, Sounga Dossdo, Wali, and Sawani. The progressive introduction of diesel tractors creates another opportunity for biodiesel use.

Niger seems to offer a high potential for biogas generation, owing to its vast livestock industry. The pastoral area extends over more than 240,000 km² and includes more than 7 million head of livestock. There is an ongoing assessment of this potential, with the goal of producing household electricity and cooking fuel from biogas.

SENEGAL AT A GLANCE:



Population: 12,853,259 (2008)

Urban population: 51%

Rural population: 49%

Human Development Index: 0.499 (2005)

Electricity Access: 42%

GDP per capita: \$1,700 (2007)

Major Agricultural Crops: peanuts, millet, maize, sorghum, rice, cotton, tomatoes, green vegetables; cattle, poultry, pigs; fish

% of Land under Cultivation: 0.24% (2005)

Oil production: 0 bbl/day (2005)

Oil consumption: 35,000 bbl/day (2005)

Oil imports: 37,180 bbl/day (2004)

2.7 SENEGAL

2.7.1 COUNTRY OVERVIEW

With 192,000 km² of land, Senegal borders the North Atlantic Ocean between Guinea Bissau and Mauritania. The country's principal natural resources are fish, phosphates, and iron ore. Just over 12% of the land is arable and 1,200 km² are irrigated, with 0.24% of land devoted to permanent crops. Its total renewable water resources are 39.4 km³ (1987). Key environmental challenges include wildlife populations threatened by poaching, deforestation, overgrazing, soil erosion, desertification, and overfishing.

Senegal has a total population of almost 13 million (July 2008 est.), and a growth rate of 2.58% (2008 est.), with 54% of the population living below the poverty line (2001 est.). Agriculture products include peanuts, millet, maize, sorghum, rice, cotton, tomatoes, green vegetables, cattle, poultry, pigs, and a sizeable fish industry. Since its economy contracted by 2.1% in 1993, Senegal has made reforms that have resulted in real GDP growth averaging more than 5% annually over the period 1995 to 2007. Major exports include fish, groundnuts (peanuts), petroleum products, phosphates, and cotton; imports include food and beverages, capital goods, and fuels.

Senegal was beset by an energy crisis that caused widespread blackouts in 2006 and 2007. However, today, production of 2.159 million kWh outstrips consumption of 1.859 million kWh. Senegal remains highly dependent on foreign oil, importing 37,180 bbl/day (2004). Senegal has

a substantial current account deficit of \$906 million (2007 est.), compounded by sharply reduced output in the phosphate industry, which has reduced GDP.

2.7.2 BIOENERGY FEEDSTOCKS—POLICIES AND PROGRAMS

Senegal has adopted a national bioenergy strategy that is largely centered on the development of jatropha for biodiesel and sugarcane for ethanol. The special program for biofuels began in 2006. It is being implemented by a national technical committee under the authority of the Minister of Cooperation that consists of local elected officials—notably the National Association of Rural Councilors (ANCR)—and producer organizations. The Senegalese Institute for Agricultural Research will monitor production. The strategy for the program implementation depends, in part, on the country's plan to Return to Agriculture (REVA). The set objective is the planting of 320,000 ha of jatropha bushes by 2012, providing 1,000 ha per rural community. This program would yield 3.2 million tonnes of seeds by 2012, netting 1.2 billion gallons of straight Jatropha oil, or 1.1 billion liters of refined oil that could be used as biodiesel. Senegal expects jatropha to contribute to a significant reduction in oil imports and make the country a net producer of energy.

Meanwhile, ethanol production has been underway at the Senegalese Sugar Company (CSS). The company produces approximately 35,000 tonnes of molasses with a strong sugar content. It projects that it can transform the molasses into 2,500 m³ of industrial ethanol and 10,000 tonnes (12,500 m³) of anhydrous ethanol as biofuel.

The national oil seeds company (SANACOS) has been employing groundnut shells in cogeneration with a production estimated at 341 kilotonnes. Nonetheless, energy generation from groundnut shells remains limited in comparison to the large volume of groundnut production available within the country.

TOGO AT A GLANCE:



Population: 5,858,673 (2008)

Urban population: 36.1%

Rural population: 63.9%

Human Development Index: 0.512 (2005)

Electricity Access: 10%

GDP per capita: \$800 (2007)

Major Agricultural Crops: coffee, cocoa, cotton, yams, cassava (tapioca), maize, beans, rice, millet, sorghum; livestock; fish

% of Land under Cultivation: 2.11% (2005)

Oil production: 0 bbl/day (2005)

Oil consumption: 16,000 bbl/day (2005)

Oil imports: 15,130 bbl/day (2004)

2.8 TOGO

2.8.1 COUNTRY OVERVIEW

A narrow strip of 54,385 km² of land between Ghana and Benin, Togo is rich in phosphates, limestone, and marble.

It also has a considerable amount of arable land, 44%, with 2% of that land devoted to permanent crops. The areas under irrigation extend more than 70 km² (2003), and total renewable water resources are 14.7 km³ (2001). Togo has a total population of more than 5.8 million, an annual growth rate of 2.7% (2008 est.), and has 32% of the population below the poverty line (2007). Key environmental challenges include deforestation due to slash-and-burn agriculture and fuelwood use, water, and air pollution. Togo is heavily dependent on both commercial and subsistence agriculture, which provides employment for 65% of the labor force and comprises the greatest part of GDP, at 40%. Industry makes up 25% of GDP and 5% of the labor force; services account for 35% of GDP and 30% of the labor force. Agriculture products include coffee, cocoa, cotton, yams, cassava, maize, beans, rice, millet, sorghum, livestock, and fish industries. Cocoa, coffee, and cotton generate about 40% of export earnings with cotton being the most important cash crop. The country is the world's fourth-largest producer of phosphate. However, it has a current account deficit of \$160 million (2007). Exports include cotton, phosphates, coffee, and cocoa; imports include machinery and equipment, foodstuffs, and petroleum products.

Togo relies on the import of electricity from neighboring Ghana, which supplies 486 million kWh of the 576 million kWh consumed (2005). Oil imports to meet domestic consumption are 15,130 bbl/day (2004).

2.8.2 BIOENERGY FEEDSTOCKS—POLICIES AND PROGRAMS

Biomass accounts for 76% of final energy consumption in Togo, petroleum products 20%, and electricity 4%. Biomass resources come from agriculture, forests, and associated residues, biofuels, and biogas. The total area of full forest cover is estimated at 449,000 ha. The national consumption of charcoal was around 1.9 million tonnes in 2006, of which 62% was consumed in rural areas and 38% in urban areas. The country satisfies much of its energy needs for cooking and heating from traditional biomass resources. Replacing charcoal production with modern, cleaner biomass fuels should be a top priority for Togo. This effort, combined with an active reforestation and forest management strategy, could significantly improve rural incomes and contribute to sustainable development.

Agricultural crops include several potential feedstocks, including sugarcane, cashew, sorghum, maize, cassava, groundnuts, and palm oil. Sugar production is undertaken on an industrial scale at Anié (200 km north of Lomé, the capital of the country) by a Chinese-owned sugar company. The area exploited—1,250 ha—is relatively small, which limits the production to 8,000 tonnes per year. Most of the molasses produced is used in the pharmaceutical industry; some is exported to Burkina Faso and Ghana. Togo produced approximately 750,000 tonnes of cassava in 2006, making it the third-largest producer of cassava in the region, after Benin and Côte d'Ivoire. Current cassava production is for human consumption; production would need to be significantly increased to generate feedstock for energy beyond food requirements. Both cotton and palm oil production have recorded a decline in production in the past years, with the cotton decline driven largely by low international prices.

While a few pilot projects have been initiated to develop biogas from animal wastes, applications remain limited due to competition from cheap woody biomass. In developing Togo's national development strategy, which was adopted in May 2007, use of jatropha to produce biodiesel was identified as one of the priority action areas to be developed during 2008 to 2010 as part of the poverty reduction program for achieving the MDGs. This could open up new opportunities for future production of biodiesel from jatropha.

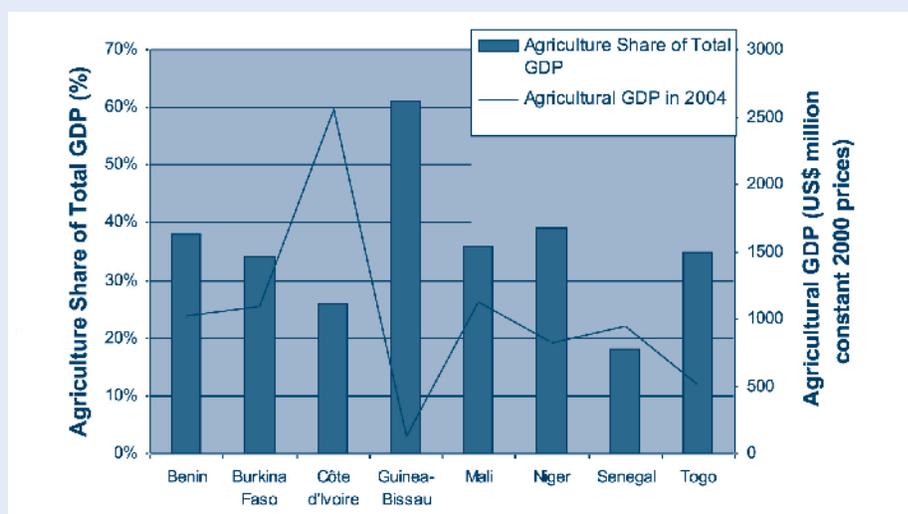
2.9 SUMMARY

- Approximately 60% of the population is below 25 years of age, and based primarily in rural areas where unemployment levels are high and there is a significant migration to urban areas.
- Agriculture accounts for the bulk of GDP; cotton and groundnuts are key cash crops and both are experiencing significant price declines and susceptibility to weather patterns.
- Most UEMOA member countries have established biofuels production policies and several have attracted investor interest in establishing plantations. The combination of pro-biofuels policies, investor interest, and existing and potential feedstocks offers an opportunity to enhance energy access in the region. Examples of related activities include:
 - » **Benin** has a small operating ethanol plant and initiatives underway for jatropha/biodiesel development.
 - » **Burkina Faso** is producing biodiesel from cotton seeds and is developing jatropha plantations.
 - » **Côte d'Ivoire** has the largest potential for palm oil. Biomass produced from agro-industrial enterprises is used to produce electricity. There is also much interest in industrial-scale production of ethanol from sugarcane, maize, cassava, and other crops. Jatropha plantations have been initiated only recently.
 - » **In Guinea Bissau**, cashew presents the highest potential for bioenergy, potentially using cashew fruit and/or agro-forest residues to generate electricity and produce cleaner cooking fuels. Ethanol production is possible and it could contribute to other energy needs.
 - » **Mali** has adapted its 2006 legislation on agriculture with the specific objective of energy production from agricultural crops. Jatropha has been a centerpiece of Mali's experience with bioenergy. The development of ethanol from sugar is also underway and there is potential to use agricultural residues and forest resources for modern energy generation (biogas, electricity).
 - » **In Niger**, the national strategy for rural development adopted in 2003 seeks to promote the development of renewable sources of energy, including vegetable oils, ethanol, and biodiesel. Niger is also pursuing biogas generation, due to its vast livestock industry.
 - » **Senegal** has adopted a national bioenergy strategy focused on jatropha for biodiesel and large-scale sugarcane for ethanol.
 - » **Togo** has initiated biogas projects and incorporates biodiesel from jatropha in its national development strategy.

3. Agriculture, Rural Development, and Food Security

Agriculture plays a central role in the development of the UEMOA member countries, on average contributing to about 36% of total GDP in 2004 (FAO, 2005). Not only does agriculture contribute immensely to GDP, it is also the main income-generating activity for the majority of UEMOA's rural population (see Figure 3-1). Furthermore, agriculture production is essential to meeting the food consumption needs of an ever-growing population in this region.

Figure 3-1: Agricultural Share of Total GDP



Source: FAOSTAT, 2008.

- The UEMOA is characterized by a largely rural population practicing subsistence farming and export-oriented agriculture.
- The region has significant land, but much of this is infertile and plagued by erosion and degradation.
- About 13% of arable land is under permanent cultivation, leaving a potentially significant portion available for cultivation.
- Only 2% of the total arable land is irrigated. Expanded irrigation use, combined with sound water management, could rapidly expand production.
- Public sector retreat from the agricultural sector, combined with reduced donor support, hindered agriculture development in the last two decades. Food price increases and export crop revenue declines exacerbate the problem.
- Bioenergy, developed in a sustainable manner, can create new opportunities in rural areas while increasing food and fuel production.

3.1 AGRICULTURE PROFILE OF UEMOA MEMBER COUNTRIES

West Africa consists of four climatic zones from north to south: Saharan, Sahelian, Sudanic, and Guinean (humid, equatorial). Rainfall ranges from less than 100 mm to more than 3,000 mm. Agricultural production is weather dependent and rainfall patterns are variable, creating significant instability. Soils in the region are low in nutrients and degraded. The total land area of the UEMOA region is 345,415,000 hectares. Recent Food and Agriculture Organization (FAO) studies estimate that 33,802,000 ha comprise total arable land, slightly less than 10% of total land area. Of total arable land, 4,445,000 ha are under permanent cultivation, or 13% of total arable land (see Table 3-1).

Important river systems traverse the region: the Niger (2,090,000 km²), the Senegal (440,000 km²), the Gambia (69,900 km²), the Sassandra (68,200 km²), the Bandama (97,500 km²), the Comoé (78,100 km²), the Volta (412,800 km²), the Mono (22,000 km²), and Lake Chad (2,388,700 km²). These river flows are directly linked to rainfall, which is also dependent on the maintenance of ground cover and forest watersheds in these fragile regions.

Deforestation rates in the UEMOA region average 1.61% annually, twice that of sub-Saharan Africa as a whole. Rates are highest in Togo, which recorded a 4.5% annual rate in 2005. Population

Table 3-1: Agricultural Areas

Country	Total land area (thousand ha)	Arable land (thousand ha)			Permanent crops (thousand ha)		
	2005	1980	1990	2005	1980	1990	2005
Benin	11,062	1,500	1,615	2,750	85	105	267
Burkina Faso	27,360	2,745	3,520	4,840	40	55	60
Côte d'Ivoire	31,800	1,955	2,430	3,500	2,300	3,500	3,600
Guinea Bissau	2,812	255	300	300	48	117	250
Mali	122,019	2,010	2,053	4,800	40	40	40
Niger	126,670	10,212	11,036	14,482	8	11	18
Senegal	19,253	2,341	2,325	2,550	9	25	48
Togo	5,439	1,950	2,100	2,490	85	90	140
Total	346,415	22,968	25,379	35,712	2,615	3,943	4,423

Source: FAOSTAT, 2007.

growth is a major driver of deforestation and land degradation. High average population growth rates of 3%—significantly higher than the 2.5% of all sub-Saharan Africa—place heavy demands on the ecosystems of the region. The population within the eight UEMOA countries grew from 40 to 80 million between 1980 and 2005.

Overall, agricultural areas under irrigation are limited in the UEMOA region. In 2003, agricultural land under irrigation represented 571,000 ha—less than 2% of the total arable land (see Table 3-2). This compares to 39% in South Asia and 29% in East Asia (World Bank, 2007). Potential underground water sources exist, but appear limited, although a comprehensive assessment is needed. With known pressure on water tables, expansion of irrigation has limits, as aquifer replenishment is variable. These factors pose constraints on irrigation initiatives without better studies.

Table 3-2: Water Use and Irrigated Land

Country	Share of total water use (%)			Irrigated land (thousand ha)			
	Agriculture 2000	Industry 2000	Domestic 2000	1979-1981	1989-1991	1999-2001	2003
Benin	45.4	23.1	31.5	9	10	12	12
Burkina Faso	86.3	0.8	13.0	10	19	25	25
Côte d'Ivoire	64.5	11.8	23.7	44	66	73	73
Guinea Bissau	82.3	4.6	13.1	17	17	24	25
Mali	90.1	0.9	9.0	60	78	224	236
Niger	95.4	0.5	4.1	23	66	72	73
Senegal	93.0	2.6	4.4	62	85	104	120
Togo	45.0	2.4	52.6	1	7	7	7
Regional	75.3	5.8	18.9	226	348	541	571

Source: FAOSTAT, 2007.

Like irrigation, there is low use of other modern agronomic practices. Sub-Saharan Africa has the lowest use of fertilizer in the world, at 10% of average global use. Similarly, there are far fewer tractors per hectare than in other developing regions. As a result, yields per hectare are lower than those achieved in other developing countries.

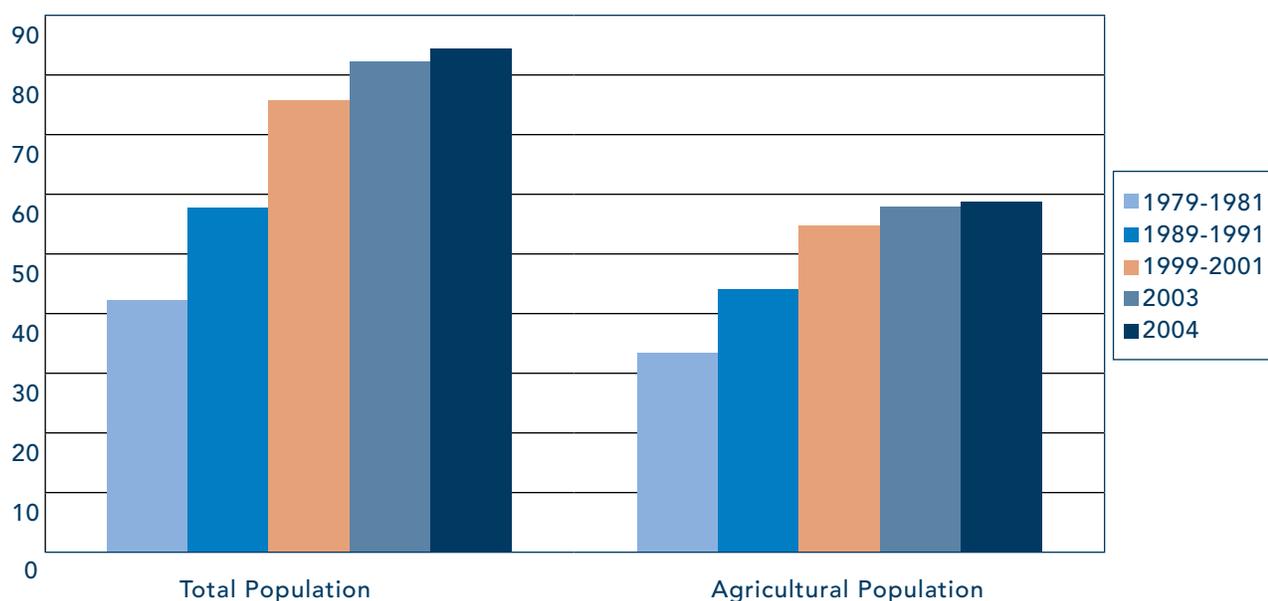
Total UEMOA population, as well as the agricultural share of the population, is shown in Table 3-3 and Figure 3-2. As evidenced, agriculture accounts for a major share of total population in all of the UEMOA countries.

**Table 3-3: Total UEMOA Population and Agricultural Population
(Including Forestry and Fishing)**

Country	Total population (thousands)					Agricultural population (thousands)				
	1979 – 1981	1989 – 1991	1999 – 2001	2003	2004	1979 – 1981	1989 – 1991	1999 – 2001	2003	2004
Benin	3,461	4,654	6,225	6,736	6,918	2,340	2,948	3,360	3,438	3,463
Burkina Faso	6,823	8,923	11,909	13,002	13,393	6,291	8,247	10,987	11,988	12,345
Côte d'Ivoire	8,433	12,503	15,826	16,631	16,897	5,474	7,449	7,786	7,635	7,571
Guinea Bissau	792	1,017	1,368	1,493	1,538	693	868	1,133	1,225	1,257
Mali	7,047	9,049	11,909	13,007	13,409	6,270	7,759	9,644	10,312	10,549
Niger	5,588	7,654	10,748	11,972	12,415	5,101	6,871	9,430	10,425	10,782
Senegal	5,539	7,345	9,395	10,095	10,339	4,468	5,642	6,929	7,345	7,488
Togo	2,523	3,453	4,558	4,909	5,017	1,736	2,260	2,721	2,842	2,873
Total	40,206	54,598	71,938	77,845	79,926	32,373	42,044	51,990	55,210	56,328

Source: FAO, 2007b.

**Figure 3-2: Total UEMOA Population and Agricultural Population
(Including Forestry and Fishing) (Millions)**



Source: FAO, 2007b, Table A1.

Average annual per capita economic growth in the sub-Saharan region from 1990 to 2007 was 0.61% (World Bank, 2008), although from 2004 on, it has been better than 3% annually. Among UEMOA members, the agricultural population has a lower per capita GDP than national averages. For example, per capita agricultural GDP was only about half of national per capita GDP in both 2003 and 2004 in the UEMOA region. The gap between the agricultural per capita income and the national average varies widely by country (see Table 3-4).

Over the last 30 years, agriculture has played a large part in total GDP in UEMOA member countries. On average, agriculture has maintained a 30% share of GDP or higher since 1979, accounting for as much as 36% of total GDP in 2004 (see Table 3-5). There is significant country to country variation. In Guinea Bissau, agriculture made up 61% of total GDP in 2004. However, in Senegal, agriculture's share of total GDP was merely 18%.

The agricultural production systems in West Africa are characterized by a dual system combining subsistence farming with export-oriented agriculture. The traditional food crops, such as millet, sorghum, maize, rice, and cassava, are principally destined for national or regional consumer needs. Export crops, which were introduced during the colonial period, include cotton, groundnuts, cocoa beans, coffee, sugar and cashews.

Food staples in the UEMOA include yams, rice, wheat, maize, and cassava, among others. Cereals represented 50% of total food staple consumption in the UEMOA in 2003, constituting the major food base in the region. Yams and cassava each made up less than 13% of total food consumption.

Table 3-4: Per Capita GDP and Per Capita Agricultural GDP of the Agricultural Population

Country	Per capita GDP (US\$ constant 2000 prices)					Per capita agricultural GDP of the agricultural population (US\$ constant 2000 prices)				
	1979 – 1981	1989 – 1991	1999 – 2001	2003	2004	1979 – 1981	1989 – 1991	1999 – 2001	2003	2004
Benin	317	305	362	387	387	131	163	243	278	295
Burkina Faso	187	203	222	236	238	66	70	78	77	88
Côte d'Ivoire	967	668	675	615	591	295	239	315	330	338
Guinea Bissau	163	183	154	135	137	84	92	98	99	102
Mali	218	182	210	234	232	96	101	105	115	107
Niger	275	199	172	175	170	92	82	78	80	76
Senegal	420	421	466	492	509	126	119	122	119	126
Togo	362	310	292	289	291	121	150	171	172	176
Total	363.62	308.87	319.12	320.37	319.37	126.37	127	151.25	158.25	163.5

Source: FAO, 2007b, Table A9.

Table 3-5: Agricultural Share of Total GDP (% share of GDP)

Country	1979 - 1981	1989 - 1991	1999 - 2001	2003	2004
Benin	28	34	36	37	38
Burkina Faso	33	32	33	30	34
Côte d'Ivoire	20	21	23	25	26
Guinea Bissau	45	43	53	60	61
Mali	39	47	40	39	36
Niger	31	37	40	40	39
Senegal	24	22	19	18	18
Togo	23	32	35	34	35
UEMOA Average %	30	34	35	35	36

Source: FAO, 2007a.

3.2 FOOD SECURITY

The UEMOA region remains food deficient. The decline of malnutrition, which went from a regional average of 33% of total population over the period 1979 to 1981 (14.2 million people) to a regional average of 21% over 2001 to 2003 (16.3 million people), has not reduced the number of undernourished people. (see Table 3-6) Undernourishment remains prevalent and continues to represent a major challenge. Food insecurity is a daily concern for more than 40% of the population (CILSS, 2002) and is likely to increase with rising fuel and food prices.

Food insecurity exists when people do not have physical, social, or economic access to food (FAO, 2003). A number of factors contribute to food insecurity in the UEMOA, including low productivity, rural poverty, rapid urbanization, population growth, minimal diversification of rural income sources, and limited availability of agricultural products. Poverty eradication is essential to improve access to food. The vast majority of those who are undernourished either cannot produce or cannot afford to buy enough food. They have inadequate access to means of production such as land, water, improved seeds and plants, appropriate technologies, and farm credit. In addition, wars, civil strife, natural disasters, climate-related ecological changes, and environmental degradation have adversely affected millions of people. Although food assistance may be provided to ease their plight, it is not a long-term solution to the underlying causes of food insecurity (FAO, 2007b).

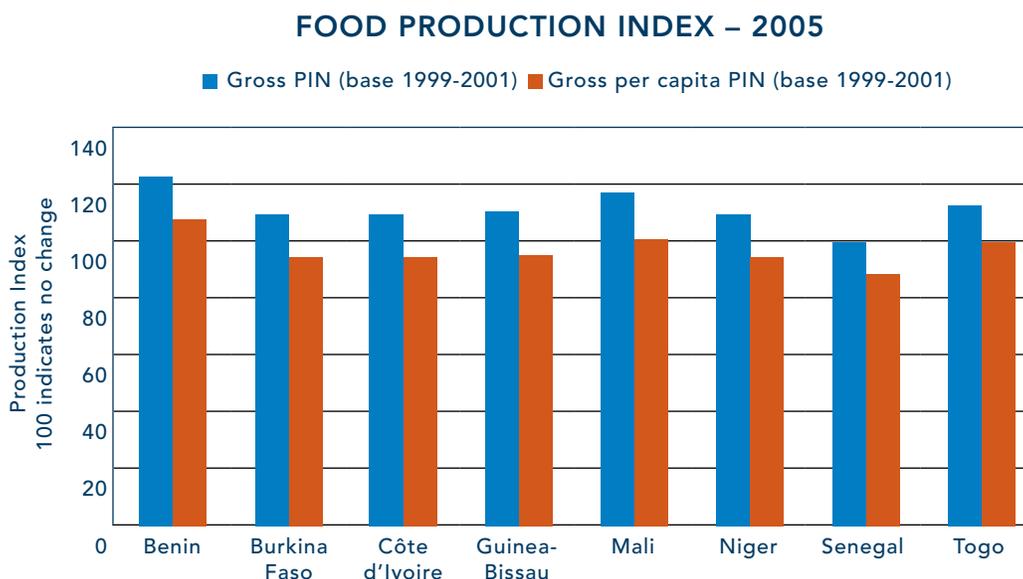
In the UEMOA region, gross food production increased between 2000 and 2005 but per capita food production fell, demonstrating the difficulty in outpacing population growth with domestic production (see Figures 3-3 and 3-4).

Table 3-6: Number of Undernourished People as a Share of Total Population

Country	Number of undernourished people (millions)				Proportion of undernourished in the total population (%)			
	1979 – 1981	1990 – 1992	1995 – 1997	2001 – 2003	1979 – 1981	1990 – 1992	1995 – 1997	2001 – 2003
Benin	1.3	1.0	0.9	0.9	37	20	17	14
Burkina Faso	4.2	1.9	2.0	2.1	62	21	19	17
Côte d'Ivoire	0.7	2.3	2.3	2.2	8	18	16	14
Guinea Bissau	0.3	0.3	0.4	0.5	41	24	31	37
Mali	4.5	2.7	3.4	3.5	64	29	32	28
Niger	1.9	3.2	3.9	3.7	33	41	42	32
Senegal	1.3	1.8	2.2	2.2	23	23	25	23
Total	14.2	13.2	15.1	15.1	33	22	23	21

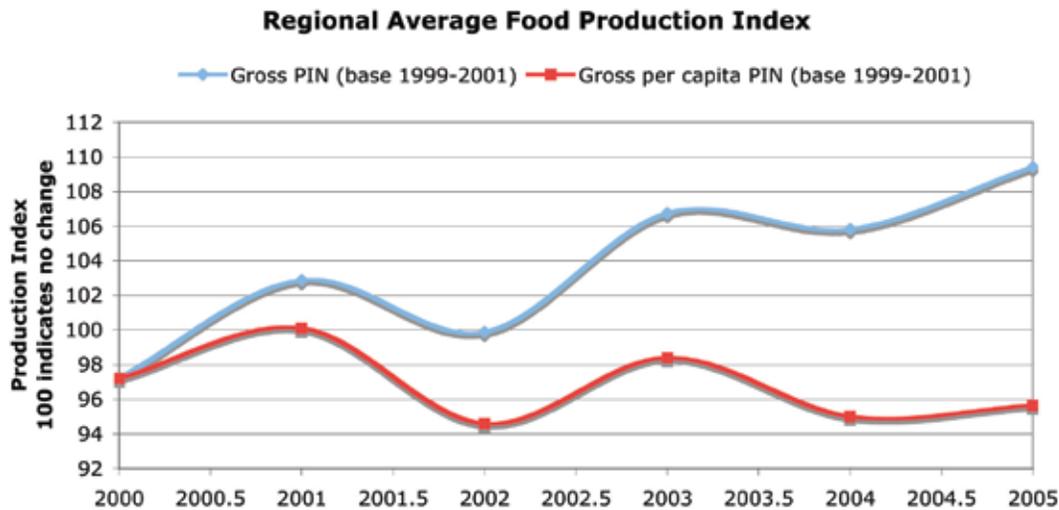
Source: FAO, 1999, 2007b, Table A11.

Figure 3-3: Food Production Index 2005



Source: FAOSTAT, 2008.

Figure 3-4: Regional Average Food Production Index



Source: FAOSTAT, 2008.

In 2003, imports made up a 7% share of food staple consumption. While cereal imports are fairly insignificant in comparison to total cereal consumption, wheat and rice imports account for a large share of consumption. In particular, in 2003 wheat imports fulfilled nearly 75% of total wheat consumption and rice (milled) imports met almost 36% of rice consumption needs in UEMOA member countries (see Table 3-7). Rising prices for these commodities (see Figure 3-5) present a serious issue for local consumers and national budgets.

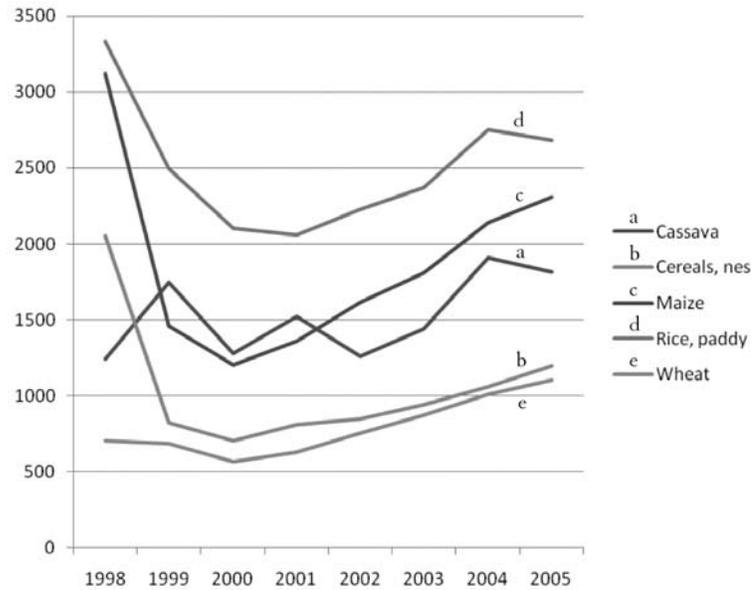
Gross production suffered additional setbacks in 2007–2008 due to a number of weather-related shocks (see Box 3-1).

Past agricultural policies in many UEMOA member countries have also promoted an expansion of export crops to earn foreign exchange. In five of the member countries, non-food production increases have outstripped food production increases since 2000. Senegal, the only country with a decrease in gross food production since 2005, saw the largest non-food production increase at nearly 230% (see Figure 3-6). Subsidy policies in developed countries through the 1990s created surplus production in the global market that reduced food import prices for a number of years, reinforcing this approach. Surpluses have now globally declined for a variety of reasons, putting pressure on prices. Countries that did not anticipate these increases are now making painful adjustments.

Box 3-1: Food Security in West Africa: Recent Events

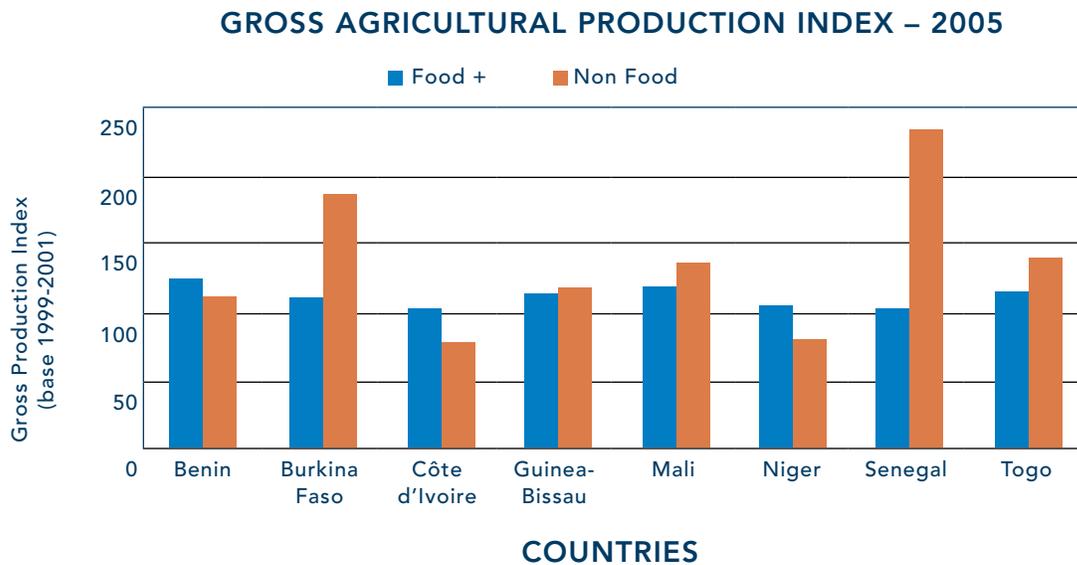
The West Africa subregion was hit by three different shocks that began during 2007, and are impacting food security and nutrition. Initially, the subregion was beset by a late and erratic start to the rainy season, which then gave way to torrential rains and widespread flash flooding. The rains ended earlier than normal, which shortened the rainy season and compromised agricultural production. These production deficits, coupled with the global trends of increasing prices for food and fuel, have led to unusual price increases for locally produced cereals and sharp increases for imported commodities (FAO et al., 2008).

Figure 3-5: Food Staple Prices 1998 to 2005 (US Dollars/tonne)



Source: FAOSTAT, 2008.

Figure 3-6: Gross Agricultural Production: Food versus Non-Food Production



Source: FAOSTAT, 2008.

3.3 AGRICULTURAL SUPPORT

Reduction in support for the agricultural sector by governments, multilateral organizations, and bilateral agencies further contributed to food insecurity. The stagnation of agriculture, especially in the food crop sector, was compounded by the public sector's steady retreat from its main

Table 3-7: 2003 Consumption and Imports of Food Staples

Item	2003 Consumption (tonnes)	2003 Imports (tonnes)	Consumption from Imports (%)
Cassava	3,349,502	-	0
Cereals	13,365,904	4,715	0
Maize	2,532,675	129,856	5
Rice (Milled Equivalent)	3,216,534	1,142,995	36
Wheat	971,101	726,461	75
Yams	3,471,654	6,019	0
Grand Total	26,907,370	2,010,046	7

Source: FAOSTAT, 2008.

supporting functions of marketing, seed supply, credit schemes, and producer price guarantees. The overall impact of these policies has been:

- Disengagement of the state from production activities, transformation, and commercialization.
- Privatization of agricultural services to replace functions traditionally fulfilled by the state.
- Liberalization of prices and markets for products, agricultural inputs, and agricultural services.
- Decentralization through the transfer of power to the territorial bodies and the reinforcement of their planning capacity.

After the public sector's withdrawal, investments in the rural sector stagnated as the private sector did not step in to replace state funding.

As public sector involvement waned, national producer groups became influential players in the organization of the economy and in the formulation of agricultural policy. These groups include the Confederation of Faso Farmers (CPF) in Burkina Faso, the National Council for Rural Coordination (CNCR) in Senegal, the National Council of Farm Policy (CNFPF/N) in Niger; the National Council of Farm Organizations (CNOP) in Mali, and the National Association of Organizations of Agricultural Producers of Côte d'Ivoire (ANOPACI). At the subregional level, this evolution has led to the creation of the Council of Sahelian Farmers and the Network of Farmer Organizations and Agricultural Producers of West Africa (ROPPA).

Against this backdrop, the common agricultural policy of the UEMOA has identified three major challenges, which also serve as objectives of the common agricultural policy:

- Feeding the population of the region against the backdrop of strong demographic growth and urbanization while reducing dependence on the international market for food supplies.
- Increasing agricultural production in a sustainable manner via increased productivity.
- Reducing poverty in the rural sector by improving revenues and farmer status.

3.4 SUMMARY

- Rainfall in the region is very unpredictable, subjecting production systems to significant instability. Deforestation is a significant concern and has rainfall impacts.
- Only about 13% of arable land is under permanent cultivation; this leaves a potentially significant portion of arable land available for cultivation.
- Only 2% of the total arable land is irrigated. Expanded irrigation use should expand production, but in arid and semi-arid zones this must be done with caution. Water availability throughout the region is constrained by a number of ecological factors.
- West Africa is characterized by a largely rural population (68% of the subregion's population). Agriculture production is characterized by a dual system combining subsistence farming with export-oriented agriculture.
- The agricultural population, most of which is located in rural areas, has a lower per capita GDP than national averages in all UEMOA member countries.
- Agriculture has maintained a 30% share of GDP or higher since 1979, accounting for as much as 60% of total GDP in 2004 for UEMOA member countries.
- Gross food production is growing in the region, but struggling to keep pace with population growth.
- Past agricultural policies, led by export promotion and reduced food crops per capita; state retreat from the agricultural sector; and reductions in support by multilateral and bilateral donors have left the UEMOA member countries in a difficult situation, threatened by food price increases and export crop revenue declines. This situation, compounded by rising fuel prices, is placing increased pressures on already fragile economies.

4. Energy and Agriculture

4.1 ENERGY PROFILE OF UEMOA MEMBER COUNTRIES

Final energy consumption in the UEMOA zone is composed of biomass (73%), oil products (23%), and electricity (4%), as shown in Figure 4-1. The region lacks an efficient, effective, and sustainable energy infrastructure, which is a precondition for economic development. Enhancement of this infrastructure, diversification of energy supply and demand, promotion of clean and affordable energy sources and technologies, and decentralization of energy production through development of local energy resources and systems are among the key challenges the UEMOA confronts both collectively as a region and within each of its member countries. "Heavy reliance on the inefficient and unsustainable use of traditional biomass fuels ... are both manifestations and causes of poverty." (OECD, 2007).

4.1.1 BIOMASS

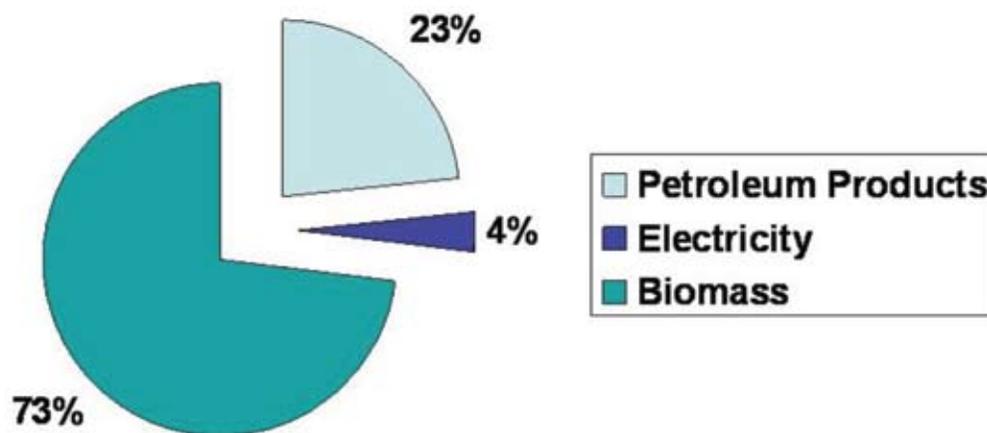
Wood, charcoal, and agricultural wastes constitute the bulk of the traditional biomass resources in the UEMOA countries, primarily for cooking and heating needs. Figure 4-2 illustrates biomass energy consumption in UEMOA member countries.

Wood. At present, burning wood is the largest use of energy from solid biomass. This practice has enormous human consequences, particularly for women and children, who spend up to one-third of their day in the collection and transport of wood and suffer the effects of indoor air pollution from poorly ventilated cookstoves. Wood collection for cooking applications is also a key cause of deforestation. Traditional woodstoves are highly inefficient, as shown in Figure 4-3.

Forests, which are the principal sources of wood, are unequally distributed across the UEMOA. As shown in Table 4-1, the forest cover in UEMOA member countries is estimated to be 44.5 million hectares, which is equivalent to 13% of total land area. West Africa's forests and other wooded lands are diverse and include steppes, tropical forests, mangroves, and wetlands.

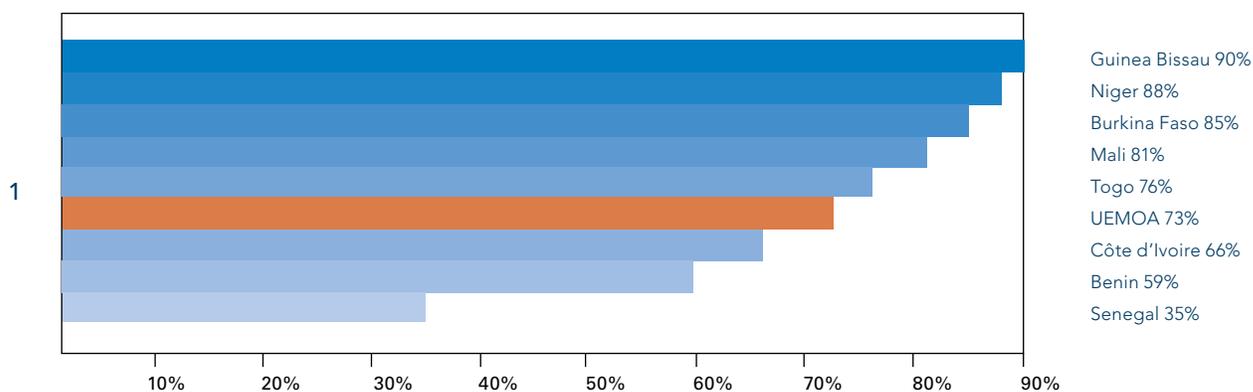
- Wood, charcoal, and vegetable wastes constitute the bulk of the biomass resources in UEMOA countries.
- Agriculture has a dual role as an energy user and energy supplier in the form of bioenergy.
- Energy for agricultural practices in the UEMOA member countries continues to be based to a large extent on human and animal energy, and on traditional wood fuels.
- Access to energy to advance development objectives in the agricultural sector in Africa represents a major challenge in the current context of high oil prices.

Figure 4-1: Distribution of End-Use Energy Consumption in the UEMOA Zone



Source: IEA, 2005 and SIE, 2005 (Senegal, Niger, Togo).

Figure 4-2: Biomass in Energy Consumption, 2005

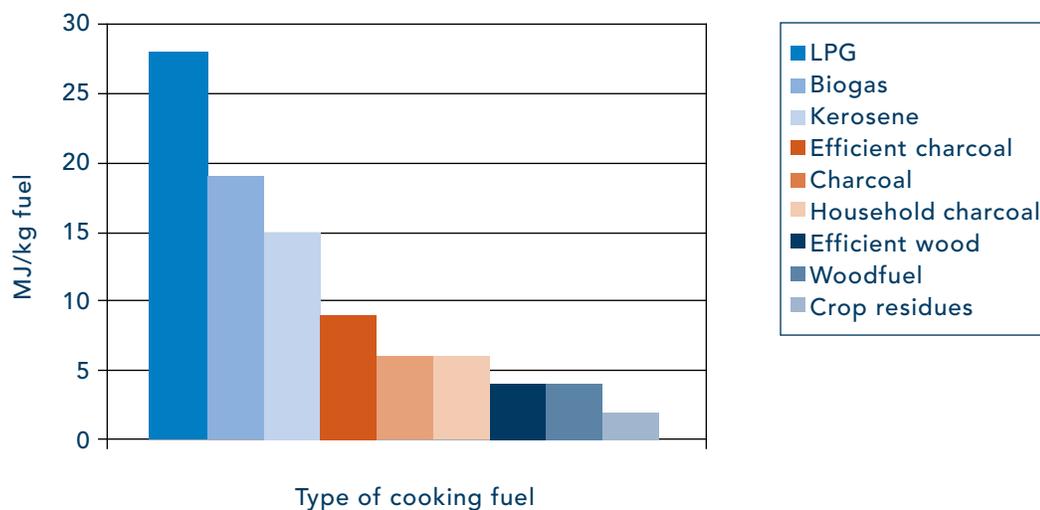


Source: IEA, 2005 and SIE, 2005 (Senegal, Niger and Togo).

A key issue confronting the UEMOA countries is deforestation. The combination of poverty and population growth is taking a toll on the forests in the region, as deforestation is primarily due to human settlement, agricultural expansion, and the use of wood for cooking. Overall, the average deforestation rate³ was 1.25% per year for all UEMOA member countries over the period 2000 to 2005. This is in sharp contrast to the annual deforestation rate for Africa as a whole of 0.62% per year. However, Togo had a much higher annual deforestation rate of 4.5%. At the other extreme is Côte d'Ivoire, which had a 0.1% reforestation rate.

³ The average deforestation rate from 2000 to 2005 is defined as loss in percent of the remaining forest area each year within the given period.

Figure 4-3: Energy Efficiency of Selected Cooking Fuels



Source: FAO, 2000.

Table 4-1: Extent of Forests and Other Wooded Lands in the UEMOA, 2005

UEMOA Countries	Forest Area		Deforestation Rate (Average 2000-2005) ^a	Total Land Area 1000 ha
	1000 ha	% total land area		
Benin	2,351	21.3	2.5	11,062
Burkina Faso	6,794	29.0	0.3	23,400
Côte d'Ivoire	10,405	32.7	-0.1	31,800
Guinea Bissau	2,072	73.7	0.5	2,812
Mali	12,572	10.3	0.8	122,019
Niger	1,266	1	1	126,670
Senegal	8,673	45	0.5	19,253
Togo	386	7.1	4.5	5,439
UEMOA Total	44,519	13%	1.25	342,455

^a Loss in percent of the remaining forest area each year within the given period.

Source: FAO, 2006.

Deforestation is a major threat in the UEMOA member countries, with an annual loss of over 555,000 ha of forest. The permanent destruction of indigenous forests and woodlands results in declines in habitat, biodiversity, wood for fuel, and quality of life. Local climates, including the water cycle, are altered as soil erodes, silting rivers and lakes, and desertification sets in. Addressing this problem is a huge priority.

Agricultural residues provide another important source of biomass. Cashew tree residues, cotton stalks, and sugarcane provide sustainable energy resources.

Agricultural Residues. Agricultural residues provide another important source of biomass, amounting to about 5 tonnes of dry matter per hectare of sorghum, 4 tonnes of straw and 2.5 tonnes of bran per hectare of rice, 2 tonnes of tops per hectare of groundnut and cowpea, and 10 tonnes of stubble per hectare of maize. In some countries, using these residues as substitutes for fuelwood is an important first step.

In Guinea Bissau, for example, biomass residues represent an estimated 65% of the cashew tree, providing a potential of 67,000 m³ of residue per year. This is equivalent to 12,000 tonnes of charcoal. Mali has about one million tonnes of cotton stalks per year after harvest. In Côte d'Ivoire, Mali, and Senegal, sugarcane residues (stalks, etc.) can be co-fired to generate electricity or reduced to biochar for soil fertilization.

Charcoal. Despite rapid urbanization in all UEMOA member countries, the transition of urban dwellers to become consumers of modern fuels remains slow.

At present, urban centers absorb the bulk of the charcoal produced in rural areas. Rapid urbanization and future population growth throughout UEMOA member countries is expected to continue to exert heavy pressure on this resource. The traditional production and use of charcoal is one of the most environmentally damaging practices in the UEMOA. All bioenergy strategies should make phasing out traditional charcoal use a priority and develop programs to produce cleaner, biomass-based fuels in rural areas. Such programs, combined with local production of cooking stoves, could make a significant contribution to reducing deforestation, increasing rural incomes, and reducing respiratory infections in women and children.

4.1.2 PETROLEUM PRODUCTS

Most of the UEMOA member countries are net importers of oil products. Only Côte d'Ivoire produces relatively significant quantities of oil, estimated at 2,109 kilotonnes in 2005. A number of other countries have potential petroleum reserves (e.g., Benin, Mali, Niger, Senegal, and Togo), none of which are in production.

Over the last five years, oil costs have strained state budgets. For certain countries, the oil bill represents more than 50% of their export earnings. For example, in Senegal, it accounted for 55%

of export revenues in 2005. As petroleum prices have almost tripled, the situation is only becoming worse.

Oil products are the second largest source of energy consumed in the UEMOA, averaging about 23% of total energy use. They are used primarily in the transportation and industrial sectors. Figure 4-4 depicts oil consumption by country.

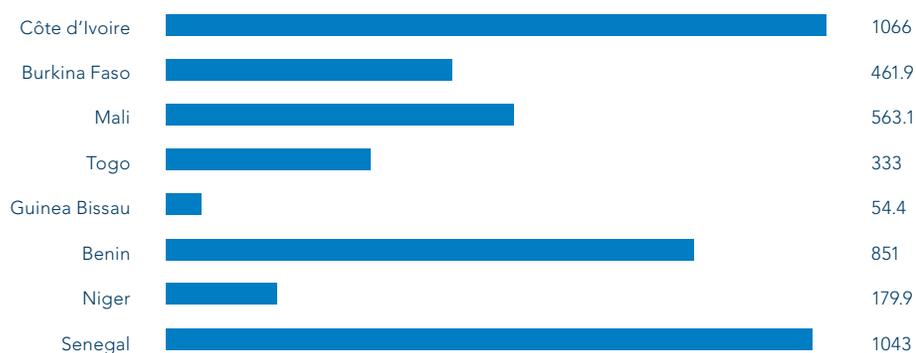
UEMOA member countries are net importers of oil. For certain countries, oil costs exceed half of their export earnings.

Charcoal and wood are the main energy resources in the residential sector, with significant social, health, and environmental consequences. To reduce pressure on traditional sources of biomass, several UEMOA members initiated programs that substituted butane and kerosene for charcoal. After years of implementation, results are mixed and with oil price increases, the cost of these programs is increasing sharply.

The introduction of liquefied petroleum gas (LPG)⁴ in the UEMOA zone, while relatively more successful, remains concentrated in the coastal countries (Senegal, Benin, and Côte d'Ivoire). Demand in Africa for LPG has grown at rate of 5.7% each year since 2000. In 2007, total LPG demand rose to 10.3 million tonnes.

In Senegal, as a result of the availability of LPG, the share of biomass in energy consumption dropped from 56 to 35% between 1994 and 2005. LPG consumption rose from 68,000 to 130,000 tonnes. In Benin, the proportion of traditional biomass in total energy consumed declined from 74% in 1995 to 59% in 2005.⁵ While this is beneficial in reducing indoor air pollution, natural gas/LPG prices are rising in tandem with oil price hikes, undermining energy security and lowering consumer purchasing power. Also, in landlocked countries, LPG distribution is hindered by high import costs, inefficiencies caused by low purchasing volumes, and inadequate distribution

Figure 4-4: Oil Products Consumption (Kilotonnes) by UEMOA Countries, 2005



Source: IEA, 2005 and SIE, 2005.

⁴ Varieties of LPG bought and sold include mixes that are primarily propane, mixes that are primarily butane, and the more common mixes including both propane (60%) and butane (40%), depending on the season—in winter more propane, in summer more butane. Propylene and butylenes are usually also present in small concentrations.

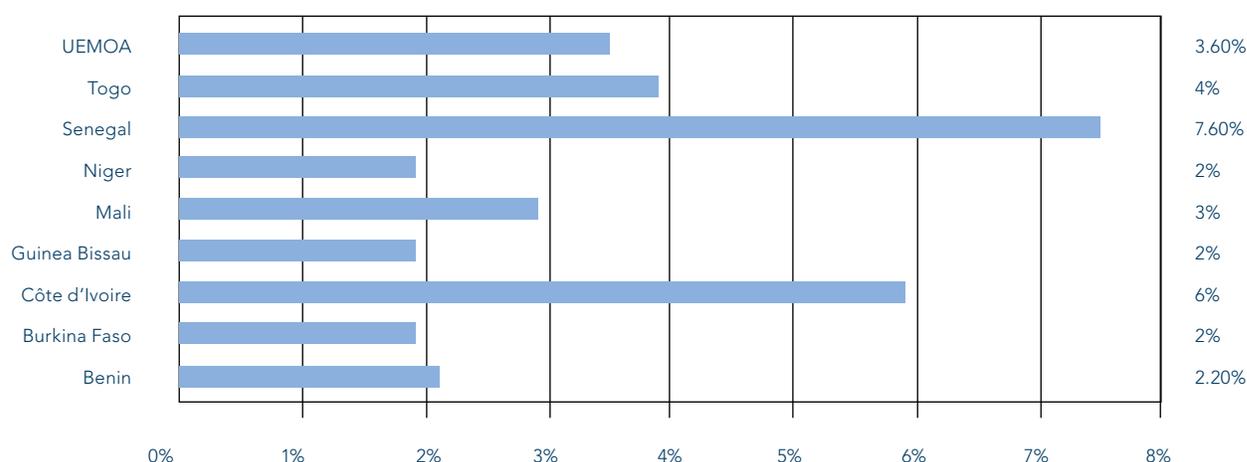
⁵ Energy balance sheet, Benin

networks. This has resulted in divided levels of LPG penetration between cities and rural areas, and between the Atlantic Sahel and the interior Sahel (ENDA TM, 2004).

4.1.3 ELECTRICITY

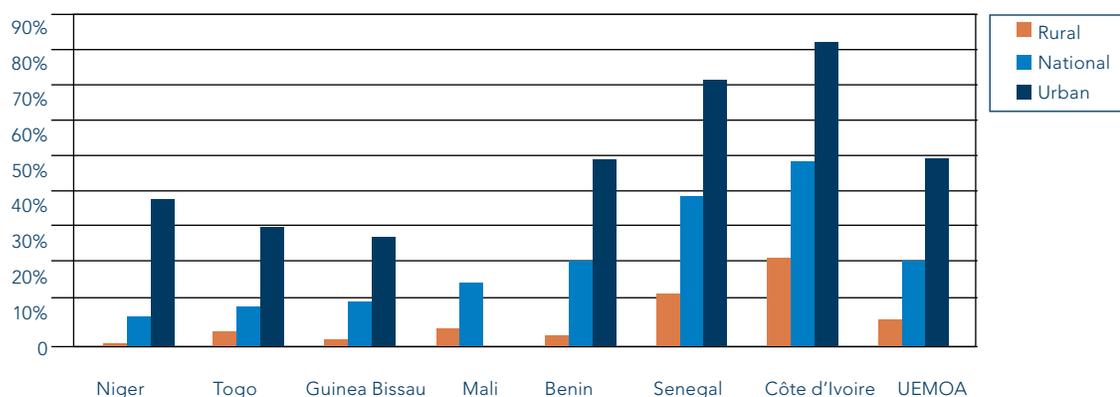
Electricity constitutes only 3.6% of total energy consumption in West Africa (see Figure 4-5). The region lacks infrastructure to produce, distribute, and store electricity. Existing means of generating electricity are inadequate and inefficient. High levels of poverty translate into a small base of consumers who can afford electricity.

Figure 4-5: Electricity as a Share of Energy Consumption



The average rate of electrification is 23%, but there is a huge disparity between access to electricity in urban and rural areas (see Figure 4-6). While in urban areas, electrification can be as high as 85% (Côte d'Ivoire), in rural areas it can be as low as 0.28% (Niger). Overall, rural electrification remains below 7% and is improving only marginally despite reforms.

Figure 4-6: Level of Electrification in the UEMOA Region



The majority of Côte d'Ivoire's electricity is generated through natural gas-powered stations. The country has turned into a regional exporter of electricity with Benin, Togo, Mali, Burkina Faso, and Ghana connected to the Ivoirian grid.

4.2 THE ENERGY CHALLENGE IN AGRICULTURAL PRODUCTION

Agriculture requires energy at all stages of production (see Box 4-1). Energy is used by agricultural machinery (e.g., tractors and harvesters) and irrigation systems and pumps, which may run on electricity, diesel, or other energy sources. Energy is also needed for processing and conserving agricultural products, transportation, and storage. In that respect, it is a critical factor in adding value in the agricultural sector. Indirect energy use occurs mainly through the production and application of mineral fertilizers and chemicals required to improve crop yields.

Box 4-1: Energy Use in Agriculture

Direct Uses

- Tractors and Other Agricultural Machinery
- Irrigation Pumps
- Drying Equipment
- Processing and Preservation of Products
- Agro-industrial Units
- Transportation of Agricultural Products

Indirect Uses

- Chemicals for Pest Control
- Fertilizers

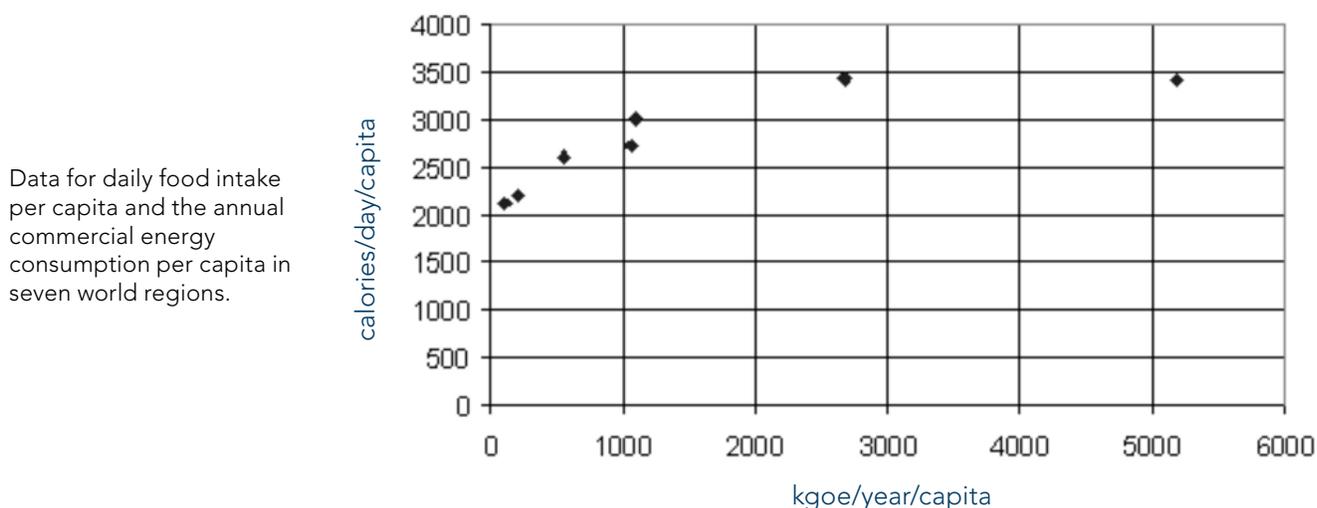
Energy for agricultural practices in the UEMOA member countries continues to be based to a large extent on human and animal energy, and on traditional wood fuels. As Figure 4-7 shows, there is a correlation between high per capita modern energy consumption and food production. Countries with higher energy consumption have higher agricultural yields (FAO, 2000). Any modernization in production methods presupposes sustainable access to energy.

At the national and regional levels, with few exceptions, rural energy access and energy for agriculture have not been incorporated into policy initiatives. This can be explained by several factors:

- Non-integration of energy needs of rural populations.
- Lack of linkages between energy and agricultural programs.
- Insufficient data about energy needs of agricultural activities.
- Little overall focus on agricultural and rural sectors.

In addition to these obstacles is an institutional vacuum. Typically, there is no institution “in charge” of energy for rural and agricultural development. As a result, energy usage data in the agricultural context is almost non-existent.

Figure 4-7: Modern Energy Consumption and Food Intake



Source: FAO, 2000. kgoe = kilograms of energy equivalent.

Stable, predictable access to water is also a major challenge for agriculture in West Africa. Overall, only 4% of the total agricultural land in Africa is estimated to be irrigated, with the remaining being rain-fed and therefore subject to climate and rain variability. Since the late 1980s, irrigation systems employing small water pumps have been expanded and are gradually taking the place of large dams, which have been criticized for their related social and environmental impacts. Decentralized irrigation systems contributed to enhancing water access and water control.

Limited expansion of irrigation may improve agricultural productivity in some areas, but it needs to be carefully studied. Better attention to water conservation and harvesting, as well as identifying water-retaining crops that could have multi-purpose applications, is likely to be a more sustainable approach for the entire region.

Mechanization of agricultural production is relatively limited when compared to other world regions, as shown in Table 4-2. For 2003, FAO estimated that African agriculture utilized a total of 537,917 tractors, compared to 1,765,242 in Latin America and 10,737,469 in Europe. There were 394 agricultural workers per tractor in Africa, compared to 24 in Latin America and 3 in Europe, with a world average of 51 workers per tractor (FAOSTAT, 2008).

Views differ on whether a mechanized model of agriculture is appropriate for Africa, given the abundant and relatively low-cost labor combined with the traditional communal form of agricultural

practice. However, mechanization versus non-mechanization is not the key issue; rather what are the best and most sustainable mechanized applications for smallholders? If they are planting annual or even perennial crops, use of community-owned tractors or plows might make sense. Very few smallholders need individual mechanical devices—rather, they need occasional access.

Table 4-2: Indicators of Agricultural Mechanization in Africa and the World (2003)

Designation	Africa	Latin America	Europe	World
Tractors	537,917	1,765,242	10,737,469	25,530,184
Agricultural workers per tractor	394	24	3	51
Hectares per tractor	2,113	67	45	187

Source: FAOSTAT, 2008.

Finally, with respect to nutrients, sub-Saharan Africa as a whole, including the UEMOA, has the world's lowest fertilizer usage (only 8 kg of nutrients per hectare; see Table 4-3), representing about 10% of average global use. Despite the availability of oil, gas, and phosphate reserves in the region, sub-Saharan Africa imports more than 90% of the agricultural fertilizers it consumes (IFDC, 2005). This factor is adversely affecting the agricultural sector/economy in Africa, underscoring the continent's current capacity constraints that make it difficult to expand domestic fertilizer production. Elsewhere in the world, increases in agricultural production and productivity were achieved through the intensification of land use and fertilizer applications. Sub-Saharan Africa is unique in the evolution of food production; its production increases were achieved not by increasing yields per hectare, but mainly by expanding the areas under cultivation at the expense of forests and grasslands (Riedacker, 2007). Clearly, this appears to be an opportunity for the region to develop its own fertilizer industry, increase agricultural production and productivity, and reduce dependence on fertilizer imports. This strategy should be coupled with promotion of sustainable fertilizer application practices.

In the absence of inorganic or organic fertilizers, soil mineral depletion exacerbates the low productivity while contributing to land erosion and degradation. This fact poses unique challenges for Africa where soils are nutrient deficient and of poor quality to begin with. The FAO estimates that stopping the depletion of existing mineral soils would probably require at least 70 kg of nutrients per hectare. At a special summit on fertilizers in Africa in 2006, the African Union set the objective of increasing fertilizer usage from the current average of 8 kg of nutrients per hectare to at least 50 kg per hectare by 2015. Views differ, however, as to whether higher levels of fertilizer use are the best way to increase soil fertility given the potentially dangerous environmental, health, and other effects. In the current context of rising oil and fertilizer prices, many of these plans could be jeopardized.

Table 4-3: Fertilizer Use Intensity by Country, 2002

Country	kg/ha
Benin	17
Burkina Faso	0.4
Côte d'Ivoire	15.8
Guinea Bissau	4.4
Mali	8.9
Niger	0.3
Senegal	13.4
Togo	6.5

Source: FAOSTAT, 2006.

A partnership between producers and agricultural research institutions needs to be developed and nurtured to explore the best ways to use energy in order to improve yield and production. What must be avoided, however, is repeating the mistakes of countries like the United States, which used this type of partnership to create industrial-scale monocultures. The InterAcademy Council report (InterAcademy Council, 2004) makes it clear that such approaches have failed before in Africa. Rather, this is an opportunity to exploit the characteristics of African agriculture patterns—smallholders, diverse production, multicropping—in ways that improve both productivity (yield per hectare) and production (quantities).

4.3 SUMMARY

- Final energy consumption in the UEMOA is comprised of traditional biomass (73%), oil products (23%), and electricity (4%). Wood, charcoal, and agricultural wastes constitute the bulk of the biomass resources in UEMOA countries.
- Forests—the main biomass sources—are unequally distributed across the region; they are diverse, including steppes, tropical forests, mangroves, and wetlands. Overuse has led to land degradation and deforestation and threatens key watersheds. Correcting this use pattern is a main priority.
- Energy is an essential component of agricultural production. It is required directly as a fuel to operate agricultural machinery, irrigation systems, and pumps that run on electricity, diesel, and other energy sources. Energy is also required in processing and conserving agricultural products, transportation, and storage. Indirect energy use occurs mainly through the production and application of

fertilizers and chemicals required to improve crop yields. Yet, with few exceptions, access to energy remains a low priority in policies that are already initiated or are on the drawing board in UEMOA member countries.

- Mechanization of agricultural production is relatively limited, particularly when compared to other world regions (e.g., Asia). Lack of mechanization puts real constraints on the amount of land that can be in permanent crops.
- With respect to soil nutrients, sub-Saharan Africa has the world's lowest level of fertilizer use in its agriculture and seriously nutrient-deficient soils. In the absence of inorganic and organic fertilizers, soil mineral depletion exacerbates low productivity and contributes to land erosion and degradation.
- Raising agricultural productivity overall is a better strategy than focusing on bioenergy crops alone.
- Other barriers to incorporating energy into agriculture and rural development in Africa include the non-integration of energy needs of rural populations; lack of linkages between energy and agricultural programs; insufficient data; and little focus on agricultural and rural sectors.
- High oil prices are having a direct effect on the agricultural sector—stifling growth, productivity, and production.

5. Biomass Conversion Technologies

Bioenergy consists of solid, liquid, or gaseous fuels. Liquid fuels can be used directly in the existing road, railroad, and aviation transportation network stock, as well as in engine and turbine electrical power generators. Solid and gaseous fuels can be used for the production of electrical power from purpose-designed direct or indirect turbine-equipped power plants. Chemical products can also be obtained from all organic matter produced. Additionally power and chemicals can come from the use of plant-derived industrial, commercial, or urban wastes, or agricultural or forestry residues.

Biomass resources include primary, secondary, and tertiary sources of biomass. Primary biomass resources are produced directly by photosynthesis and are taken directly from the land. They include perennial short-rotation woody crops and herbaceous crops, the seeds of oil crops, and residues resulting from the harvesting of agricultural crops and forest trees (e.g., wheat straw, corn stover, and the tops, limbs, and bark from trees). Secondary biomass resources result from the processing of primary biomass resources either physically (e.g., the production of sawdust in mills), chemically (e.g., black liquor from pulping processes), or biologically (e.g., manure production by animals). Tertiary biomass resources are post-consumer residue streams including animal fats and greases, used vegetable oils, packaging wastes, and construction and demolition debris.

There are various conversion technologies that can convert biomass resources into power, heat, and fuels for potential use in UEMOA countries. Figure 5-1 summarizes the various bioenergy conversion processes.

- Various technologies exist to convert biomass resources into power, heat, and fuels for use in UEMOA countries.
- Several technologies for converting bioenergy are commercial today while others are being piloted or in research and development.
- As new technologies and processes develop, the UEMOA needs to monitor progress to determine potential applications for biomass expansion.

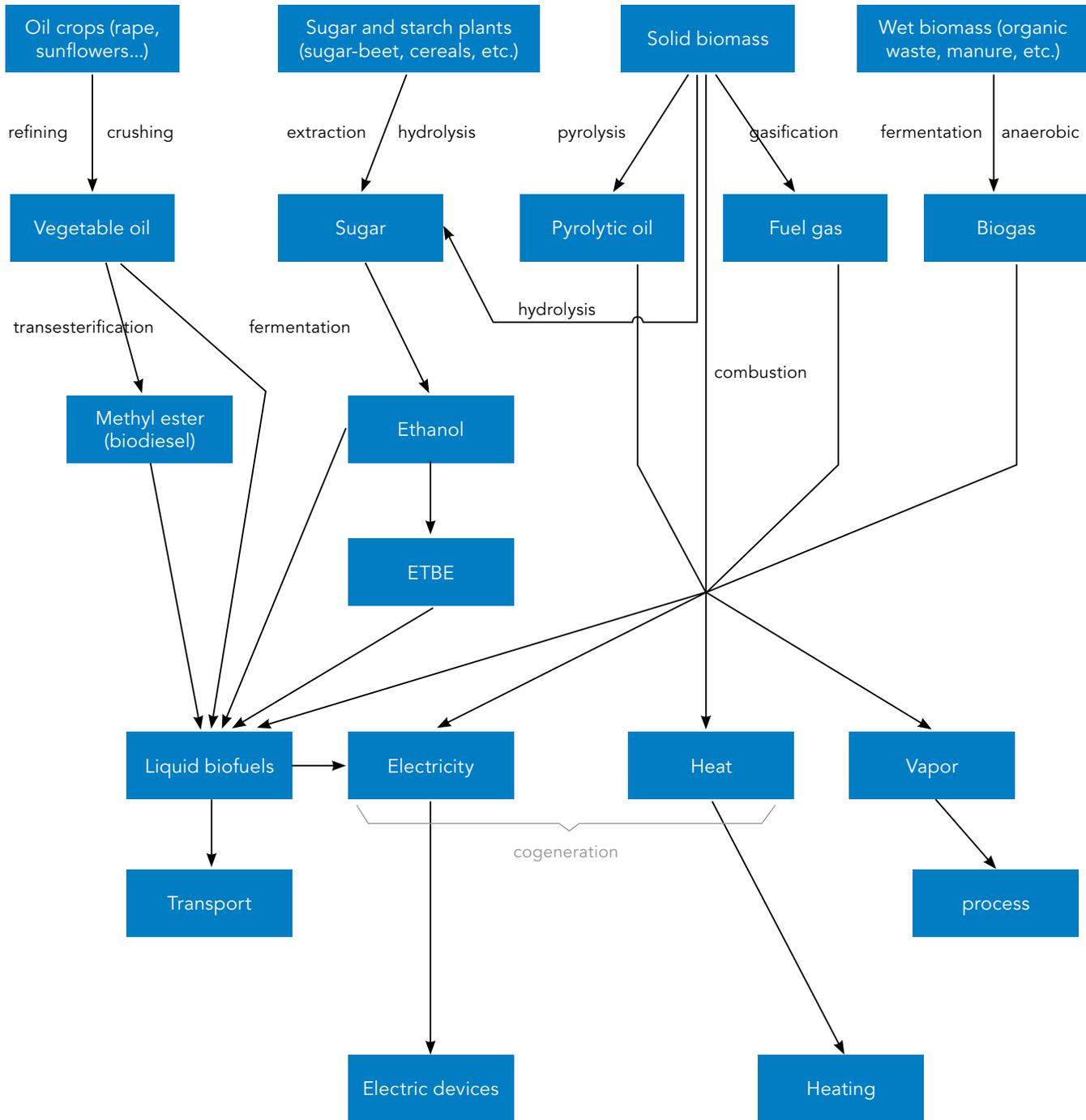
5.1 BIOMASS FOR POWER AND HEAT⁶

5.1.1 COMBUSTION

Biomass power technologies convert renewable biomass fuels to heat and electricity using processes similar to those employed with fossil fuels. At present, the primary approach for generating electricity from biomass is combustion direct-firing. Combustion systems for electricity and heat production are similar to most fossil-fuel fired power plants. The biomass fuel is burned in a boiler to produce high-pressure steam. This steam is introduced into a steam turbine, where

⁶ ESMAP, 2005.

Figure 5-1: Biomass Energy Conversion Overview



Source: Renewable Energy World, 2006.

it flows over a series of turbine blades, causing the turbine to rotate. The turbine is connected to an electric generator. The steam flows over and turns the turbine. The electric generator rotates, producing electricity. This is a widely available, commercial technology.

Combustion boilers are available in different designs, depending on application and biomass characteristics. The main options are to burn the biomass on a grate (fixed or moving), or to fluidize the biomass with air or some other medium to provide even and complete burning. Steam turbine designs also vary in terms of their application. To maximize power production, condensing turbines are used to cool steam.

5.1.2 COMBINED HEAT AND POWER

Most biomass-fired steam turbine plants are located at industrial sites that have a steady supply of biomass available. These include factories that make sugar and/or ethanol from sugarcane at pulp and paper mills. At these sites, waste heat from the steam turbine can be recovered and used for meeting industrial heat needs—further enhancing the economic attractiveness of such plants. Referred to as combined heat and power (CHP) facilities (also called cogeneration facilities), these facilities are highly resource efficient and they provide increased levels of energy services per unit of biomass consumed compared to facilities that generate power only.

Conventional thermoelectric stations convert only about one-third of the fuel energy into electricity. The rest is lost as heat. The adverse effect on the environment through wasteful use of power—particularly detrimental in light of rising fuel costs—means that the efficiency of thermoelectric stations must be increased. CHP provides more efficient production of electricity, where more than four-fifths of the fuel's energy is converted into usable energy, resulting in both economic and environmental benefits. Cogeneration is the consecutive (simultaneous) production and exploitation of two energy sources, electrical (or mechanical) and thermal, from a system utilizing the same fuel. CHP could be applied to industry in West Africa where there is simultaneous demand for electricity and heat.

In UEMOA countries, there is also significant need for cooling (including refrigeration and air conditioning). Heat from a CHP plant can be used to produce cooling via absorption cycles.

At present, most biomass-fired power plants rely on low-cost (or no-cost) biomass residues. In the UEMOA, given the breadth of sugarcane processing industries, significant opportunities exist, particularly for steam-based CHP generation.

5.2 BIOGAS

5.2.1 GASIFICATION

Like coal, biomass can be a cumbersome fuel source because it is a solid. By converting biomass into a gas, it can then be made available for a broader range of energy devices. For example, biomass-sourced gas can be burned directly for heating or cooking, converted to electricity or

mechanical work (via a secondary conversion device such as an internal combustion engine), or used as a synthetic gas for producing higher quality fuels or chemical products such as hydrogen or methanol.

Gasifiers operate by heating biomass in an environment where the solid biomass breaks down to form a flammable gas. The biogas can be cleaned and filtered to remove problem chemical compounds. The gas can be used in more efficient power generation systems called combined-cycles, which combine gas turbines and steam turbines to produce electricity.

5.2.2 ANAEROBIC DIGESTION

Anaerobic digestion is a commercially proven technology and is widely used for recycling and treating wet organic waste and waste waters. It is a type of fermentation that converts organic material into biogas, which mainly consists of methane (approximately 60%) and carbon dioxide (approximately 40%) and is comparable to landfill gas.

Similar to gas produced via gasification above, gas from anaerobic digestion can, after appropriate treatment, be burned directly for cooking or heating. It can also be used in secondary conversion devices such as an internal combustion engine for producing electricity or shaft work. Virtually any biomass except lignin (a major component of wood) can be converted to biogas—including animal and human wastes, sewage sludge, crop residues, industrial processing byproducts, and landfill material.

The conversion of animal wastes and manure to methane/biogas can yield significant health and environmental benefits. Methane is a greenhouse gas (GHG) that is 22 to 24 times more powerful than carbon dioxide (CO₂) in trapping heat in the atmosphere. By trapping and utilizing the methane, GHG impacts are avoided. Further, the pathogens existing in manure are eliminated by the heat generated in the biodigestion process and the resulting material provides a valuable, nutrient-rich fertilizer.

Small-scale biogas digesters have been used throughout many developing countries, most notably China and India, but also Nepal, South Korea, Brazil, and Thailand.

5.3 BIOFUELS

5.3.1 OVERVIEW⁷

Liquid biofuels include pure plant oil, biodiesel, and bioethanol. Biodiesel is based on esterification of plant oils. Ethanol is primarily derived from sugar, maize, and other starchy crops. Global production of biofuels consists primarily of ethanol, followed by biodiesel production. These are described below.

⁷ UNDESA, 2007.

- **Straight Vegetable Oil (SVO)/Pure Plant Oil (PPO):** SVP/PPO can be used in most modern diesel vehicle engines only after some technical modifications. Principally, the viscosity of the SVO/PPO must be reduced by preheating it. However, some diesel engines can run on SVO/PPO without modifications. PPO is obtained from edible oil-producing plants such as the African palm, groundnuts, cotton seeds, sunflower, canola, or non-edible oils such as jatropha, neem, or even balanites. These raw oils, unused or used, can be employed in certain diesel engines, for cooking, or in diesel generators for the production of electricity.
- **Biodiesel:** Biodiesel can be used in pure form or may be blended with petroleum diesel at any concentration for use in most modern diesel engines. Biodiesel is raw vegetable oil transformed, treated, and standardized through chemical processes. The standardization of this product, and its industrial production, renders its use much more diverse than PPO. Biodiesel is used in diesel engines and diesel vehicles. Biodiesel can be produced from different feedstocks, such as oil feedstock (e.g., rapeseed, soybean oils, jatropha, palm oil, hemp, algae, canola, flax, and mustard), animal fats, and/or waste vegetable oil.
- **Alcohols:** Ethanol, butanol, and methanol are produced principally from such energy crops as sugarcane, maize, beets, yam, or sweet sorghum. Ethanol is the most widely used alcohol, primarily as a fuel for transportation or as a fuel additive. Bioethanol can be produced from a variety of feedstocks, including sugarcane, corn, sugar beet, cassava, sweet sorghum, sunflower, potatoes, hemp, or cotton seeds, or derived from cellulose waste.

Several processes exist to convert feedstocks and raw materials into biofuels. First-generation biofuels refer to the fuels that are produced through well-known processes such as cold pressing/extraction, transesterification, hydrolysis and fermentation, and chemical synthesis. The resulting fuels have been derived from sources such as starch, sugar, animal fats, and vegetable oil. First-generation biofuels are already established in the fuel markets and usually produced from fuel crops. The most popular types of first-generation biofuels are biodiesel, vegetable oil, bioethanol, and biogas.

Second-generation biofuels are not yet commercial on a large scale as their conversion technologies are still in the research and/or development stage. Second-generation biofuels are produced through more advanced processes, including hydro treatment, advanced hydrolysis and fermentation, and gasification and synthesis. A wide range of feedstocks can be used in the production of these biofuels, including lignocellulosic sources such as short-rotation woody crops. These produce biodiesel, bioethanol, synthetic fuels, and bio-hydrogen (see Box 5-1).

Table 5-1 shows the production and use of liquid fuels for first- and second-generation biofuels.

5.3.2 FIRST- AND SECOND-GENERATION TECHNOLOGIES: ADVANTAGES AND DISADVANTAGES

Both first- and second-generation technologies offer advantages and disadvantages. The primary advantage of first-generation biofuels is they are available today with existing technologies; their promotion is based on non-technical issues such as policies and cost-effectiveness. First-generation biofuels can also be produced in decentralized facilities. Disadvantages include emissions produced in growing and refining these fuels, land use concerns, their complex effect on food and grain prices, and that only specific crops can be used in biofuels production.

For second-generation biofuels, a larger variety of feedstocks can be used. Advanced biofuels (e.g., biobutanol and synthetic diesel) and other biofuels derived from switchgrass, garbage, and algae are under development. New conversion technologies are expected to expand production potential by allowing for the use of an array of non-food resources. Additionally, the energy input for agriculture and feedstock production could be significantly reduced and the technologies are expected to be more efficient as they will entail large-scale conversion operations. It is anticipated that second-generation technologies will yield better energy, economic, environmental, and carbon performance than first-generation options, yet this remains to be proven (Hunt, 2008; Janssen et al., 2008).

Box 5-1: Biodiesel and Bioethanol Production

In the first-generation production of biodiesel, oilseeds are crushed to extract oil. The residue cake, depending on its characteristics, can be used as a fertilizer, animal feed, or biomass energy feedstock. To produce the biodiesel, the raw plant oils extracted are filtered and mixed with ethanol or methanol to initiate an esterification reaction. This process separates fatty acid methyl esters, which are the basis for biodiesel; the glycerin can be used in soap manufacture. Small-scale cultivation of fuel crops for biodiesel is typically more cost-effective if the various byproducts are used economically or commercially. Direct use of plant oils for cooking or lighting is possible, but requires modified cookstoves or lamps.

Bioethanol is primarily produced by fermentation of sugarcane or sugar beet. The sugarcane or sugar beet is harvested and crushed, and soluble sugars are extracted by washing the pulverized cane with water. Alternatively, second-generation bioethanol can be produced from wood or straw using acid hydrolysis and enzyme fermentation. This developing process is currently more complex and expensive. First-generation bioethanol from a cereal such as wheat requires an initial milling and malting (hydrolysis) process. Malting occurs under controlled conditions of temperature and humidity. Enzymes present in the wheat break down starches into sugars. Production of bioethanol from maize is a similar fermentation process, but the initial processing of the corn is different. First, the corn is milled either by a wet milling or by a dry milling process. Enzymes are then used to break down the starches into sugars that are fermented and distilled. Residues from corn milling can be used or sold as animal feed.

Table 5-1: Production and Use of Liquid Biofuels

First Generation (Conventional) Biofuels				
Biofuel Type	Specific Names	Biomass Feedstock	Production Process	Uses
Vegetable/Plant Oil	Straight Vegetable Oil (SVO)/ Pure Plant Oil (PPO)	Oil crops (e.g. Rapeseed, Corn, Sunflower, Soybean, Jatropha, Jojoba,	Cold pressing/ extraction	Diesel engines, generators, pumping (all after modifications); Use for cooking and lighting, as possible; Transportation
Biodiesel	Biodiesel from energy crops	Coconut, Cotton, Palm, etc.)	Cold pressing/ extraction & transesterification	Diesel engines for power generation, mechanical applications, pumping;
	Rapeseed methyl ester (RME), fatty acid methyl/ethyl ester (FAME/FAEE)	Algae		Transportation (diesel engines)
	Biodiesel from waste FAME/FAEE	Waste/cooking/ frying oil/animal fat	Transesterification	
Bioethanol	Conventional bioethanol	Sugarcane Sweet sorghum Sugar beet Cassava Grains	Hydrolysis & fermentation	Internal combustion engine for motorized transport
Bio-ETBE	Ethyl Tertiary Butyl Ether	Bioethanol	Chemical synthesis	
Second Generation Biofuels				
Biodiesel	Hydro-treated biodiesel	Vegetable oils and animal fat	Hydro-treatment	Internal combustion engine for motorized transport
Bioethanol	Cellulosic bioethanol	Lignocellulosic material	Advanced hydrolysis & fermentation	
Synthetic biofuels	Biomass-to-liquids (BTL): Fischer-Tropsch (FT) diesel Biomethanol Biodimethyl-ether (Bio-DME)	Lignocellulosic material	Gasification & synthesis	
Bio-hydrogen		Lignocellulosic material	Gasification & synthesis or biol.	

Source: UNDESA, 2007.

5.4 BIOREFINERIES

An emerging concept for the UEMOA to be aware of is biorefineries. A biorefinery involves the co-production of a spectrum of bio-based products (food, feed, materials, chemicals) and energy (fuels, power, heat) from biomass (IEA Bioenergy Task 42).

A biorefinery is a facility that integrates biomass conversion processes and equipment to produce fuels, power, and value-added chemicals from biomass. The biorefinery concept is analogous to today's petroleum refinery, which produces multiple fuels and products from petroleum.

Box 5-2: Green Charcoal: An option to reduce deforestation

Several endeavors are underway across Africa to replace wood charcoal with environmentally friendly alternatives.

After taking part in the Tanzanian Environmental Education Programme (TEEP), funded by the conservation organization World Wide Fund for Nature (WWF), Yohana Komba used traditional knowledge and local resources to create an environmentally friendly alternative to traditional charcoal.

The green or vegetable charcoal Komba developed is made from soil, ash, and wild vegetation. The vegetation is boiled in water until a thick, elastic paste forms and then the paste is mixed with soil and ash. The mixture can then be molded into fist-sized nuggets that are dried for five days before they are ready for use. Tests on the green charcoal have shown that it burns longer than conventional charcoals, is environmentally friendly, and has no side effects for users. It has also reduced deforestation in the region.

The NGO Pro-Natura International has patented an innovative continuous process of biomass carbonization that can transform agricultural residues or renewable biomass into green charcoal pellets or briquettes that perform the same as charcoal made from wood, at half the cost. This new system will create new jobs in rural areas, and represents a release from the constraints of scarcity, distance, and cost of available fuels in Africa. The Pro-Natura pyrolysis system has been successfully piloted in Senegal and South Africa, and there are plans to introduce the system in Mali.

While similar to wood charcoal in terms of calorific properties, green charcoal presents several advantages:

- Job creation in rural areas;
- Reduced deforestation related to the production of wood charcoal;
- Avoidance of methane emissions resulting from traditional wood charcoal production techniques; and
- Abatement of CO₂, methane, and nitrous oxide emissions resulting from the burning of agricultural residues.

By producing several products, a biorefinery takes advantage of the various components in biomass and their intermediates, therefore maximizing the value derived from the biomass feedstock. A biorefinery could, for example, produce one or several low-volume, but high-value, chemical products and a low-value, but high-volume liquid transportation fuel such as biodiesel or bioethanol. At the same time, it can generate electricity and process heat, through CHP technology, for its own use and perhaps enough for sale of electricity to the local utility. The high-value products increase profitability, the high-volume fuel helps meet energy needs, and the power production helps to lower energy costs and reduce GHG emissions from traditional power plant facilities. Although some facilities exist that can be called biorefineries, the biorefinery concept has yet to be fully realized. Future biorefineries may play a major role in producing chemicals and materials that traditionally were produced from petroleum.

5.5 COOKING AND RELATED APPLICATIONS

Displacing fuelwood for cooking is a key interest of many UEMOA member states. Options are discussed below (ESMAP, 2005):

- *Biomass densification or briquetting.* This is the process of compacting loose biomass feedstocks into a uniform dense form, producing a higher quality fuel. Better and more consistent thermal and physical qualities allow for more complete combustion of briquettes, providing greater efficiency, reduced emissions, and greater control for residential and industrial applications. Briquettes offer easier transport, storage, and mechanical handling in both household and industrial settings. Briquettes can be efficiently produced using relatively simple technologies. Stalks, husks, bark, straw, shells, pits, seeds, sawdust—virtually any solid organic byproduct of agricultural or silvicultural harvesting—can be used as a feedstock. Biomass wastes with relatively low moisture content (less than 15%) are most suitable for efficient production of briquettes.
- *Ethanol gel.* Ethanol gel is a clean-burning fuel that consists of gelatinized ethanol bound in a cellulose thickening agent and water. Cookstoves specially designed for use with ethanol gel have been developed in the last few years, as have ethanol gel burners that can be retrofitted into several traditional African cooking stoves. Used in such appliances, ethanol gel is a highly controllable, easily lit cooking fuel with a heating efficiency of roughly 40%. Initial market penetration has taken place in several countries in Africa, such as Zimbabwe, Malawi, and South Africa. Experience has shown that ethanol gel can substitute for wood fuels and kerosene, stabilize household energy markets, and reduce CO₂ emissions and indoor air pollution (see Box 5-3).
- *Improved cookstoves.* The key use for fuelwood, charcoal, and other forms of biomass in the UEMOA is for cooking. Utilizing smokeless, efficient, and low-cost stoves that exist in the marketplace today can help reduce wood fuel demand, improve indoor air pollution, and lessen deforestation.

Box 5-3: Using Ethanol Gel to Combat Indoor Air Pollution

While interest in alternative energy and green politics is often seen as the preserve of the upper classes, working-class people in Johannesburg's inner city are already using renewable energy in their homes. On a pavement in Joubert Park in Johannesburg, shoppers cluster around Tumelo Ramolefi's stall exclaiming and asking questions about his products. Ramolefi is not selling the usual inner-city hawker stock of facecloths and socks. Instead, it is his display of innovative renewable-energy gadgets that attracts the attention of passers-by.

His bestselling items are ethanol gel stoves and lamps, which offer a healthier, safer, and more efficient alternative to paraffin or coal fires. Ethanol gel is a renewable form of energy made by mixing ethanol with a thickening agent and water. The ethanol is extracted through the fermentation and distillation of sugars from sources such as molasses, sugar cane, and sweet sorghum, or starch crops like maize. Ramolefi sells ethanol gel products and appliances for GreenHeat South Africa, with branches in Durban, Johannesburg, and Cape Town. The stoves and ethanol gel—produced from sugarcane—are manufactured in Durban. A two-plate stove sells for R160 (US\$23); a lamp for R50 (US\$7).

"This stove is number one," said Maria Ndlela, who works in a recycling centre in Joubert Park and has owned her stove for two months. She says it is easy to use and, while paraffin is cheaper than the gel, the gel is more cost-efficient in the long run. Five liters of gel cost R60 (US\$8.50) and paraffin costs R21.99 (US\$3.13) for the same amount. "Gel lasts. If you don't use it too much, five liters of gel takes you a month to use, but five liters of paraffin lasts only three days." Ndlela says an added attraction of ethanol is that the paraffin price fluctuates. "The price of paraffin is going up and down with the petrol price," she said. "So now I'm forgetting about paraffin."

"What I like about the stove is that it will conquer our unreliable electricity," said Florah Thulare. She says pre-paid electricity cards are often unreliable and problems with them can take a day or two to be resolved, leaving her without electricity to cook with at night. Safety is also a big selling point. Paraffin stoves, which explode or are easily knocked over, cause fires, and poor ventilation can lead to asphyxiation. "Coal can kill you during the night," says Ramolefi.

Gel fuel burns with a carbon-free flame, so it does not cause respiratory problems like asthma, which can be caused by emissions from paraffin, coal, and wood fuel. The gel also does not produce any smoke or smell. Gel fuel will not ignite if spilled like gas or paraffin, and it is non-toxic and thus not poisonous if swallowed by children. The stoves are designed so they will not fall over if bumped and the stove's legs allow it to slide when pushed instead of toppling over.

Ramolefi says that, even if an ethanol lamp is overturned, the gel will extinguish the wick—and if a stove is knocked over and a fire starts, it will not spread rapidly because the gel moves slowly. The stoves are designed for cooking, but half of his customers buy them as heaters. While talking to Ramolefi, Monty Marees stopped to buy a stove for her "auntie" who had just moved to the area. Marees said the elderly woman took hours each evening to collect wood and warm her mbaula, a brazier-type heater. She was buying the stove to warm her aunt before bed.

Ramolefi has sold about 70 stoves in the past eight months and hopes the market will grow and prices will drop, making the stoves more affordable for the poor. While sales were slow initially, word-of-mouth and seeing neighbors cooking on ethanol stoves has increased customers. "You can't buy something you haven't seen working anywhere. We need to demystify them for people."

Source: UNDESA, 2007.

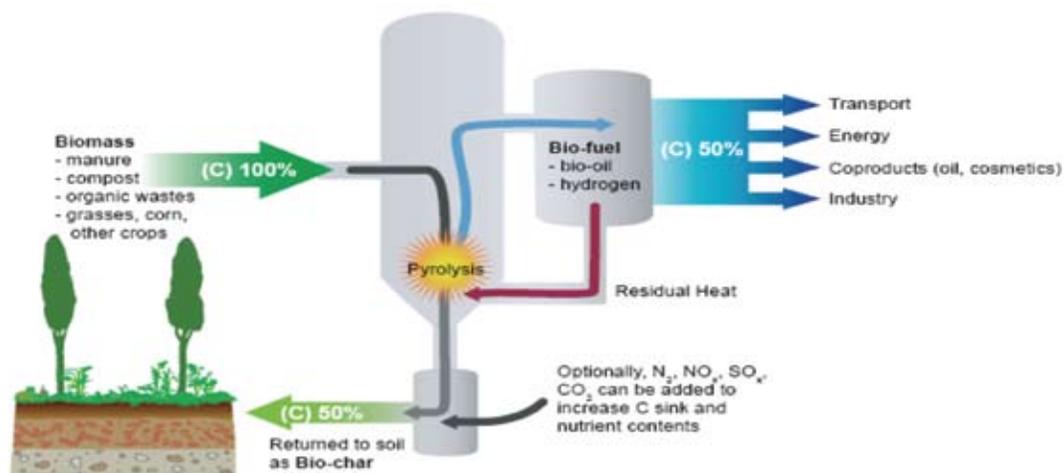
- *Improved charcoal kilns.* More efficient kilns in charcoal production are a priority for UEMOA countries as a means of minimizing wood use.

For the above options, markets may be constrained by cost factors. However, policies and incentives to reduce deforestation; eliminate subsidies for fossil fuels, such as butane; and promote alternatives to fuelwood can help address the cost constraint. Also, it is important to note that these activities should be linked to improved forest management programs and practices.

5.6 BIOCHAR

Any bioenergy production will lead to a removal of biomass from the land. This potentially leads to soil degradation, with negative effects on soil productivity, habitats, and off-site pollution. Pyrolysis (explained below), coupled with organic matter returned through biochar, addresses this dilemma, as about half of the original carbon can be returned to the soil. Figure 5-2 graphically depicts the biochar process.

Figure 5-2: Production of Biochar



Source: Lehmann, 2007.

Biochar is a fine-grained charcoal high in organic carbon and largely resistant to decomposition. Biochar is produced by heating biomass in the absence (or under reduction) of air, or pyrolysis. It is found in soils around the world as a result of vegetation fires and historic soil management practices. Intensive studies of biochar-rich dark earths in the Amazon (Terra Preta), have led to a wider appreciation of biochar's unique properties as a soil conditioner.

In developing countries, biochar systems can reverse soil degradation and create sustainable food and fuel production in areas with severely depleted soils, scarce organic resources, and inadequate water and chemical fertilizer supplies. Low-cost, small-scale biochar production units can produce biochar to build garden, agricultural, and forest productivity, and bioenergy for eating, cooking,

drying and grinding grain and producing electricity and thermal energy (International Biochar Initiative, 2008).

Given the serious land degradation facing many of the UEMOA member states, biochar could be an option to consider.

5.7 SUMMARY

- A variety of technology options exist for biomass that rely on several feedstock alternatives. These options can serve many different energy needs, from large-scale industrial applications to small-scale, rural end-uses.
- A number of technologies are mature and fully commercial. These include industrial-scale biogas production and steam turbine CHP systems. Today, CHP systems satisfy electricity demand in several agro-industries (e.g., sugar, pulp, and paper industries) and provide excess power to the grid. Tremendous opportunities exist for further expanding this potential in the UEMOA.
- Other technologies are demonstrated and disseminated, but are not broadly in use in the UEMOA. Ethanol biodiesel for transport, household biogas digesters, improved cookstoves, and biomass gasifiers for thermal applications in agro-industries are technologies that have not yet broadly penetrated in the UEMOA. In other countries/regions, they have benefited from publicly supported dissemination programs and have required varying levels of public sector financial input.
- As new technologies and processes continue to develop, including second-generation options, they should be tracked and assessed by UEMOA countries for future potential application.

6. Bioenergy Resources in the UEMOA

A number of resources in the UEMOA could potentially be used for bioenergy development.⁸ Table 6-1 identifies available feedstocks by country, and Table 6-2 summarizes the characteristics of key feedstocks, including those found in the region and others in use elsewhere in similar climates.

This information is provided as background for UEMOA member countries and others in determining future bioenergy plans and activities. Actual development of any of the feedstocks discussed will need to be considered against a variety of economic, environmental, and food security issues.

- Several agriculture crops and waste streams in the UEMOA member countries can serve as feedstocks for bioenergy development.
- Key crops include sugarcane, sweet sorghum, cassava, cashew fruit, jatropha, palm oil, groundnut, cotton, and neem.

Table 6-1: Existing Bioenergy Feedstocks in UEMOA Countries

	Sugar-cane	Sweet Sorghum	Cassava	Cashew	Jatropha	Palm Oil	Ground-nut	Cotton	Agri. and Forest Residues
Benin	●	●	●	●		●		●	●
Burkina Faso	●				●			●	●
Côte d'Ivoire	●		●			●		●	●
Guinea-Bissau				●	●				●
Mali	●				●		●	●	●
Niger	●				●		●		●
Senegal	●		●		●		●	●	●
Togo		●	●		●			●	●

Source: UEMOA Country Studies (to be published).

⁸ Country data presented in this chapter are sourced from UEMOA country reports prepared as background material for this report. These country reports are planned to be produced by the UEMOA Biomass Energy Regional Program in the near future.

Table 6-2: Key Feedstock Characteristics

CROP TYPE	SOIL	WATER	NUTRIENTS	CLIMATE	COMMENTS
Cassava/ Manioc	<ul style="list-style-type: none"> • Range, prefer porous • Prefer ph 6-7, no saline 	<ul style="list-style-type: none"> • Drought resistant • Will not survive water log 	<ul style="list-style-type: none"> • High nutrient absorption 	<ul style="list-style-type: none"> • Tropical, subtropical 	<ul style="list-style-type: none"> • Important for food supply (carbohydrate) • High productivity; labor intensive
Coconut	<ul style="list-style-type: none"> • Sandy soil • Salinity tolerant 	<ul style="list-style-type: none"> • Prefer high humidity 		<ul style="list-style-type: none"> • Tropical 	<ul style="list-style-type: none"> • Excellent production yield • Many productive applications beyond energy
Hemp	<ul style="list-style-type: none"> • Deep soil, good water supply, pH 6/7 	<ul style="list-style-type: none"> • Some moisture the entire season 	<ul style="list-style-type: none"> • Moderate, no pesticide needed 	<ul style="list-style-type: none"> • Varied, preferably warmer climates 	
Jatropha	<ul style="list-style-type: none"> • Undemanding, does not require tillage 	<ul style="list-style-type: none"> • Can be cultivated under irrigated and rain-fed conditions 	<ul style="list-style-type: none"> • Low-fertility sites and alkaline soils • Better yields with fertilizers 	<ul style="list-style-type: none"> • Tropical and subtropical but also arid and semiarid 	<ul style="list-style-type: none"> • Does not compete with food • 2 harvests per year; able for village use • Yield determinants of wild seed not known • Labor intensive
Maize/corn	<ul style="list-style-type: none"> • Soil should be well-aerated and well-drained 	<ul style="list-style-type: none"> • Efficient user of water 	<ul style="list-style-type: none"> • High fertility • Continuous maintenance 	<ul style="list-style-type: none"> • Temperate to tropic conditions 	<ul style="list-style-type: none"> • Important for food supply • High energy need • Produces less ethanol than sugarcane
Miscanthus/ perennial grass	<ul style="list-style-type: none"> • Brown soils with high humus % • pH 5.5 – 7.5 	<ul style="list-style-type: none"> • Crucial during the main growing seasons 	<ul style="list-style-type: none"> • Low 	<ul style="list-style-type: none"> • Adapted to warmer climates but fairly cold-tolerant 	
Oil Palm	<ul style="list-style-type: none"> • Good drainage • pH 4 – 7 • Soil flat/rich/deep 	<ul style="list-style-type: none"> • Even distribution of rainfall 	<ul style="list-style-type: none"> • Low 	<ul style="list-style-type: none"> • Tropical, subtropical • Temperature 25 – 32°C 	<ul style="list-style-type: none"> • Excellent yield • Less manual labor to harvest
Rapeseed	<ul style="list-style-type: none"> • Mild, deep loamy • Medium texture, well-drained 	<ul style="list-style-type: none"> • 600 mm minimum yearly precipitation 	<ul style="list-style-type: none"> • Similar to wheat 	<ul style="list-style-type: none"> • Sensitive to high temperatures • Best at 15 and 20°C 	

Table 6-2: Key Feedstock Characteristics (continued)

CROP TYPE	SOIL	WATER	NUTRIENTS	CLIMATE	COMMENTS
Sweet Sorghum	<ul style="list-style-type: none"> • Light-to-medium • Aerated/ drained • Tolerant to short water log times 	<ul style="list-style-type: none"> • Drought resistant 	<ul style="list-style-type: none"> • Very high nitrogen feeding crop 	<ul style="list-style-type: none"> • Optimum temperatures for high producing varieties over 25°C 	<ul style="list-style-type: none"> • High productivity • Significant starch/sugar/ lignocellulosic material • Low fertilizer, pesticide needs • High photosynthetic efficiency
Soybean	<ul style="list-style-type: none"> • Moist alluvial soil • High water capacity 	<ul style="list-style-type: none"> • High 	<ul style="list-style-type: none"> • Optimum soil pH of 6 to 6.5 	<ul style="list-style-type: none"> • Tropical, subtropical, and temperate climates 	<ul style="list-style-type: none"> • Most-used raw material in world, but low efficiency for biodiesel production • Important food supply
Sugarbeet	<ul style="list-style-type: none"> • Medium/heavy • Well-drained • Salinity tolerant 	<ul style="list-style-type: none"> • Moderate:550-750 mm in growth period 	<ul style="list-style-type: none"> • Ample nitrogen early • High fertilizer 	<ul style="list-style-type: none"> • Variety of temperate climates 	<ul style="list-style-type: none"> • High energy need for production and transformation to ethanol
Sugarcane	<ul style="list-style-type: none"> • Soil flexibility • Well-aerated soil, water content >15% 	<ul style="list-style-type: none"> • High and evenly distributed through the growing season 	<ul style="list-style-type: none"> • High nitrogen/potassium needs early; low at maturity 	<ul style="list-style-type: none"> • Tropical or subtropical climate 	<ul style="list-style-type: none"> • More than 40% of ethanol world production • Sugar concentrated in stem, thus harvesting is easy, economical
Sunflower	<ul style="list-style-type: none"> • Grown under rain-fed on range of soils 	<ul style="list-style-type: none"> • 600-1,000 mm, based on climate & growth period 	<ul style="list-style-type: none"> • Moderate 	<ul style="list-style-type: none"> • Range from arid (irrigation) to temperate (rain-fed) 	<ul style="list-style-type: none"> • Yield is higher than soybean, lower than rapeseed.
Switchgrass	<ul style="list-style-type: none"> • Prairie to arid or marsh 	<ul style="list-style-type: none"> • Drought-resistant • Good water use 	<ul style="list-style-type: none"> • Low 	<ul style="list-style-type: none"> • Warm-season plant 	
Wheat	<ul style="list-style-type: none"> • Medium-textured 	<ul style="list-style-type: none"> • High 	<ul style="list-style-type: none"> • High 	<ul style="list-style-type: none"> • Temperate to tropical climates 	<ul style="list-style-type: none"> • Important for food supply • Less efficient than corn, sugarcane, sorghum

The first directive of bioenergy use is to identify current consumption; improve efficiency; and ensure the sustainability of its use. The second directive is to ensure that it is renewable and that it contributes to an overall reduction in GHG emissions. A third directive is to produce and consume bioenergy locally as this generally improves its competitiveness with fossil fuels. These “rules for use” should help shape UEMOA’s decisions on how best to develop a modern bioenergy economy.

6.1 WOOD, WASTE, AND RESIDUES

Forests comprise a major natural resource in UEMOA, covering 44.5 million ha. Due to deforestation and degradation, this resource is under severe pressure. Traditional biomass in West Africa includes fuelwood, wastes from timber processing, agricultural and other forest residues, and animal waste. Together these products comprise the largest source of primary energy consumption (73%) in the UEMOA area. Similar trends are observed in neighboring countries. While long-term data sets are incomplete, FAO estimates that wood waste from mills alone in Cameroon would be sufficient to sustain average annual electricity consumption in the nation. If all forest residues are taken into account, Cameroon could generate five times its annual consumption of electricity (FAO, 2007c). The scale of the resource illustrates that properly managed forests and their residues could make a greater contribution to a modern bioenergy system than any existing first-generation feedstocks.

The challenge for UEMOA policymakers is to determine if new conservation strategies can ensure sustainable and efficient use of these resources. This assessment requires an understanding of the risks and opportunities within the forest resource base and the urgent need to reform its management. Forests are a vast source of undervalued fuels for cooking and heating that are consumed unsustainably. The demand for fuelwood and charcoal in rapidly growing urban centers is accelerating deforestation. Countering these trends with sustainable conservation, reforestation, afforestation, production, and use would also offer the UEMOA economic benefits and many additional ecosystem services—protection of soils, watersheds, and forest biodiversity—and reduce the competition between food and energy crops. Such a strategy could provide alternatives to traditionally supplied biomass energy. Collecting and using forest residues sustainably are essential components of a solution that improves energy security and broadens energy access.

6.2 BIOENERGY AND FOOD CROPS

The UEMOA region produces several food or feed crops that can be processed to provide bioenergy. These crops include sugarcane, sweet sorghum, cassava, cashew fruit, palm oil, and groundnuts.

6.2.1 SUGARCANE

Sugarcane cultivation requires a tropical or subtropical climate, with a minimum of 600 mm of annual moisture. It is one of the most efficient photosynthesizers in the plant kingdom, able to convert up to 2% of incident solar energy into biomass. More than 40% of the ethanol production worldwide is from sugarcane. Sugar is concentrated in the plant stem and thus proves simple and economical to harvest.

Sugarcane is grown from cuttings, rather than from seeds. The cuttings are usually planted by hand. Once planted, a stand of cane can be harvested several times. After each harvest, the cane sends up new stalks, called ratoons. Usually, each successive harvest gives a smaller yield, and eventually the declining yields justify replanting. Depending on agricultural practice, 2 to 10 harvests may be possible between plantings. Sugarcane is harvested by hand or mechanically. Hand harvesting accounts for more than half of the world’s production, and is especially dominant in the developing world. Once cut, sugarcane loses its sugar content and damage inflicted on the cane during mechanical harvesting accelerates this decay. As a consequence, processing on site is critical to optimize energy outputs.

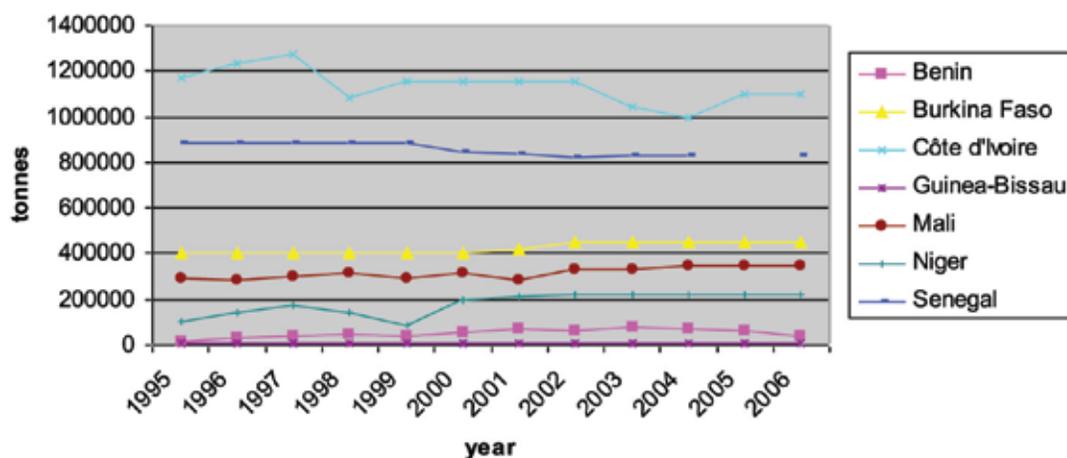
Practically all UEMOA member countries produce sugarcane that could be used for making ethanol. In many countries, molasses, a byproduct of cane, is already being used to supply factories (see Figure 6-1).

Côte d’Ivoire has a large potential to produce ethanol, since molasses is available at low cost, permitting profitable production of ethanol, gel fuel, and/or biofuel.

Mali has two sugar-producing units that belong to Sukala-S.A. (Dougabougou and Siribala). Sugar production is 400,000 tonnes per year, and molasses between 8,000 and 10,000 tonnes per year. Approximately 50% of molasses is dedicated to the production of ethanol; the remainder is sold for animal feed or to the agro-food industry. Ethanol is sold to the pharmaceutical industry and to the agro-food and beverage industries in Mali. Large quantities (about one million liters per year) are exported to Burkina Faso. Cane production could be doubled or tripled with the implementation of new sugar projects in development.

In Senegal, the Senegalese Sugar Company (CSS) produces approximately 35,000 tonnes of molasses with strong sugar content. It projects this can be transformed into 2,500 m³ of industrial ethanol (96%) and 10,000 tonnes (12,500 m³) of anhydrous ethanol as biofuel.

Figure 6-1: Production of Sugarcane in UEMOA Countries



Source: FAOSTAT, 2008.

A sugar factory produces nearly 30% bagasse out of its total crushing. Bagasse is a renewable feedstock for power generation and the production of bio-based materials. Also, the cellulose-rich bagasse is being tested for production of commercial quantities of cellulosic ethanol (second-generation biofuel).

Bagasse is often used as a primary fuel source for sugar mills, when burned in quantity. It produces sufficient heat energy to supply all the needs of a typical sugar mill, with energy to spare. A significant application for this waste product is in cogeneration, to provide both heat energy and electricity.

Bagasse is often used as a primary fuel source for sugar mills, when burned in quantity. It produces sufficient heat energy to supply all the needs of a typical sugar mill, with energy to spare. A significant use for this waste product is in cogeneration, the use of a fuel source to provide both heat and electricity.

6.2.2 SWEET SORGHUM

Sweet sorghum is one of the many varieties of sorghum, a cane-like plant with high sugar content. Able to thrive under drier, warmer conditions than many other crops, sweet sorghum is grown primarily for forage, silage, and sugar production. Although a part of the food base of several countries of the subregion, this crop offers significant potential in terms of energy uses. Sweet sorghum provides fuel (ethanol), power, food (grains), and fodder (leaves). Benefits of sweet sorghum include high productivity with substantial amounts of starch (grains), sugar, and lignocellulosic materials; broad adaptability to tropical and semi-arid climates and soil conditions;

Box 6-1: Multi-Faceted Sweet Sorghum Applications



Sweet sorghum provides a variety of food, feed, and energy needs. In the foreground, grain sorghum is used primarily for animal feed. In the background, efficient sweet sorghum is grown for the biofuels industry.

resistance to drought and saline-alkaline solutions; low irrigation requirements (one-third the needs of sugarcane, one-half that of corn); and low fertilizer and pesticide needs.

The European Biomass Industry Association (EUBIA) has proposed a Biorefinery Sweet Sorghum program for arid and semi-arid ecosystems in Africa that can satisfy rural village energy needs while producing a variety of commercial products.

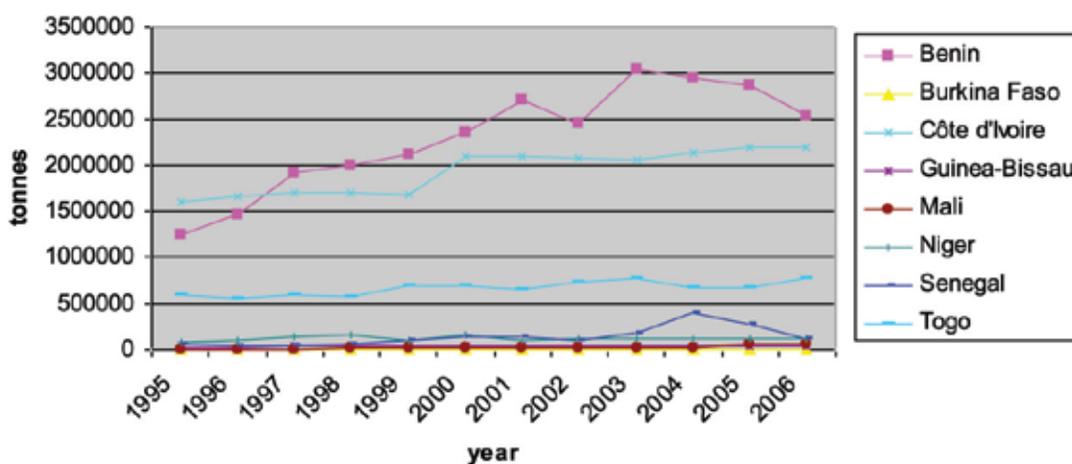
6.2.3 CASSAVA

Cassava is a starch-rich energy crop that thrives in relatively poor soils and requires a limited amount of inputs. As cassava is a major food crop in Western Africa, countries in the region are trying to kick-start an industrial cassava sector. As an energy crop, cassava yields biofuels with an excellent energy balance; that is, the fuels contain more energy than is required to produce them.

With current best technologies, the growing global demand for ethanol, and record oil prices, cassava ethanol is now commercially viable. According to the International Center for Tropical Agriculture (CIAT), one of the Green Revolution institutions and a member of the Consultative Group on International Agricultural Research (CGIAR), small farmers and the rural poor in the developing world would benefit from cassava ethanol.

Cassava is produced in all UEMOA countries. As Figure 6-2 shows, Benin produced approximately 2.5 million tonnes of cassava in 2006, although production has been in decline since it peaked in 2003. Côte d'Ivoire produced about 2.11 million tonnes in 2006 and Togo approximately 767,000 tonnes in this time frame. Table 6-3 shows projected ethanol production from cassava and sweet sorghum in Benin.

Figure 6-2: Cassava Production in UEMOA Countries



Source: FAOSTAT, 2008.

**Table 6-3: Projected Ethanol Production from Cassava and Sweet Sorghum in Benin:
Case Covering 20,000 Hectare Surface**

Crop	Surface Cultivated (ha)	Yield in Ethanol (liters/ha)	Production of Ethanol (1,000 liters)
Cassava	20,000	2,196	43,923
Sweet Sorghum	20,000	2,100	42,000
Total			85,923

6.2.4 CASHEW FRUIT

Guinea Bissau has the greatest potential for the exploitation of cashew fruit, a byproduct in cashew nut production. The residue could be transformed for energy use, notably for the production of “gel fuel” (fuel based on ethanol). Since the cashew tree is the most important agricultural product in the country (165,000 ha), it will be at the core of strategies and investment programs with regard to bioethanol. Annual production is estimated at 400,000 to 600,000 tonnes, of which only 30% is transformed into juice for the production of wine and spirits. It is estimated that approximately 70% of the total production is discarded after the nut has been removed. If the fruit remnants were reused, the potential for ethanol production would be approximately 8,400 to 12,700 m³ per year. This is equivalent to 6 to 9% of Guinea Bissau’s total annual imported oil. However, one major drawback is that the cashew season lasts only three months per year, running from April to June. Biomass in the form of cashew nut shells represents another renewable source of energy that could supply efficient biocombustion systems.

6.2.5 PALM OIL

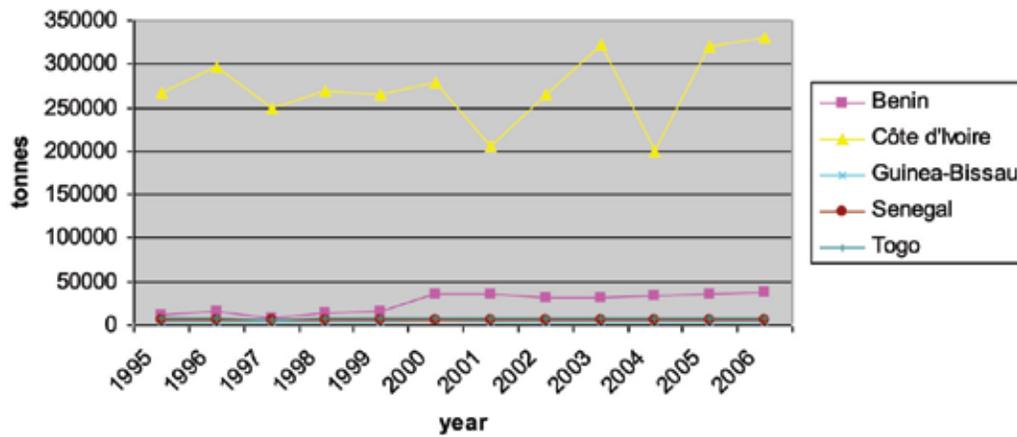
Palm oil provides excellent yields. It had been used primarily for domestic applications, but exports have been increasing due to growing biodiesel demand.

Côte d’Ivoire offers the largest potential for palm oil among UEMOA countries, with production in 2006 of more than 300,000 tonnes. Benin is also a palm oil producer, with almost 50,000 tonnes in 2006 (see Figure 6-3). There is no facility producing biofuels from palm oil in the subregion. Instead, a large portion of the production is used for human consumption or for local export.

6.2.6 GROUNDNUTS

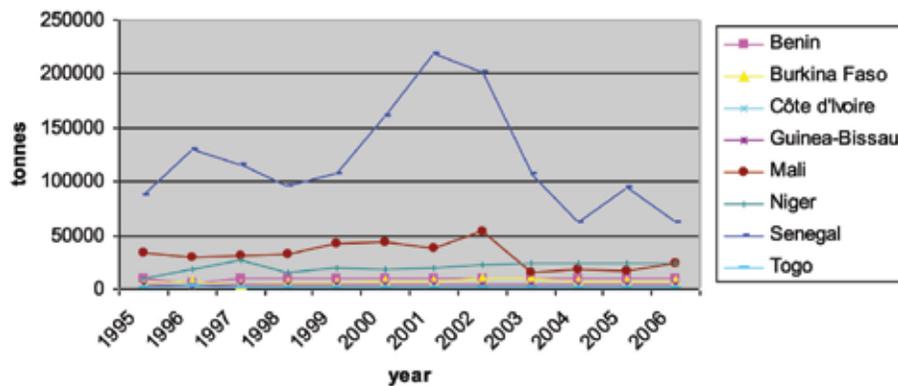
Groundnut production in the UEMOA has been decreasing rapidly over the last few years, with production in 2006 at approximately the same levels as it was 10 years ago (see Figure 6-4). Supply and demand trends do not seem to encourage this prospect in the short term.

Figure 6-3: Palm Oil Production in the UEMOA, 1995 to 2006



Source: FAOSTAT, 2007.

Figure 6-4: Groundnut Production in the UEMOA, 1995 to 2006



Source: FAOSTAT, 2007.

6.3 BIOENERGY AND NON-FOOD CROPS

Non-food crops or plants that may also be applicable include cotton, jatropha, and neem. Currently, only cotton is grown as a crop; both jatropha and neem are found throughout the region and are often used as hedgerows or for traditional medicine.

6.3.1 COTTON

Oil production from cotton seeds has experienced erratic trends in recent years in most UEMOA countries. Despite a significant increase in cottonseed oil production over the last three years by Mali and Burkina Faso, other countries have seen a production decline, particularly as the prices

of cotton have gone down (see Figure 6-5). In the majority of countries, low cotton prices on the world market have lead to a reduction of net cottonseed exports and a search for alternative cotton applications (see Figure 6-6).

Figure 6-5: Cottonseed Oil Production in the UEMOA, 1995 to 2006

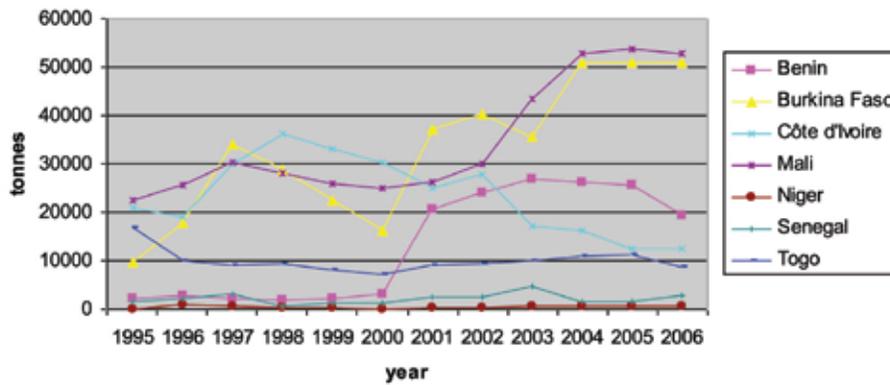
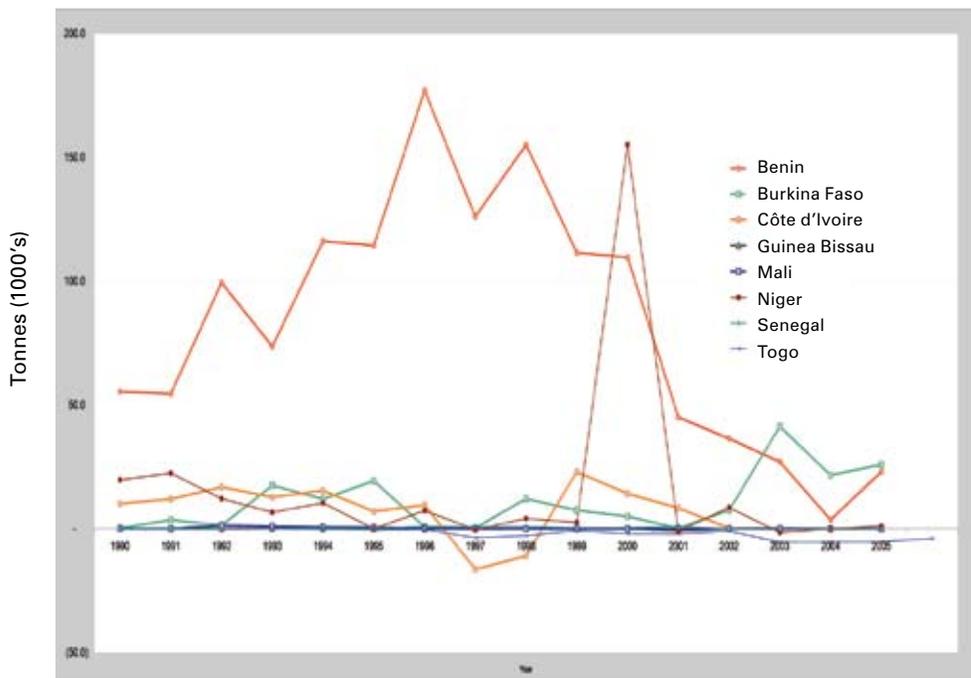


Figure 6-6: Net Exports of Cottonseed in the UEMOA: 1990 to 2005



Source: FAOSTAT, 2008.

6.3.2 JATROPHA

Jatropha Curcas is a shrub that is fairly common in West African countries. Jatropha seeds and fruits are non-edible, and the plant is typically used as a protective hedge or to delimit agricultural lots. Jatropha seeds can be used to produce oil, soap, medicines, and candles. Jatropha is easy to cultivate in marginal and semi-arid areas; it has the capacity to develop on poor soils. It is particularly drought- and pest-resistant, and can produce seeds containing up to 40% oil. The plant develops very rapidly and can begin to produce seeds in less than one year, but does not reach full productivity until three to five years, depending on the climate and nature of the soil. The plant's longevity is 30 to 40 years, and it requires little maintenance. Two harvests per year are possible. When the seeds are crushed and processed, the resulting oil can be used in a standard diesel engine, while the residue can be processed into biomass power electricity plants.

Though jatropha can exist with little water, production yields have been shown to be higher with water and fertilizer. Additionally, despite its abundance, none of the jatropha species have been properly domesticated and, as a result, its productivity is highly variable. The long-term impact of its large-scale use on soil quality and the environment is unknown. Outside West Africa, extensive research on jatropha is underway in Latin America, India, China, and Indonesia.

In West Africa, most programs and initiatives concerning the development of modern forms of bioenergy have focused on jatropha. This is most notable in Burkina Faso, Mali, Niger, Senegal, and Togo. To date, the potential for planting jatropha in UEMOA member countries has not been fully estimated. However, experiments are being conducted to evaluate the potential for seed and oil production. For example, in 2000, there were 17,000 km of jatropha hedges in Mali. Seed production is estimated to be two kilograms per linear meter, resulting in potentially 34,000 tonnes yearly. Furthermore, the potential for developing the plant remains considerable since areas not suitable for food crops could be planted with jatropha. In Mali, many experiments have been conducted over several years to demonstrate the possibilities of using jatropha oil to mechanize agriculture and bring electricity to rural areas. The results of these activities have been mixed. After food crops and other applications are considered (e.g., cotton and groundnuts, forest surfaces, pasture lands), approximately four million hectares of land are projected to be available that could potentially be used for jatropha or other energy crops.

In Niger, land use studies have indicated that approximately one million hectares are available for planting jatropha, taking into account protected zones and forest reserves, which total 313,599 ha. Given jatropha's ecological demands, the Sahelo-Sudanic zone is considered the most desirable development area.

In Senegal, the national biofuel program is based on the promotion of jatropha oil production. Begun in 2006, this program foresees the planting of 320,000 ha of jatropha bushes by 2012, providing 1,000 ha per rural community. Program implementation will occur through a national technical committee under the authority of the Minister of Cooperation, local elected officials, notably the National Association of Rural Councilors (ANCR), and producer organizations. The Senegalese Institute for Agricultural Research will monitor production. The program's

implementation strategy depends partly on the country's plan to Return to Agriculture (REVA). The program is expected to produce 3.2 million tonnes of seeds each year, amounting to 1.19 billion liters of raw jatropha oil or 1.124 billion liters of refined oil usable as biodiesel. If this target

Box 6-2: High-Level Consultation on Pro-Poor Jatropha Development (April 2008)

The International Fund for Agricultural Development (IFAD) in collaboration with UNF hosted an International Consultation on Jatropha April 10-11, 2008, in Rome. The consultation brought together a number of global experts to look at jatropha's energy potential. Among the key findings were:

Jatropha yields high quality oil that can easily run diesel engines with relatively high efficiency.

- It grows on marginal land in many areas and still produces seeds.
- It requires minimal water.
- It is a perennial and continues to produce oil for as long as 30 years.
- It is nitrogen fixing—it acts as a soil enhancer.
- It is already used for hedgerows—and effectively protects many small crops from domestic or wild animals.
- Collecting and processing seeds can provide additional income for rural poor women.
- It provides a unique opportunity to provide sustainable and renewable energy supply to off-grid areas.

Concerns included:

- Productivity per hectare and variability of production from each plant.
- Toxicity—which discourages animals—can sometimes prove dangerous to small children.
- New varieties need field testing; plant breeding needs to be systematically organized so results can be monitored.
- Determination of what constitutes marginal land.
- How to minimize competition with food crops.
- How to change consumer behavior and build demand for cleaner fuels.
- How to ensure smallholders benefit from this initiative.

Papers presented at this meeting explored better agronomic techniques to improve yields; outlined results of field trials; and underscored the need for further research and investment in improving plant varieties. As energy is a key component of development, jatropha may serve as an important bridge crop until second-generation feedstocks are available.

is achievable it would represent 45 to 55% of Senegal's current annual oil imports. Senegal expects jatropha to contribute to a significant reduction in oil imports and to make the country a net producer of energy.

6.3.3 NEEM

Neem (*Azadirachta indica*) is a common tree found in most countries of West Africa. It originated in the semi-arid zones of India and is in demand due to its traditional medical applications and its uses in afforestation, animal and human health, and as fuelwood. Neem is often planted to provide shade and control pests. Neem oil can serve as a feedstock for biofuel production, but its energy properties have not been thoroughly studied. Nonetheless, certain trials indicate production possibilities for vegetable oils from neem seeds.

Niger has demonstrated the most interest in neem for biofuels development. In June 2005, a demonstration of the use of neem oil in a diesel motor pump took place at the National Council of the Environment for Sustainable Development (CNEDD). The mix was 0.5 liters of diesel and 0.5 liters of neem oil. As an experiment, a Nigerian NGO—the School Instrument of Peace (EIP)—initiated the use of neem oil to operate some motor pumps and grain mills in their participating villages of Seno, Sounga Dossdo, Wali, and Sawani. The progressive introduction of tractors using diesel opens opportunities for using biodiesel.

Though more research is needed, the EIP program has already provided some useful information. Studies conducted by EIP indicate a capacity for development where rainfall is of the order of 150 mm per year, with optimum productivity between 450 and 750 mm per year. Neem seeds are estimated at 1,500 Franc de la Coopération Financière en Afrique Centrale (FCFA) per 30 to 35 kg bag. The production per season, which lasts only for one month, averages 30 bags. In addition to medical usage, the leaves can be used as fertilizer with 20 kg of green fertilizer priced at 1,000 FCFA.

Several other woody varieties cultivated or in the wild state, such as balanites and Moringa, can also produce oil for energy purposes. However, there has been no experience to date with them in the UEMOA for energy applications. Further research is required on these feedstocks.

Box 6-3: Assessing Liquid Biofuels in the UEMOA

In 2006, UEMOA's Biomass Energy Regional Program conducted a feasibility study to identify market opportunities, the supply chain, and technological and economic benefits of promoting liquid biofuels in its member countries.

The report found that from a regional perspective, the agricultural production potential for the ethanol sector is very consistent with: (1) the humid areas of Côte d'Ivoire, Guinea Bissau, Benin, and Togo where rain-fed sugarcane, cassava, and cashew tree are cultivated; and (2) the geographical zones around the Niger, Senegal, and Gambia Rivers with intensive irrigation of sugarcane and rain-fed oilseeds such as cotton and jatropha.

Results are highlighted below.

- **Household Fuels.** At 2005 prices, household fuels based on ethanol could not compete with subsidized butane. The price levels of wood and charcoal, on an energy basis, were definitively lower than those of butane, but gel fuel production costs were typically 20 to 30% higher than those of butane. In Senegal and Côte d'Ivoire, however, ethanol could compete with butane gas when subsidies for butane are eliminated or if equivalent subsidies are introduced for ethanol. At today's fossil fuel prices, ethanol gel may now be competitive.
- **Motor Fuel.** In all countries studied, the production of anhydrous ethanol for use as motor fuel is advantageous. With the exception of Benin and Guinea Bissau, the local production of anhydrous ethanol can compete with gasoline. Feasibility in Benin suffers from illegal import of hydrocarbons from Nigeria, while production costs in Guinea Bissau are based on high raw material costs and low capacity utilization as a result of the limited seasonal availability of cashew fruit. In these countries, modest support measures (e.g., tax exemptions) could render the production of anhydrous ethanol viable. In Côte d'Ivoire, Senegal, Mali, and Burkina Faso, production should be particularly stimulated. These countries with important resources can save on the import of hydrocarbons, especially by developing local resources. Regarding the production of biodiesel in Niger and Togo, preliminary calculations indicate that this fuel can compete with (fossil) diesel. Biodiesel production costs are 5 to 11% less than those of diesel. These costs are highly sensitive to the price of jatropha seeds.

In summary, though ethanol-based household fuels were not competitive with butane in 2005, steep increases in fossil fuel prices since that time may change these results and the figures should be reexamined. Incentives for cleaner-burning fuels such as ethanol gel, and/or elimination of butane and related subsidies, could also change the market dynamics. Other uses of ethanol, such as motor fuels, were competitive in 2005, and should be even more so today. Yet, the countries will need to develop a blending scheme for the ethanol product. Appendix 1 provides economic and price data in more detail.

6.4 SUMMARY

- Fuelwood represents the largest biomass resource in UEMOA. Identifying the most productive varieties and developing active forest management strategies could make this resource sustainable. As it supplies 73% of primary energy in the UEMOA area, ensuring it is converted into efficient fuels, burned cleanly, and consistently replenished is an urgent priority. Reforestation and community forest management are essential to attaining these objectives.
- Major export crops can provide large amounts of agriculture residues for power generation, especially at the village level. Collecting and processing these residues in small-scale processing systems can create jobs as well as provide energy.
- Oil crops can provide energy for local equipment and transportation as well as export revenues.
- Nontraditional plants (e.g., jatropha) may contribute to domestic energy supplies, but more research and investments in plant breeding are probably needed for this promise to be realized.
- Sugarcane and sweet sorghum can yield ethanol at competitive costs that can be used as cooking fuel or blended with transport fuels. Such strategies, however, depend on relatively high petroleum prices and low sugar and feed prices; requiring opportunity cost analyses during the growing and processing period.

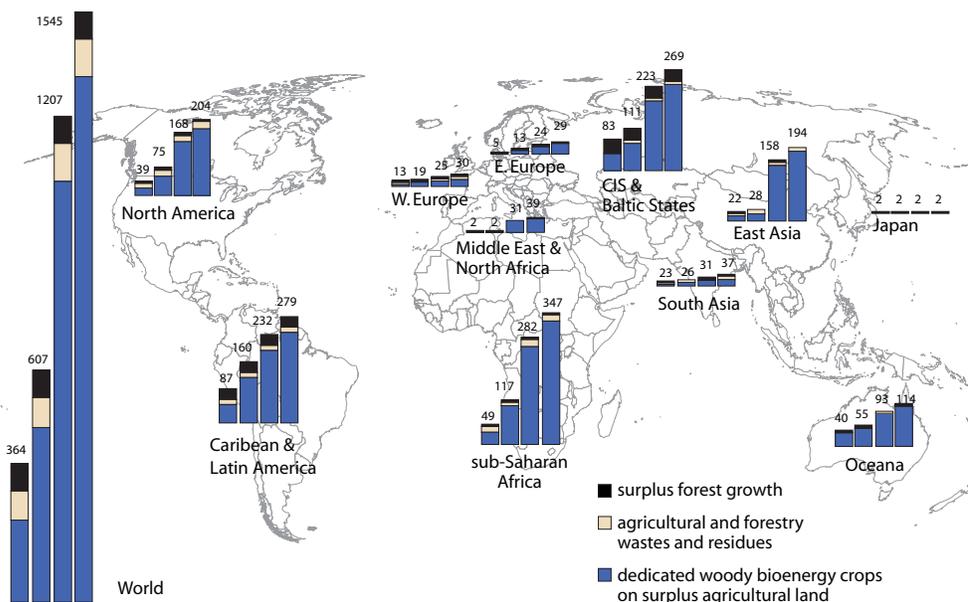
7. Opportunities and Challenges for Bioenergy Development

The IEA Bioenergy Task 40 reports (Smeets et al., 2004) that “Africa has the largest bioenergy potential in the world.” This is defined as the production of biofuels after food, fuel, and fodder needs for local populations and livestock have been satisfied—and without deforestation (see Figure 7-1).

Though there is some dispute over whether Africa has the “largest” potential, the expert community does believe there is significant opportunity to use biomass for energy development to displace fossil fuel and enhance energy access. Figure 7-2 demonstrates the range of resources available in the UEMOA and Africa-wide.

- Using existing woody biomass resources more wisely can help displace fossil fuel and enhance energy access in the UEMOA.
- Opportunities exist for expanding biomass production using certain crops, residues, and non-food oils.
- Challenge is how to engage the poor.
- Second-generation feedstocks and processing technologies hold greater promise for the UEMOA.

Figure 7-1: Sustainable Bioenergy Production Potential under Four Scenarios by 2050



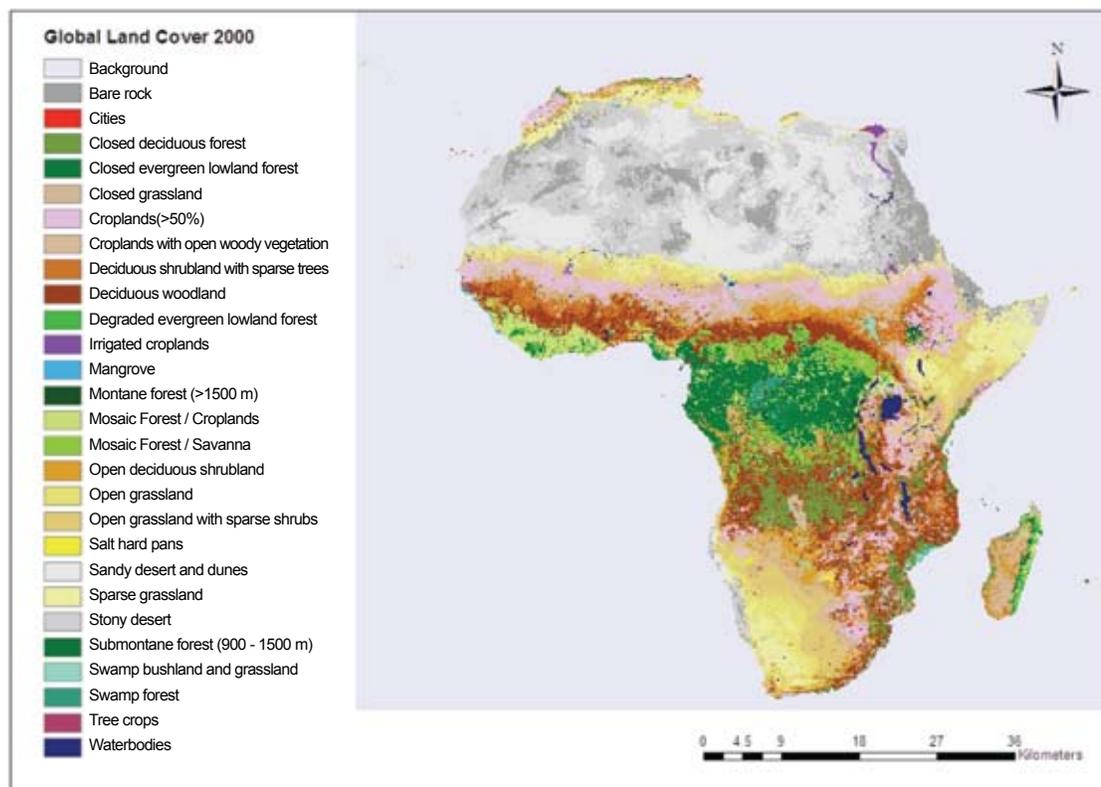
Total bioenergy production potential in 2050 based on system 1 to 4 (EJy⁻¹); the left bar is system 1, the right bar is system 4



Source: Smeets et al., 2004. The four bars indicated for each region reflect four levels of advancement of agricultural technology in the year 2050; these vary with respect to the efficiency of food production.

Nonetheless, this potential must be further examined in view of the many issues posing both opportunities and constraints for sustainable bioenergy development.

Figure 7-2: Land Cover 2000, Africa



Source: COMPETE, 2007.

7.1 OPPORTUNITIES

At present, a number of converging trends provide opportunities for enhanced bioenergy consideration in the UEMOA member countries. These bioenergy options span potential technological, social, economic, environmental, and security benefits as outlined below.

7.1.1 LEVERAGING TECHNOLOGY ADVANCES

Though bioenergy is not a new concept, advances in the last few years have improved the performance and reliability of these technologies and reduced costs for a range of power, heat, and fuel applications. Further, research, development, and demonstration efforts focusing on second-generation technology applications promise continued cost, performance, efficiency, and environmental gains that could significantly expand market opportunities for these technologies worldwide.

7.1.2 SUPPORTING MODERNIZATION AND DIVERSIFICATION OF THE AGRICULTURAL SECTOR

Mechanization of the agricultural sector in West Africa is very limited in the production and processing of agricultural products. Yet, several initiatives to alleviate this problem and assure sustained productivity are underway. Both national and regional level policies have made broader access to mechanization among the top priorities for modernizing the agriculture sector. To achieve this goal, farmers will need access to energy.

The rising cost of and limited access to fuel in rural areas is a major threat to achieving success in this area. Thus, bioenergy can make a valuable contribution to modernizing the agricultural sector. Locally produced biofuels offer a reliable, cost-effective alternative to diesel for powering motorized agricultural equipment (e.g., water pumps, tractors, cultivators, processors, grain grinders, etc.). As bioenergy supports increased mechanization, it helps to improve agricultural production efficiency and enhance output processing and distribution. Bioenergy also presents significant new cropping opportunities and improved crop management (see Box 7-1).

Box 7-1: Expanding Bioenergy Crop Opportunities in West Africa

- *Multi-cropping.* Multiple cropping is the practice of growing two or more crops simultaneously in the same space during a single growing season. It can take the form of double-cropping, in which a second crop is planted after the first has been harvested, or relay cropping, in which the second crop is started amidst the first crop before it has been harvested.
- *Intercropping.* Another kind of multi-cropping is intercropping, which can also be appropriate for bioenergy. Intercropping is the agricultural practice of cultivating two or more crops in the same space at the same time, with the most common goal to produce a greater yield on a given piece of land. In intercropping there is typically one main crop and one or more added crops, with the main crop being of primary importance for economic or food production reasons. An example of successful intercropping exists in Senegal, where jatropha has been integrated with local banana plantations. As a result of the jatropha–banana intercropping, arable land is more efficiently used; pest control, weed control, and soil quality are improved; and overall crop yields have been increased. This crop diversification has also led to a reduction in farmer risk.
- *Crop cascade management.* Cascade management is a process in which every single part of the crop is used—from the grain as food, to the straw as biomass for heat and power applications. The grain and stem can be further processed by crushing to produce oil or by fermentation to produce sugars. The cake can then be used as animal feed or fertilizer, or energy from biomass. Crop cascade management is being done today in a number of countries and will be further advanced as second-generation technologies come to market.

7.1.3 ENHANCING POWER ACCESS

Currently, less than 7% of the rural areas in UEMOA member countries are electrified. On average, electricity in rural areas costs seven times more than it does in urban areas.⁹ Most rural energy needs are met by traditional biomass, primarily for cooking.

The lack of access to modern energy constrains economic and social development, contributes to poverty, and reduces the chances of achieving the MDGs. Modern energy—provided at affordable prices in sustainable and appropriate ways to people living in rural and peri-urban areas—is key to poverty reduction, increased food production and consumption, and improvements in environment, education, and health. Bioenergy can play a major role in helping to achieve broader energy, agriculture, poverty reduction, and national development strategies and should occupy an important place in framework documents and in the basic laws of almost all the subregion's countries.

7.1.4 IMPROVING ENERGY SECURITY

As noted previously, with the exception of Côte d'Ivoire, the UEMOA member countries are virtually 100% dependent on petroleum imports. Near record oil prices are consuming cash-strapped country budgets, hampering economic growth, and threatening to roll back advances made through anti-poverty campaigns. For example:

- FAO states that “Increasing oil prices in recent years have had devastating effects on many poor countries, some of which spent six times as much on fuel as they did on health.”
- The World Bank documents that “even a small percentage increase in oil prices takes a high toll on a country's GDP.”
- The Ministries of Agriculture in UEMOA coastal countries report that fishermen can no longer afford to pay for fuel, thus negatively impacting business, revenues, and livelihoods.

Bioenergy can assist in advancing energy security in the UEMOA region by diversifying the country's energy mix, reducing demand for petroleum imports, and decreasing the impact of fossil fuel price uncertainty on the balance of payments.

7.1.5 ACCELERATING ECONOMIC DEVELOPMENT AND EMPLOYMENT

The UEMOA is a region where the population grows at an average rate of 3% per year. This is significantly higher than sub-Saharan Africa overall, which has an average annual rate of 2.5%, and regions such as Latin America and Asia with rates of 1.2%. At this pace, Africa's population would double in approximately 28 years. More than 80% of UEMOA's population lives in rural areas, and

⁹ Dr. Ibrahim Mayaki, Executive Director, HUB RURAL, Dakar, Senegal.

most are unemployed or under-employed. Challenged by poverty and worsening living conditions, many migrate to cities and foreign countries.

Box 7-2: Côte d'Ivoire Raising Oil Prices to Keep Up With Costs—But Still Not Enough

In early July 2008, Côte d'Ivoire—an exporter to Benin and Mali—significantly increased its oil products prices. This step occurred at the recommendation of the IMF, which found in June that the country was heavily subsidizing its oil consumption. Among the increases were 44% for diesel, 29.2% for gasoline, 33% for butane gas, and 17% for lamp oil (largely used even in urban areas where the poor cannot afford electricity and where shortages often happen). Even with these increases, the government says it is still not covering the rising costs of crude oil.

By providing energy to rural areas and improving agricultural productivity, bioenergy has the potential to bring significant economic and social improvements in living conditions. In particular, the income-generating potential of bioenergy is linked to the production, transformation, and commercialization of biomass resources. Local production and consumption of biomass can play an important role in sustainable livelihood strategies, particularly for rural women in developing countries. Many biofuel production processes are labor intensive, thus bioenergy programs can generate employment opportunities and contribute to the overall development of the region. The local availability of energy is fundamental to intensifying agriculture and agricultural development, another essential step in alleviating poverty.

At the seed production level, for example, the need for labor is very high. In Senegal, intercropping of jatropha with peanut plants and bananas has enabled the creation of an inter-season vegetable crop. Agricultural workers have been able to stay employed throughout the year instead of having to stop work during the rainy season.

Beyond direct employment in bioenergy production, access to cost-effective energy services in rural areas has significant spillover effects that could create a new dynamic for job creation and development. Such jobs increase employment and revenues, which will lead, in turn, to higher consumption and demand for goods and services. Such demand generates more employment.

7.1.6 ENHANCING THE ROLE OF WOMEN

According to FAO studies, while women in most developing countries are the mainstay of the agricultural sector, the farm labor force, food systems, and day-to-day family subsistence—they are the last to benefit. Throughout sub-Saharan Africa, women are responsible for between 70 and 80% of household food production. They tend livestock, grow vegetable gardens, and cultivate subsistence crops, such as rice. Women are also responsible for gathering wood for home cooking and heating, and carrying water for household needs and farm irrigation. This consumes their days and leaves little time for studying or income earning.

Gender bias and gender blindness persist throughout the UEMOA region. Farmers are generally perceived as “male” by policymakers, development planners, and agricultural service providers. Women find it more difficult than men to gain access to valuable resources such as land, technology, training, and services that would enhance their production capacity. Moreover, as women are typically unable to use land as collateral, they lack access to formal credit schemes and are limited in their ability to acquire productive inputs. High oil prices further reduce women’s access to modern fuels and make agricultural activities less efficient and more burdensome. By growing biofuel feedstock alongside food crops, women can spread their risk and gain access to additional energy sources, thus making their own work more efficient and freeing up time to spend on other activities. Women’s organizations can be empowered to implement a sustainable “food-and-fuel” system, allowing local energy needs to be met and providing income opportunities from the sale of biofuels and byproducts to broader markets.

7.1.7 IMPROVING HEALTH BENEFITS

The collection of traditional fuels for cooking—wood and charcoal—represents a large part of the daily chores of women and children. This activity subtracts from time that could be devoted to other more productive activities, such as education or women’s participation in socially productive and revenue-generating activities. Beyond the considerable loss of time to collect them, traditional fuels engender health problems (respiratory) among women and children linked to their exposure to harmful domestic pollution from open air smoke and indoor airborne pollutants.

In fact, many studies have shown the negative impacts of exposure to internal pollution from fossil fuels, which alone cause more deaths among women and children than malaria and tuberculosis combined (UNDESA, 2007). Recognizing the health and other environmental impacts of inefficient cooking fuels, the ECOWAS/UEMOA white paper, *Increasing Access to Energy Services for Rural and Periurban Areas in Order to achieve the Millennium Development Goals in West Africa*, set the objective of increasing access to modern cooking fuels and stoves in West Africa (ECOWAS and UEMOA, 2006).

Using modern forms of biomass in more efficient stoves can contribute substantially to improving air quality, health, and nutrition for rural populations. As processed wood pellets or ethanol gel are used in stoves, time spent collecting firewood is reduced, therefore freeing up women’s time in particular to undertake new income-generating activities. Moreover, using bioenergy permits wider use of refrigeration to keep vaccines and other heat-sensitive medical products safe from deterioration, thus improving health conditions for children in rural communities.

7.1.8 SLOWING LAND DEGRADATION

The United Nations Environment Programme (UNEP) Global Environment Outlook (UNEP, 2007b) singled out land degradation as the “biggest threat” to Africa’s achievement of the MDGs. In the arid and semi-arid regions of Africa that encompass most UEMOA member countries, land degradation, deforestation, and desertification, compounded by global warming, are extremely

alarming issues. The Intergovernmental Panel on Climate Change (IPCC) projects that Africa will be among the regions worst affected by climate change.

Agricultural and forestry-based means of generating bioenergy can play an important role in addressing these key environmental challenges. In their National Plans of Action for Adaptation, UEMOA member countries have identified several adaptation strategies and options related to bioenergy. These include the development of agro-forestry, reforestation, and afforestation.

Box 7-3: Population Growth—A Social Constraint

The UEMOA countries have the highest population growth rates in sub-Saharan Africa (an average annual rate of 3%), the lowest levels of women's literacy, and among the poorest levels of access to family planning and broader reproductive health services. Between 1980 and 2005, the total population in the UEMOA countries doubled from 40 to over 80 million due to some of the highest total fertility rates in the world (five or six children per woman, according to the United Nations Population Division) and young average ages of childbearing.

Yet, most of the subsistence food crops are produced and marketed by women; men often confine their role to the export crops. For a small-producer revolution to occur, women farmers will need access to land, credit, and inputs. They will need extension services and support. Their functional literacy (closely related to their capacity to effectively access credit and take advantage of extension services) and their economic productivity could be vastly improved if they could determine for themselves when and how often to bear children.

East Asia's economic success is closely correlated with strong social programs, including primary health care, universal education, and access to family planning. These corollary investments reinforced gains in agricultural productivity that resulted from investments in agriculture. This complementary strategy was crucial to East Asia's ability to grow out of the "poverty trap" where annual population growth exceeds the growth in food production.

The UEMOA member countries have a high percentage of unused arable lands. The cultivation of certain bioenergy crops such as jatropha, which has the potential to grow in marginal lands, could help revive certain areas. However, more agronomic research is needed to determine the best species and conditions for these lands.

7.1.9 IMPROVED WASTE MANAGEMENT

Modern biomass technologies can enhance waste management practices in the UEMOA. For example, biomass power plants can process a range of agricultural, forestry, and crop residues as a feedstock to produce energy. This could be done in a village generator, a multi-system platform, or in large generators.

7.2 CHALLENGES

Though there are several prospective benefits to bioenergy development, a number of barriers exist.

The debate is thus not about *food or fuel*, but about how to best integrate *all biomass resources* in a win-win relationship benefiting the poorest of the poor.

7.2.1 FOOD AND FUEL

Biofuel mandates in the developed world have been linked to rising food prices globally—resulting in demands that biofuel production be stopped or constrained. For countries dependent on fuel and food imports, such as those examined in this report, cost increases in both fuel and staple food imports threaten the very survival of the rural poor. Policies over the last two decades in this region have favored export crops over basic food crops, promoting declines in domestic per capita food production. Conversely, policy changes that improve overall agricultural productivity and bring more arable land into sustainable use have the potential to improve both food and fuel production. The challenge is to adopt the right policies and provide support to small farmers. For much of rural West Africa, food and fuel production may yield important synergies that advance development.

7.2.2 WATER AVAILABILITY

Water availability is essential for food security and sustainable agriculture. The water requirements of sugarcane and cotton, for example, need to be carefully considered given the groundwater shortages and limited rainfall in the UEMOA area. The expansion of irrigation systems and greater access to untapped surface and groundwater resources through the use of bioenergy powered pumps may be an important option in some regions. Moreover, certain bioenergy feedstocks can improve water retention in fragile soils, thus improving water access for neighboring plants and countering desertification. Given limited rainfall and low water tables, water conservation, rainfall harvesting and other techniques might be more appropriate for some countries. Identifying how to best use water and what technology options to deploy will be critical to success.

7.2.3 LAND TENURE

Land access will underpin successful agriculture and bioenergy development in the UEMOA. The current land tenure system fails to ensure the security of land ownership. Given the importance of access to land for growing agricultural or forestry-based feedstocks, some experts fear that small producers may be forced out of their land in favor of large or foreign producers. Protecting the interests of small farmers and balancing the interest of potential investors demand effective and fair land policies. Although beyond the scope of this report, the UEMOA must identify “best practices” and promote them if rural development plans are to succeed (see Box 7-4).

Box 7-4: Land Access and Land Rights

The implications of bioenergy development for land rights and land access have yet to be fully studied and the experience so far does not allow a general answer to the question of whether risks exist for small producers. A recent study examines the current and future impacts of the spread of biofuels on access to land (Cotula et al., 2008). It emphasizes caution prior to presenting its results, due to the recent biofuels debate and the “scarcity of empirical research on the linkages between the spread of biofuels and land access,” noting that “the findings of this study can only be considered as preliminary, and as a stepping stone for more in-depth research.”

The literature review supports the belief that such disquiet is well founded. Policies and markets that promote biofuels production will tend to raise land values. Where appropriate conditions are not in place, especially where small-scale farmers do not benefit from security of rights to their land, the poorest groups will tend to lose access to the plots on which they depend. Indeed, increases in land value are likely to cause or to accelerate individualization of land rights, which in turn is likely to cause or to accelerate commercialization of land rights. Without regulation, such development of the land rights market will lead to the exclusion of the poorest small-scale farmers and marginalized groups.

The fact that biofuels crops can be cultivated on poor soils should not lead to the conclusion that risks related to land tenure and land access will be avoided. Because those soils seem to be useless, they are categorized as “idle,” “underutilized,” or “marginal” lands. These terms should not lead to the belief that these lands are “free.” Such lands are used by pastoralists or for gathering and occasionally for farming activities: they provide vital resources for the survival of vulnerable groups.

Local land tenure systems bring into play complex social relations, elaborate relations with power and authority, deep issues of social identity, and various micro-political regulation systems. These features are highly important to social stability and should be taken into account, even if the information needed to predict the extent to which the development of large-scale biofuels production will disturb such social mechanisms is still lacking.

7.2.4 SCALE OF PRODUCTION

A risk of bioenergy development is the tendency toward large industrial projects, given the economies of scale. This approach works against small land holders and producers. Organizing rural producers into village-scale, market-based cooperatives has proven elsewhere (e.g., Malawi) to respond to production scale issues. While village-based power is limited, connecting villages to more efficient subgrids might provide a better solution than a national grid. These models merit consideration given their potential contribution to rural development and poverty alleviation—priority areas for all UEMOA governments.

7.2.5 LACK OF INFRASTRUCTURE

A key obstacle to agriculture and bioenergy development in the UEMOA is inadequate infrastructure. This includes roads, railways, and telecommunications to ensure market access and to bring new areas into cultivation.

7.2.6 KNOWLEDGE BASE

The widespread neglect of agriculture in developing countries at the global, regional, and national levels since 1980 has created gaps in the knowledge base. Comprehensive and accurate data on land area potential, optimal land use, crop production potential, and agronomic techniques is essential for decisionmakers and farmers. One positive result of the current food price crisis may well be the willingness to invest in new information systems that will provide timely data to policymakers. The Gates Foundation has already responded with a commitment to support enhanced agricultural and related data collection in the UEMOA region.

7.2.7 RESEARCH AND DEVELOPMENT

Bioenergy research is in an embryonic state in West Africa. Crops and plants have been identified as potential sources of energy, but greater understanding is required of their energy properties and the most efficient energy conversion options. Other plants may have unassessed potential as energy sources. Research needs to expand to tap traditional knowledge, identify optimal growing conditions, assess environmental impacts, and determine production costs. Such research will pave the way for introduction of second-generation feedstocks that promise greater productivity. UEMOA countries have participated in several successful regional research alliances—this best practice approach should be applied here as implementation proceeds nationally.

7.2.8 CLIMATE CHANGE

West Africa is among the most vulnerable regions to climate change worldwide. Examples of the effects of climate change include rainfall decline, water shortages, recurring drought, degradation of water quality, threats to ecosystems and biodiversity, rising sea levels, coastal flooding, damage to housing and infrastructure, social and economic costs of extreme climate events, conflicts over water, and negative impacts on agricultural productivity. A recent study has shown that global climate change will reduce agricultural production in developing countries, led by Africa (see Box 7-5). Mitigation of climate change impacts through active reforestation and land management, sustainable bioenergy production, and other technological innovations, combined with adaptation to climate change and climate variability, will help to constrain potential risks and increase resistance to prospective impacts in the future.

Investments in bioenergy in the UEMOA member countries should take the predicted regional climate change impacts into account. Crop choices and agronomic practices will need to be adaptable, adjusting to changes in precipitation and other impacts. Similarly, investments in

bioenergy infrastructure such as processing facilities should be done with an eye towards climate change adaptation.

Box 7-5: Climate Change and Agriculture

In 2007, the Intergovernmental Panel on Climate Change released its Fourth Assessment Report, confirming that climate change impacts were accelerating and cautioning that developing countries will be the most vulnerable. In a country-by-country study of the global trends, Dr. William Cline concluded that all agriculture is likely to experience modest global damage and cautioned that assumptions that a “carbon-enriched” atmosphere would improve yields had yet to be proven. For sub-Saharan Africa, average losses due to climate change by 2050 were estimated at 17% of production and losses as high as 28% were possible, if the “fertilization effect” failed to materialize. Africa, in general, is among the worst affected regions in Cline’s analysis. Clearly, production losses in this range would have severe implications for food and human security—underscoring the urgent need to adopt policies that can improve the resilience of agriculture to the potential impacts of climate change (Cline, 2007).

Nonetheless, while bioenergy offers significant potential for GHG emission reductions, there are concerns that some types of biofuels may generate net increases, rather than reductions in GHG emissions. One of the latest rounds in the biofuels debate centers on GHG emissions from indirect land use changes. At present, biofuels are made predominantly from food crops. But while biofuels worldwide account for a small fraction of total agricultural acreage, new fields and land are being cleared in some countries to produce biofuels and meet market demand. Increased cultivation adds pressure to already stressed ecosystems, requiring more land, water, and other natural resources. There are also risks to native ecosystems, such as forests, that store large amounts of carbon that can be released from burning vegetation to clear fields and from tilling soil. At present, the field of research on environmental impacts of biofuels is fairly new, with a number of efforts ongoing to better understand the dynamics of land use and GHG emissions. As we move forward in this area, it will be important to take a full life-cycle accounting of biofuel agriculture and production, including direct and indirect land use changes, feedstock type, agricultural practices, energy replacement options, conversion and refining processes, and end uses. Putting aside the potential GHG emissions from indirect land use change, conventional corn-based ethanol is believed to produce 15 to 35% reductions in GHG emissions; soy-based biodiesel results in a net GHG emission reduction of 30 to 50%; and Brazilian sugarcane ethanol reduces net GHG emissions by 80 to 90%. These are important gains to consider (Hunt, 2008).

7.2.9 TRADE AND STANDARDS

The focus on trade with respect to bioenergy centers on policies to promote ethanol and biodiesel as a replacement for petroleum in the transport sector. Several countries, including the United States and those of the European Union, provide policy support to promote the use of biofuels, spurred by three primary objectives: energy security concerns regarding increasing world petroleum prices; environmental concerns about reducing rising GHG emissions, primarily in the transport sector; and an interest in supporting domestic agriculture production in the context of international negotiations for agricultural trade liberalization. The key policy issues affecting the potential for trade are import barriers, agricultural policy regimes (including domestic support and market access) affecting feedstocks, and tax reduction and production subsidies affecting biofuels. In general, lowering trade barriers will increase global welfare in the long run by increasing competition, which should lead in turn to improved efficiency, reduced costs, and enhanced market share for efficient producers.

Where bioenergy development proves economic, production should address domestic energy needs rather than those that seek to supply export markets. (COMPETE, 2007).

As international trade in biofuels increases (today it is very small), non-policy issues such as technical barriers may also emerge. The major technical barrier is likely to be certification of and standards for environmentally sustainable biofuels. In the case of the UEMOA, therefore, it will be important to work with standard-setting bodies to ensure that their activities benefit the member countries, and do not serve as an obstacle to local use and trade of biofuels.

7.3 SUMMARY

- Significant opportunities exist for bioenergy development in the UEMOA. These include leveraging of technology advances, supporting the modernization and diversification of the agricultural sector, enhancing energy access, improving energy security, accelerating economic development and employment, bettering the role of women, improving health benefits, enhancing land degradation, and improving waste management.
- Nonetheless, a number of barriers hinder advancement of these technologies: food and fuel issues, water availability, land access and land rights, scale of production, lack of infrastructure, insufficient knowledge base, research and development support, trade and standards, and climate change adaptation.
- The UEMOA's challenge is to build upon the opportunities and reduce or eliminate the barriers. Though constraints persist, the potential to enhance the region's living standards through bioenergy—recognizing the various trade-offs in food security, environmental impacts, and others—warrants further attention.

8. Policy and Regulation

Bioenergy from agriculture- and forestry-based products and byproducts could provide significant opportunities for UEMOA member countries. In general, there are three key market drivers for bioenergy in this region:

- Stimulate *economic and rural development*, including developing markets, building industries, generating jobs and incomes, and reducing poverty.
- Increase *energy security*, by diversifying a country's energy mix, reducing dependence on fossil fuel imports, and hedging against fossil fuel price uncertainty.
- Address *climate change*

To realize bioenergy potential in the UEMOA, it will be necessary to secure political commitment and build effective policy and regulatory

frameworks. UEMOA member-country governments, working in cooperation with the private sector and members of civil society, have an essential role to play, drawing on the experience of other countries. Such frameworks are urgently needed not only to guide government interventions through better intersectoral coherence, but also to send the right signals to local and foreign producers, investors, donors, and the international community.

Policy and regulatory initiatives can encourage private investment in bioenergy industries and financial support to public and/or private investors from national, multilateral, and bilateral sources. Regional commitments to promote the production and use of bioenergy can help facilitate the development of national policy frameworks.

There are a number of renewable energy policies and programs, including bioenergy, that are underway worldwide. It is necessary for UEMOA policy makers to use these experiences as background and "lessons learned" in the design of bioenergy policies and programs for the member countries.

- Policy and regulatory frameworks create the market push and market pull needed to develop bioenergy in the UEMOA.
- Currently, there is a lack of policies and incentives to support development, particularly at the smaller scale.
- Emphasis on bioenergy development to meet local needs must be a priority, given the lack of energy access.
- Global experience provides valuable lessons learned for sustainable bioenergy development, most notably the need for long-term, stable, and clear policy measures.

8.1 GLOBAL POLICY OVERVIEW

Overall, policies put in place worldwide have had a major impact on the speed and extent of biomass/renewable energy development, despite design and implementation problems. To date, almost all of the bioenergy policies and legislation globally have focused on commercially available first-generation biofuels. Experience to date underscores that policies play a critical role in success or failure when expanding bioenergy use. The best policies provide or promote the following:

- Predictability, consistency, and longevity. Producers, investors, and consumers must have confidence that there will be a market—and a return on investment.
- Public acceptance and support—consumers must see the new products as equivalent to or better than the alternative—and local producers must share in the benefits through policies that protect access to land and ensure inputs are available and affordable.
- Pilot projects that demonstrate how best to produce and process bioenergy and illustrate the economic opportunities for small producers and processors. These programs must build human capacity at the community level to raise agriculture production and productivity and develop business planning skills.
- Commitment of officials at all levels to implement the policies.
- Sustained—and sustainable—demand for products. Producer incentives, risk reduction arrangements, and smart subsidies may all play a role in bioenergy development, but sustaining long-term production and use will be dependent on predictable demand and supply.
- Access to credit. Local banks and micro-credit institutions must be partners in financing production from the start.
- Policy coherence—for bioenergy to become a significant part of modern energy supply in West Africa, national and regional policies must reinforce each other. Common regional policies on feed-in tariffs, diesel and gasoline blending rates, and new standards for cooking fuels will be essential to create predictable markets and expand employment.
- Private and public investment. The private sector needs to provide credit—and possibly equity capital—to these activities. The public sector must provide information, training, and support applied research. Brazil's agricultural research agency, EMBRAPA, developed new plant varieties and worked with farmers to identify the best crops. Similarly, West Africa's successful regional rice research program offers a model for bioenergy research and development. Joint work on conversion technologies is also important.

- Transparent governance, clear regulations, and limited administrative procedures are vital to contain costs.

A variety of government incentives support bioenergy on the supply and demand sides. Government incentives on the energy production side—exploration, infrastructure expansion, research, and development—have included direct financial incentives (e.g., capital subsidies, concessional loans, accelerated depreciation, tax holidays, tariff exemptions), preferential regulatory treatment, and mechanisms to reduce risk. Governments also provide incentives on the energy consumption side via policies that subsidize energy prices or provide capital incentives for energy appliances such as improved cookstoves (ESMAP, 2005).

8.1.1 BIOMASS/RENEWABLE ENERGY POWER GENERATION

In 2007, at least 60 countries—37 developed and in transition and 23 developing countries—had a policy to support renewable energy power generation, including biomass (see Table 8-1). Most national targets are for electricity production, ranging from 5 to 30%, but these vary widely depending on the country. Other targets exist in some countries beyond electricity production; these can include shares of total primary or final energy supply, specific installed capacity, or total amount of energy production from renewables, including heat (Martinot, 2008).

Three major renewable energy policy options operate in electricity markets where bioenergy for power generation has a role. These options and their differences are summarized below (World Bank, 2006):

- *Feed-in tariffs*, which set prices public utilities will pay renewable energy generators for the electricity they provide to the grid. Experience with feed-in tariffs shows they produce high penetration rates in a short period, create local manufacturing opportunities, provide strong incentives for private investments, and can be cost effective if the tariff is periodically reviewed and appropriately adjusted. To date, feed-in tariffs have prompted the highest installation rates for renewable energy and are preferred by renewable energy investors.
- *Renewable Portfolio Standards (RPS)*, where all electricity providers must obtain a specific market-share quantity of renewable energy generation. RPS are good at reducing cost and price with competitive bidding, yet tend to favor least-cost technologies and established industry players unless separate technology targets or tenders exist. They are also more complex to design and administer than feed-in tariffs.
- *Tendering policies*, where set quantities of renewable energy generation are purchased through open competitive solicitations. These policies reduce costs, but they need to have a mechanism for reducing price over time.

Financial incentives also exist in many countries including: capital subsidies; grants and rebates; tax credits; sales tax, energy tax, or Value Added Tax (VAT) reduction; tradable renewable energy

Table 8-1: Renewable Energy Promotion Policies

Country	Feed-in tariff	Renewable portfolio standard	Capital subsidies, grants, or rebates	Investment or other tax credits	Sales tax, energy tax, excise tax, or VAT reduction	Tradable renewable energy certificates	Energy production payments or tax credits	Net metering	Public investment, loans, or financing	Public competitive bidding
Developed and transition countries										
Australia		✓	✓			✓			✓	
Austria	✓		✓	✓		✓			✓	
Belgium		✓	✓		✓	✓		✓		
Canada	(*)	(*)	✓	✓	✓			(*)	✓	(*)
Croatia	✓			✓					✓	
Cyprus	✓		✓							
Czech Republic	✓		✓	✓	✓	✓		✓		
Denmark	✓				✓	✓		✓	✓	✓
Estonia	✓				✓	✓				
Finland			✓		✓	✓	✓			
France	✓		✓	✓	✓	✓			✓	✓
Germany	✓		✓	✓	✓				✓	
Greece	✓		✓	✓						
Hungary	✓				✓	✓			✓	
Ireland	✓		✓	✓		✓				✓
Italy	✓	✓	✓	✓		✓		✓		
Israel	✓									
Japan	(*)	✓	✓			✓		✓	✓	
Korea	✓		✓	✓	✓				✓	
Latvia	✓								✓	✓
Lithuania	✓		✓	✓					✓	
Luxembourg	✓		✓	✓						
Malta	✓				✓					
Netherlands	✓		✓	✓		✓	✓			
New Zealand			✓						✓	
Norway			✓	✓		✓				✓
Poland		✓	✓		✓				✓	✓
Portugal	✓		✓	✓	✓					
Romania					✓					
Russia			✓			✓				
Slovak Republic	✓			✓					✓	
Slovenia	✓								✓	
Spain	✓		✓	✓					✓	
Sweden		✓	✓	✓	✓	✓	✓			
Switzerland	✓									
United Kingdom		✓	✓		✓	✓				
United States	(*)	(*)	✓	✓	(*)	(*)	✓	(*)	(*)	(*)
Developing countries										
Algeria	✓			✓	✓	✓				
Argentina	✓		✓	(*)	✓		✓			
Brazil	✓								✓	✓

Table 8-1: Renewable Energy Promotion Policies (continued)

Country	Feed-in tariff	Renewable port-folio standard	Capital subsidies, grants, or rebates	Investment excise, or other tax credits	Sales tax, energy tax, or VAT reduction	Tradable renewable energy certificates	Energy production payments or tax credits	Net metering	Public investment, loans, or financing	Public competitive bidding
Cambodia			✓							
Chile			✓							
China	✓		✓	✓	✓				✓	✓
Costa Rica	✓									
Ecuador	✓			✓						
Guatemala				✓	✓					
Honduras				✓	✓					
India	(*)	(*)	✓	✓	✓		✓		✓	✓
Indonesia	✓									
Mexico				✓				✓		
Morocco				✓						
Nicaragua	✓			✓	✓					
Panama						✓				
Philippines			✓	✓	✓				✓	
South Africa			✓							
Sri Lanka	✓									
Thailand	✓		✓					✓	✓	
Tunisia			✓	✓						
Turkey	✓		✓							
Uganda	✓								✓	

Note: Entries with an asterisk (*) mean that some states/provinces within these countries have state/province-level policies but there is no national-level policy. Only enacted policies are included in table; however, for some policies shown, implementing regulations may not yet be developed or effective, leading to lack of implementation or impacts. Policies known to be discontinued have been omitted. Many feed-in policies are limited in scope or technology. Some policies shown may apply to other markets beside power generation, for example solar hot water and biofuels. Source: All available policy references, including the IEA online Global Renewable Energy Policies and Measures database and submissions from report contributors.

Source: Martinot, 2008.

certificates; energy production payments or tax credits; and public investments, loans, or financing. Net metering—whereby the utility buys back excess power generated from a renewable energy supplier—has also been effective in many countries.

8.1.2 BIOFUELS

Mandates for blending biofuels into vehicle fuels have been enacted in at least 37 countries and at least 36 states/provinces. Table 8-2 provides a sampling of the types of mandates provided. Most mandates require blending 10 to 15% ethanol with gasoline, or 2 to 5% biodiesel with diesel fuel. These mandates are fairly recent, having been enacted in only the last two to three years.

Table 8-2: Biofuels Blending Mandates

Country	Mandate
Australia	E2 in New South Wales, increasing to E10 by 2011; E5 in Queensland by 2010
Argentina	E5 and B5 by 2010
Bolivia	B2.5 by 2007 and B20 by 2015
Brazil	E22 to E25 existing (slight variation over time); B2 by 2008 and B5 by 2013
Canada	E5 by 2010 and B2 by 2012; E7.5 in Saskatchewan and Manitoba; E5 by 2007 in Ontario
China	E10 in 9 provinces
Colombia	E10 existing; B5 by 2008
Dominican Republic	E15 and B2 by 2015
Germany	E2 and B4.4 by 2007; B5.75 by 2010
India	E10 in 13 states/territories
Italy	E1 and B1
Malaysia	B5 by 2008
New Zealand	3.4 percent total biofuels by 2012 (ethanol or biodiesel or combination)
Paraguay	B1 by 2007, B3 by 2008, and B5 by 2009
Peru	B5 and E7.8 by 2010 nationally; starting regionally by 2006 (ethanol) and 2008 (biodiesel)
Philippines	B1 and E5 by 2008; B2 and E10 by 2011
South Africa	E8-E10 and B2-B5 (proposed)
Thailand	E10 by 2007; 3 percent biodiesel share by 2011
United Kingdom	E2.5/B2.5 by 2008; E5/B5 by 2010
United States	Nationally, 130 billion liters/year by 2022 (36 billion gallons); E10 in Iowa, Hawaii, Missouri, and Montana; E20 in Minnesota; B5 in New Mexico; E2 and B2 in Louisiana and Washington State; Pennsylvania 3.4 billion liters/year biofuels by 2017 (0.9 billion gallons)
Uruguay	E5 by 2014; B2 from 2008-2011 and B5 by 2012

Note: Table shows binding obligations on fuel suppliers; there are other countries with future indicative targets that are not shown here; see the Biofuels Policies section, page 27. Mandates in some U.S. states take effect only in future years or under certain future conditions, or apply only to portions of gasoline sold. *Source:* All available policy references, including the IEA on-line Global Renewable Energy Policies and Measures database and submissions from report contributors.

Source: Martinot, 2008. The terms E2, B5, etc. refer to the percentage of biofuels or ethanol blended into the mix.

8.1.3 RURAL ENERGY

Bioenergy should expand opportunities for rural development, but this must be done in the context of broader sustainable development criteria and not at the expense of food security or negative environmental impacts. Rural development issues to consider when establishing bioenergy policies include (Common Fund for Commodities, 2007):

- Maximize rural benefits of biofuels, including promotion of producer ownership.
- Decentralize energy policies that focus on local production of biofuels aimed at improving economic resilience, particularly in remote areas.
- Promote access to and transfer of bioenergy technologies.
- Encourage access to micro-credit through soft loans and guarantees.
- Enhance producer collaboration to achieve economies of scale and enable smaller-scale producers to engage and compete.

8.1.4 FINANCING BIOENERGY/RENEWABLE ENERGY POLICIES

Several approaches are underway to cover the incremental costs of renewable energy/bioenergy policies. Most often, these include:

- Applying a very small surcharge on electricity consumption to consumer electricity bills. This charge, sometimes referred to as a systems benefits charge (SBC), can be rolled into a dedicated public fund to support bioenergy/renewable energy. This can include assistance for loan programs, research and development activities, and education programs. In the United States, for example, 17 states have created public benefit funds for renewable energy/bioenergy development that are expected to bring in \$6.8 billion in financial support for these technologies by the year 2017.
- Imposing a carbon tax on fossil fuel.
- Setting up a dedicated fund financed directly by the government or with donor support.

Overall, country-specific policy mechanisms are evolving as countries gain experience (IEA, 2004). Thus, it will be important for the UEMOA to routinely monitor progress, activities, and issues. This will likely be done most efficiently and effectively at the regional level.

8.2 BIOENERGY POLICY AND REGULATORY SUPPORT FOR THE UEMOA

8.2.1 WHAT TO DO?

The UEMOA can benefit directly from other countries' experiences in effective bioenergy policy formulation and implementation. Ideally, the UEMOA member countries can leapfrog the problems that others have encountered, thereby accelerating results. Modern bioenergy is developing fast in West Africa in a context where the "plantation"—through either small producers or large-scale units—appears to be ahead of legislation. This has major consequences for all aspects of policy coherence.

Ideally, UEMOA member countries can avoid the problems that others have encountered, accelerating results in the region.

Significant disparity exists in bioenergy policies across the UEMOA and dispersed initiatives are taking place. There are wide differences in the regulatory and institutional approaches, both existing or envisaged, at the regional and national levels. In most countries, current policies on bioenergy fall under the review/mandate of several government ministries and agencies, including energy, agriculture, environment, rural development, and trade. While this distributed approach to policy reflects the sector's multidimensional nature, the associated lack of institutional clarity prevalent in UEMOA member countries can be a source of confusion and inefficiency that undermines coordination.

Integrating energy into agricultural production systems brings into play a number of factors involving both supply and demand. On the supply side, harnessing bioenergy potential can only be successful if production is supported, encouraged, and made efficient. There are several examples of successful integration of agricultural fuels into the production systems of traditional cash and food crops in ways favoring intercropping and diversification of agro-forestry production. The potential for large-scale production also exists, where maximizing efficiency requires achieving economies of scale. In both cases, specific policies to guide and sustain supply are crucial.

On the demand side, the following issues should be considered:

- The West African economies confront a challenge of *reshaping demand* in the informal energy sector which is currently dominated by traditional biomass—and creating new markets for liquid biofuels in the transport and industrial sectors. These shifts are vital to develop production and distribution systems; organize new businesses; mobilize investment; and improve incomes among both the rural and urban poor. Policies have to promote the phase-out of traditional charcoal manufacture and use; aggressively support the production and marketing of new fuels and cleaner stoves; set mandatory blending targets in the transport sector; and ensure supplies of new, renewable energy sources in rural and urban areas. Creating a sustainable bioenergy market depends on well-defined objectives and specific, time-bound targets.
- *Land use planning* is a critical factor. Governments may choose to directly allocate land to local or foreign producers under land tenure conditions, thus guaranteeing long-term control. Such an approach has been considered in several countries, although it remains to be tested for a conclusive assessment. Regardless, strengthening of land ownership in ways that protect smallholder and industrial producers needs to be included in the policy setting.

Two major recommendations are apparent. In terms of policy and practice, governments should define precise procedures of land allocation for biofuel production. Procedures should involve the consideration of pre-existent—formal or customary—land rights, and incorporate a range of steps likely to mitigate the risks of negative impacts on local groups. These steps could include local information, consultation, mediation, fair compensation, and appeal possibilities.

In terms of research, the UEMOA and member-country governments should promote the development of research programs focused on the impacts of increased biofuels production on land access. These programs should aim to collect accurate field data and produce careful analyses, in order to build coherent regulation strategies and disseminate good practices. They should identify those conditions under which biofuels development will have negative impacts on local land tenure and local stakeholders. Moreover, they should expand opportunities for innovation in the areas of joint ventures and multi-stakeholder partnerships involving companies, governments, and local farmers.

- Given the importance of access to water in the Sahel, and the existence of shared water resources and transboundary rivers, a *regional approach to water governance* becomes even more relevant for West Africa. Regional institutions such as the Organisation pour la mise en valeur du Fleuve Sénégal (OMVS) could play a greater role in the management of water resources, including consideration of further investments in water retention schemes and allocation mechanisms among countries.
- Policies to develop productive capacities are needed to *enhance access to seeds*, thereby enabling producers to rapidly respond to market demand. At present, lack of seed access is a major drawback in the region. In this regard, creation of seed banks and capacity to manage them at the community level has been identified as an urgent priority by agricultural producers and investors.
- Further, sustained demand can only be insured if market access is facilitated through *enhanced transport and land access infrastructure*.

As noted above, experience elsewhere indicates that the creation of demand has driven the production and supply of bioenergy/renewable energy in countries around the world. The development of numerical targets has been a key policy instrument to achieve this and should be considered by the UEMOA with appropriate background research and analysis. In the meantime, the process of adapting existing energy and agricultural policies to address bioenergy development—at the national and regional levels—offers a valuable opportunity for *setting indicative, but clear policy goals* for agricultural and energy producers, investors, and consumers.

A regional bioenergy regulatory and institutional framework should benefit from and comply with existing regional policy in the energy sector. The ECOWAS-UEMOA White Paper (ECOWAS and UEMOA, 2006) offers an appropriate framework for integration of bioenergy to meet the energy access targets set in the ECOWAS region. Regulatory and institutional frameworks will need to *reflect differences* in natural endowments, the structure of agricultural and forestry sectors, the options for bioenergy development, and the structure of government decision making in the various countries. For example:

- In Mali, the regulatory framework for bioenergy is defined in the national energy policy, the national strategy for renewable energies, and the national strategy for the development of biofuels. All of these initiatives will be implemented by the National Agency for Bioenergy (BIOCARMA).
- In Benin, a National Commission for the Development of Bio Energy is being created. The presence of all institutional players, public and private, in the commission will be needed to coordinate cross-cutting sector policies for developing bioenergy.
- In Senegal, the Ministry of Biofuels and Renewable Energies plays a central role in the national government, even in instances where biofuels-related decision making

falls under the responsibility of other ministries such as energy or agriculture, as well as their affiliated institutions.

- In Niger, the bioenergy sector is overseen by the Minister of Energy, the Minister of the Environment, and the Minister of Agriculture. A national multi-sector committee for Energy was put in place in 2005, and an inter-ministerial structure for coordination was created in 2006. A national framework for consultation on domestic and alternative energies should be created under the coordination of the National Council for the Environment for Sustainable Development (CNEDD); the representatives of the structures responsible for energy, agriculture, and the environment; and other concerned technical ministries.

Box 8-1: Mauritius: A Bioenergy Policy Success Story

The Mauritian experience in cogeneration is one of Africa's success stories in the energy sector. Through extensive use of cogeneration in the country, the sugar industry is self-sufficient in electricity and sells excess power to the national grid. In 1998, close to 25% of the country's electricity was generated from the sugar industry, largely through a byproduct of bagasse. By 2002, electricity generation from sugar estates stood at 40% of total electricity demand in the country.

Government support and involvement has been instrumental in the development of the cogeneration program in Mauritius. First, in 1985, the Sugar Sector Package Deal Act (1985) was enacted to encourage the production of bagasse for electricity generation. The Sugar Industry Efficiency Act (1988) provided tax incentives for investments in the generation of electricity and encouraged small planters to provide bagasse for electricity generation. Three years later, the Bagasse Energy Development Programme (BEDP) for the sugar industry was initiated. In 1994, the Mauritian Government abolished the sugar export duty, an additional incentive to the industry. A year later, foreign exchange controls were removed and the centralization of the sugar industry was accelerated. These measures have resulted in the steady growth of bagasse-based electricity flowing into the country's grid.

Bagasse-based cogeneration development in Mauritius has delivered several benefits: reduced dependence on imported oil, diversification in electricity generation, and improved efficiency in the power sector in general. Using a variety of innovative revenue-sharing measures, the cogeneration industry has worked closely with the Government of Mauritius to ensure that substantial benefits flow to all key stakeholders in the sugar economy, including the poor smallholder sugar farmer. The equitable revenue sharing policies in Mauritius provide a model to emulate for ongoing and planned modern biomass energy projects in other African countries.

8.2.2 HOW TO DO IT?

A number of organizations and stakeholders will need to be involved in the development of sustainable bioenergy policies and programs throughout the UEMOA.

- *National.* In most countries, institutional approaches to advance bioenergy tend to lean toward multi-sectoral government bodies related to energy, agriculture, and the environment, as well as other technical agencies. Yet, the representative producer organizations, the private sector, and civil society must all be engaged in the process. In this regard, frameworks for consultation on agricultural, energy, and related policies that have been created successfully in other countries can serve as models for the UEMOA. Where multi-sectoral bodies tend to have difficulties in ensuring efficient coordination mechanisms, it may be more useful to establish a strong national autonomous agency.
- *Regional.* In addition to national level coordination, a multi-sector institutional approach is warranted at the regional level. Within the UEMOA, agricultural and food security policy functions are now under the same department that addresses rural development, environment, and renewable energies. As such, the current structure already provides a strong interface across the various policy areas that need to be coordinated for sustainable bioenergy development. Activities will also need to be conducted both vertically and horizontally within the UEMOA organizational structure.
- *Institutional.* Agricultural and energy policies, particularly as they relate to food security, are also under the umbrella of ECOWAS and CILSS. This necessitates inter-institutional coordination at the regional level in West Africa.

Finally, sustainability standards should be a part of the regulatory and institutional framework at the regional level to ensure the sustainable production and use of bioenergy. These should cover the social, environmental, and economic aspects over the complete value chain of bioenergy development. The standards should comply with existing environmental, social, and economic standards and consider all aspects related to the bioenergy sector and its byproducts.

8.3 SUMMARY

- In general, there are three key market drivers for bioenergy in the UEMOA region: *stimulate economic and rural development*; *increase energy security*, including reducing dependence on fossil fuel imports; and *address climate change and other environmental impacts*.
- Realizing bioenergy potential in the region, however, requires putting in place effective policy and regulatory frameworks that are essential for improving the investment climate for bioenergy in the region. This requires collaboration with the private sector and members of civil society.
- The challenge of putting in place such policy and regulatory frameworks is particularly crucial in the West African region given the delicate interaction that bioenergy development will have with challenges of increasing food production

and reducing the high vulnerability to energy prices while making the most efficient use of relatively limited water, land, and financial resources.

- Policy activities need to occur both at the national and regional level and address intersectoral coherence (agriculture, forestry and land use, energy, development, environment, finance, etc.).
- The UEMOA can benefit from the experiences of other countries that have established policy and regulatory frameworks promoting bioenergy power generation and fuels. However, policymakers in the UEMOA will need to reflect their own issues and priorities, with a particular emphasis on rural development. Activities will include collaborating with existing/planned national and regional strategies and plans; focusing on land use planning; addressing water governance; enhancing access to seeds and other critical inputs; and expanding transport and infrastructure.

9. Finance

Financing for bioenergy projects and programs in UEMOA member countries, particularly those targeting smallholders, remains a challenge. From the private sector perspective, the production of agro-fuels requires investments that can be significant, especially for raw material production that constitutes the key portion of production costs. Access to start-up capital remains a major obstacle to be overcome for entrepreneurs and small producers, and financing of the agricultural sector remains weak in the West Africa subregion.

- A key barrier, particularly at the small scale, is access to affordable financing.
- Governments and donors play an important role in policy development, early stage financing, and risk mitigation.

Generally speaking, the present banking system responds very timidly to the objectives of agricultural development. Banks remain inaccessible to small producers who often cannot meet their conditional requirements. In Benin, for example, it is estimated that in 2002, the activity sector “agriculture, tree growing and fisheries” received only 6.1 billion FCFA of credits out of a total of 121.1 billion FCFA in credits given by banks (or 3.6%). Of this amount, nothing went directly to agricultural producers (Adjavon, 2004). Consequently, 84% of farmers continue to count upon their own resources in order to conduct agricultural activities, and only 10% of small farms had recourse to microfinance organizations (Political-economic Analysis Group, 2003). This situation underscores the lack of access to agricultural credit.

Bioenergy development, just like any other potential crop, requires access to finance and a variety of players will need to be engaged. Identifying potential financing sources and activities to reduce risks and increase funding for bioenergy–agriculture–rural development projects is necessary for success in UEMOA member countries.

9.1 PUBLIC SECTOR

Governments have a major role to play in both facilitating the enabling environment for investment in sustainable bioenergy, agriculture, and rural development, and providing direct financial support. Progress to date, however, has been lacking. Since the 1980s, African governments have not devoted sufficient funding to the agricultural sector. Over the period 1981 to 2000, national government funding for agricultural science fell by 27% in sub-Saharan Africa; conversely, in the rest of the world this funding rose by over 30% in the same time frame. Today, many governments in sub-Saharan Africa devote less than 1% of their national budgets to agriculture, while the investment requirement is substantial. Similarly, both the energy and rural development sectors have been underfunded.

In recent years, however, there has been a renewed commitment to agriculture, rural development, and energy sector activities in sub-Saharan Africa, including a commitment from the UEMOA. The 2002 Comprehensive Africa Agriculture Development Program, prepared by senior African government officials and international experts, called for US\$250 billion in irrigation, infrastructure, education, and market investment over the period 2002 to 2015. The program indicated that half of this funding should come from African governments, with the remainder to be sourced from the international donor community. In 2003, African Union members signed the Maputo Declaration, which called for an increase in public investment in agriculture—targeting 10% of national budgets to agriculture and rural development by 2008. This would amount to approximately US\$4.6 billion. To date, however, countries have not met the commitment’s 10% target.

The public sector also has an important policy role in stimulating investment in sustainable bioenergy programs, such as improving price incentives for bioenergy products and services, increasing public investment in these technologies, leveraging access to financial services, and reducing risks (real and perceived) to investors. For example, investors may consider private and/or community-based bioenergy projects, especially small-scale ventures, more risky due to their lack of familiarity with the technology and/or borrower. In these instances, governments can play an important role in offering mechanisms to reduce investors’ risks, such as guarantees, partial guarantees, and credit enhancement mechanisms.

9.2 LOCAL FINANCIAL INSTITUTIONS

Local financial institutions can be key sources of finance for bioenergy projects. These organizations understand the markets and players and operate in local currencies—thereby reducing currency risks. However, these organizations may be reluctant to lend for bioenergy projects, particularly to smallholders, and may require education and training on the risks and rewards of these projects, and risk mitigation instruments. These programs can help local banks build new consumer loan portfolios, either by reducing risk for the lending institution or by facilitating increased demand for their loans. Extending loan durations and collateral support can also be useful support mechanisms.

Potential financial institutions to work with are identified below:

- *ECOWAS Bank for Investment and Development (EBID)*. EBID is the principal financial institution of ECOWAS. Based in Lomé, Togo, EBID operates through its two subsidiaries—the ECOWAS Regional Development Fund (ERDF), which focuses primarily on the public sector, and the ECOWAS Regional Investment Bank (ERIB), which deals with the private and commercial sectors. ERDF focuses on financing for basic economic infrastructure and poverty alleviation projects. Activities include granting medium- and long-term concessionary loans; loans for feasibility studies; assistance to member states; and implementing various activities relating to resource mobilization and management of special funds. Areas of intervention include basic infrastructure, microfinance, rural development,

environment, energy, industry, and irrigation. ERIB activities include granting medium- and long-term loans for commercial projects in all sectors; granting loans to national financial institutions for on-lending to SMEs/SMIs under refinancing agreements and lines of credit; participating in equity capital and providing quasi-capital; issuing and guaranteeing borrowings and national, regional, or international bonds and securities; financing feasibility studies of investment projects; and providing financial engineering and other financial services. Areas of intervention include energy (production, transportation, distribution), transport, and the the environment. *EBID has expressed interest in working with the UEMOA to set up a dedicated bioenergy fund.* The fund's objective is to become a local financier for renewable energy projects in order to lead the development of the biofuel industry in the African region. The fund will prioritize West African countries, and seek to advance economic development.

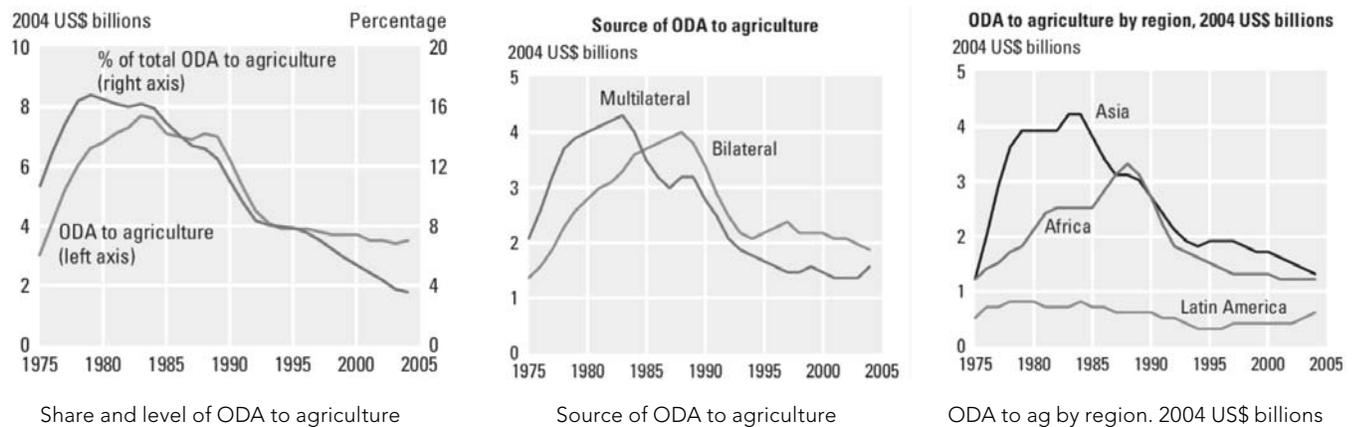
- *West African Development Bank (BOAD).* BOAD was launched in 1994 as a specialized autonomous institution of the Union. BOAD is an international public institution whose purpose is to promote balanced development of the member states and achieve economic integration in West Africa by financing priority development projects. Priority projects include rural development, basic and modern infrastructure, energy, agro-industry, financial institutions, and other services. Lending instruments include long-term loans, refinancing lines in national financial institutions, loans, equity participation, and technical cooperation.
- *European Investment Bank (EIB).* EIB opened regional representation for West Africa and the Sahel region in 2005. The Dakar-based regional representation is intended to enhance EIB activities—particularly in the private sector—and to reinforce its visibility in the African, Caribbean, and Pacific countries. Its aim is to improve the climate for energy investments, to increase the amount invested in energy projects, and to reinforce the development of renewable energy. In 2007, the EU-Africa Infrastructure Trust Fund Agreement was signed (EU Commission and nine member states) to support regional infrastructure projects in sub-Saharan Africa, including regional energy projects.
- *Commercial Banks.* A number of commercial banks are active in the marketplace and could potentially support bioenergy projects. These include Ecobank, Citibank, Souret, and Attijariwafabank from Morocco, among others. As noted above, these organizations may require technical assistance/training for bank officers and management to increase awareness/familiarity with bioenergy projects. Risk mitigation support may also be needed early on to encourage lending for bioenergy projects.
- *Microfinance.* More than 650 microfinance institutions exist in West Africa alone, offering financial services to about 6 million customers out of a total population of

80 million inhabitants. This could be a potential source of financing for bioenergy, particularly for smaller-scale projects and rural landholders.

9.3 MULTILATERAL AND BILATERAL ORGANIZATIONS

Over the last two decades, the share of agriculture in official development assistance (ODA) declined sharply, from a high of 18% in 1979 to 3.5% in 2004 (see Figure 9-1). It also declined in absolute terms from a high of about US\$8 billion in 1984 to US\$3.4 billion in 2004. The biggest decline was from the multilateral financial institutions, especially the World Bank. Total ODA to agriculture in Africa increased somewhat in the 1980s, but is now back to its 1975 level of about \$1.2 billion. A number of reasons are provided for the decline in agriculture and rural development funding. These include falling agricultural commodity prices, making agriculture less profitable in developing countries; differing priorities within ODA, particularly a focus on social sectors; emergency response to numerous crises; opposition from farmers in some donor countries to supporting agriculture in their key export markets; opposition from environmental groups that view agriculture as a contributor to natural resource destruction and environmental pollution; and failed agriculture and rural development efforts. Government and donor interest in agriculture has recently increased due to higher international commodity prices, higher priority of agriculture for developing country governments, and new “decentralization” approaches with a higher likelihood of success (World Bank, 2007).

Figure 9-1: Official Development Assistance to Agriculture Declined Sharply between 1975 and 2004



Source: World Bank, 2007.

THE WORLD BANK

The World Bank is comprised of four key organizations:

- The International Bank for Reconstruction and Development (IBRD) works with governments in middle income and creditworthy poorer countries.

- The International Development Association (IDA) works with governments in the 81 poorest countries providing highly concessional financing, interest-free credits, and grants; *the UEMOA member countries are all IDA members.*
- The International Finance Corporation (IFC) works with the private sector, investing in private enterprises in developing countries and providing long-term loans, guarantees, and risk management and advisory services.
- The Multilateral Investment Guarantee Agency (MIGA) provides political risk insurance against non-commercial risks to eligible foreign investors and commercial banks for qualified investments in member countries.

Though energy sector lending has been down in general over the last two decades, the World Bank has been a leader in supporting clean energy technology solutions—energy efficiency and renewable energy (including bioenergy). Since 1990, The World Bank Group has committed more than US\$11 billion to renewable energy and energy efficiency in developing countries. In the last fiscal year, the World Bank Group’s support for renewable energy and energy efficiency rose to \$1.4 billion dollars, accounting for 40% of the total energy sector commitment.

In the bioenergy area, the Bank is committed to a diverse project mix that includes bioenergy for power generation, heating and cooling, modern cooking, etc. In the case of biofuels, however, the Bank is conditional in its support, primarily due to the potential “sustainability” impacts that can accompany large-scale development. Accordingly, in the biofuels area the Bank supports expanded research and development in sustainable biofuels. It encourages more research on second-generation fuel production systems, such as those from cellulosic materials and agricultural wastes that do not compete with food, and research toward realizing the potential of second-generation feedstock utilizing marginal lands for production without bringing about large land use and water use changes. In addition, the Bank recognizes that efforts are also needed to allow developing countries and small-scale farmers to profit from the resulting technologies.

Recently, The World Bank Board gave formal approval to the creation of the Climate Investment Funds (CIF), a pair of international investment instruments designed to provide interim, scaled-up funding to help developing countries in their efforts to mitigate rises in GHG emissions and adapt to climate change. The two trust funds are targeted to reach US\$5 billion. One of the funds, the Clean Technology Fund, will provide new, large-scale financial resources to invest in projects and programs in developing countries that contribute to the demonstration, deployment, and transfer of low-carbon technologies; the projects or programs must have a significant potential for long-term GHG savings. The second fund, the Strategic Climate Fund, will be broader and more flexible in scope and will serve as an overarching fund for various programs to test innovative approaches to climate change. The funds are to be disbursed as grants, highly concessional loans, and/or risk mitigation instruments and will be administered through the multilateral development banks and the World Bank Group. Developing countries will have an equal voice in the governance structures of the funds, and decisions on the use of funds will be made by consensus. These funds could

potentially provide resources for the development of bioenergy in UEMOA countries, particularly second-generation biofuel technologies.

The Bank is also a leader in carbon finance. The World Bank Carbon Finance Unit (CFU) uses money contributed by governments and companies in Organisation for Economic Cooperation and Development (OECD) countries to purchase project-based GHG emission reductions in developing countries and countries with economies in transition. The emission reductions are purchased through one of the CFU's carbon funds on behalf of the contributor, and within the framework of the Kyoto Protocol's Clean Development Mechanism (CDM) or Joint Implementation (JI). Unlike other World Bank development products, the CFU does not lend or grant resources to projects, but rather contracts to purchase emission reductions similar to a commercial transaction, paying for them annually or periodically once they have been verified by a third-party auditor. The selling of emission reductions—or carbon finance—has been shown to increase the bankability of projects by adding an additional revenue stream in hard currency, which reduces the risks of commercial lending or grant finance. Thus, carbon finance provides a means of leveraging new private and public investment into projects that reduce GHG emissions, thereby mitigating climate change while contributing to sustainable development.

The carbon funds managed by the Bank include the Prototype Carbon Fund (PCF) to demonstrate how to cost-effectively achieve GHG reductions while contributing to sustainable development, and the Community Development Carbon Fund (CDCF) and Bio Carbon Fund (BioCF), which are designed to enable smaller and rural poor communities to benefit from carbon finance.

To date, Asia and Latin America have been the key developing country recipients of the CDM, with Africa accounting for only about 5% of the funding provided. In addition to the World Bank, a number of national and regional markets for emission reductions are being put into place, most notably the European Union Emissions Trading Scheme as of January 2005.

A recent report by the World Bank shows that the global carbon market grew to US\$64 billion in 2007, more than double its size in 2006. Renewable energy and energy efficiency accounted for two-thirds of CDM support. Sixty-eight developing countries participated in the CDM, including Mali, which offered climate friendly projects for the first time in 2007.

The World Bank's new Forest Carbon Partnership Facility (FCPF) aims to reduce deforestation and forest degradation by providing value to standing forests. The FCPF will build the capacity of developing countries in tropical and subtropical regions to reduce emissions from deforestation and forest degradation and to tap into any future system of positive incentives for reduced emissions from deforestation and degradation (REDD). Six African countries (the Democratic Republic of Congo, Gabon, Ghana, Kenya, Liberia, and Madagascar) were among the initial 14 developing countries selected to receive grant support.

Box 9-1: REDD—Fighting Deforestation and Forest Degradation

Deforestation and forest degradation together are the second leading anthropogenic cause of global warming—responsible for about 20% of global GHG emissions, and the main source of national emissions in many developing countries. Reducing emissions from deforestation and forest degradation (REDD) is a key strategy in the fight against climate change.

In December 2007, at the 13th Conference of the Parties (COP-13) in Bali, Indonesia, Parties agreed to strengthen efforts toward reducing emissions from deforestation and forest degradation in developing countries. The UN-REDD Programme is a collaborative effort of FAO, UNDP and UNEP to support international REDD dialogue, generate information, and work toward a consensus on REDD monitoring and verification needs and methods that will assist the international community as a whole.

THE AFRICAN DEVELOPMENT BANK (AFDB)

AfDB seeks to further the social and economic well-being of its member countries in Africa. To achieve this, the Bank uses the leverage that is afforded by its AAA rating to on-lend to its borrower countries at favorable terms resources raised in international capital markets. The African Development Bank offers a diversified menu of financial products including loans, guarantees, risk management products, and equity participations to finance both sovereign and non-sovereign projects. In order to maintain the attractiveness of its menu of lending products, the AfDB is constantly improving its offer. Additional improvements being considered include choice of currency and interest rate at each disbursement. The Bank has added local currency loans to its product range and is also in the process of finalizing the framework for the introduction of Syndicated Loans as a financial product.

As part of the Clean Energy Investment Framework development process, AfDB is revising its energy sector policy and preparing a new energy strategy that will have two strategic investment pillars: renewable energy and energy efficiency. This is a segment of the ongoing implementation process of the Financing Energy Services for Small-Scale Energy Users (FINESSE) Program supported by the Netherlands Government and involving capacity building; mainstreaming of renewable energy and energy efficiency AfDB operations, including identification and preparation of renewable energy/energy efficiency projects and project components; and support to the new energy strategy that will focus on low-carbon development options.

In the Bank's Public Sector activities, the clean energy program assists project preparation/development, with the technical and financial assistance of the FINESSE Program. The Private Sector Department, with the support of the Danish Renewable Energy Technical Assistance and FINESSE, has developed a project pipeline for 2007–2008 consisting of 921 megawatt (MW) of wind energy projects, 283 MW of small hydropower, 410 MW of cogeneration, 480 MW of geothermal, and biodiesel projects. The AfDB is also engaged in a number of other initiatives: supporting the EU Competence Platform on Energy Crop and Agroforestry Systems for Arid and

Semi-arid Ecosystems – Africa (COMPETE) on a Bio-fuel Facility to accelerate the uptake of biofuel projects in Africa; collaborating with the UN Industrial Development Organization (UNIDO) on its biofuels initiative; partnering with a number of UN agencies within the “Nairobi fuels initiative”; working with UN agencies under the “Nairobi Framework” on climate change for Africa to assist countries in accessing CDM and/or other carbon financing sources; and defining AfDB’s role in implementation of the Bio-Gas Initiative in Africa, which was launched in May 2007.

The UEMOA sustainable bioenergy program aligns with the goals and objectives of the Bank and would be a valuable addition to their program portfolio.

BILATERAL DEVELOPMENT AGENCIES

A number of bilateral development organizations are active in the clean energy area, including bioenergy. Some of these are already working on bioenergy in West Africa, while others could be considered for potential support.

The Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), the German development agency, has been active in renewable energy promotion, and provided in-kind support in capacity building and technical assistance in several West African countries. Also, sister organization Kreditanstalt für Wiederaufbau (KfW) has been one of the most active development banks in financing renewable energy, including bioenergy, providing investment support and low interest loans.

The Italian Ministry of the Environment, Land and Sea supports biofuels development in many countries, with a focus on technology research and development, standards, policy support, and project development.

The Directorate General of International Cooperation (DGIS) of the Government of the Netherlands has provided considerable support for renewable energy programs globally, including through the Netherlands Development Finance Facility (FMO) that supports the private sector. The Netherlands has been a key supporter of the FINESSE Africa program, which was conceived to assist African countries to formulate appropriate policy and regulatory frameworks and to develop capacity to generate a pipeline of investment projects in renewable energy and energy efficiency. Several other bilateral aid agencies have also been active in supporting renewable energy/ bioenergy initiatives, including those of the United States, France, Japan, Canada, and China. Additionally, the Government of Brazil has entered into a partnership with the UEMOA on biofuels.

The European Union has served as a significant source of financing for renewable energy programs in developing countries. The European Union Energy Initiative (EUEI) has created a facility to finance renewable energy, energy efficiency, and rural electrification projects in Africa, the Caribbean, and the Pacific. The Africa BioEnergy Fund is part of a project to establish an African sub-fund of the Global Energy Efficiency and Renewable Energy Fund (GEEREF) set up by the European Commission. GEEREF is an EU-financed global fund for developing countries aimed at boosting energy efficiency and the development of renewable energy in developing countries, including sub-Saharan Africa countries. Technologies include energy efficiency, cleaner fuels, and bioenergy. Its finance type is debt capital.

Box 9-2: Carbon Finance

Climate change caused by GHG emissions is one of the most serious threats facing the world today. Achieving substantial reductions in global GHG emissions necessitates a joint international effort involving governments and the private sector operating under both international treaties and independent efforts by businesses and individuals to take responsibility for their own GHG footprint. In addition to direct reductions of GHG emissions at the source, a supplementary option is to contribute to activities reducing GHG emissions elsewhere by acquiring emission reduction credits from these projects.

The *international political response* to climate change began with the United Nations Framework Convention on Climate Change (UNFCCC). The Kyoto Protocol to the Convention, which was adopted in 1997 by more than 170 countries, significantly strengthened the UNFCCC by committing many industrialized countries and economies in transition, the so-called “Annex 1 countries,” to individual, legally binding targets to limit or reduce their overall GHG emissions by at least 5% below 1990 levels during the period 2008 to 2012. In addition to setting the first ever international target for reducing GHG emissions, the Kyoto Protocol established a means for developing countries to get involved in climate change mitigation, enabling a market-based solution to an environmental problem and bringing the issue of GHGs to the mainstream of clean energy planning. The Kyoto Protocol approved the use of three “flexible mechanisms” for facilitating the achievement of its GHG emission reduction targets: (1) emissions trading, allowing the international transfer of national allocations of emission rights between different Annex 1 countries; (2) the Clean Development Mechanism (CDM), which allows for the creation of Certified Emission Reduction (CER) credits through emission reduction projects in developing countries, regulated by the CDM Executive Board; and (3) Joint Implementation (JI), which involves creation of emissions reduction credits undertaken through transnational investment between Annex 1 countries and/or companies.

While emission reductions generated by these three flexible mechanisms have different technical names dependent on which mechanism they arise from, they are collectively referred to as “carbon credits.” Carbon credits are measured in tonnes of carbon dioxide equivalent (tCO₂e). One carbon credit represents 1 tCO₂e reduced or not emitted. These three flexible mechanisms, along with the European Union Trading Scheme put in place by the European Union in order to meet its Kyoto target, created the largest environmental market in the world for the trading of these carbon credits.

In *voluntary carbon markets*, activities that reduce GHGs produce verified emission reductions (VERs) that can be sold to companies or individuals wishing to voluntarily reduce their carbon footprints. GHG emission reduction projects developed under the CDM have been highly successful in reducing emissions and generating CER credits, which are then purchased by governments and organizations in Europe and Japan to help meet their emission reduction targets. Although voluntary reductions are similar to regulated credits, they are different in some important ways. VERs can be generated from projects that are based in a country that has not ratified the Kyoto Protocol or does not have the infrastructure to support CDM project development; have not yet been registered under the CDM; fall outside of the scope of the CDM; are too small to warrant the costs of CDM approval; and/or are specifically developed for the voluntary market. Several voluntary markets are in development around the world.

Afforestation and reforestation with energy crops will provide sinks and associated reduction of carbon emissions under the climate regime.

Most recently, at the G8 Summit held in Hokkaido, Japan, in July 2008, leaders agreed to share with all Parties to the UNFCCC the goal of achieving at least a 50% reduction in global GHG emissions by 2050.

Source: EcoSecurities, www.ecosecurities.com

9.4 OTHER INTERNATIONAL AGENCIES

The Global Environment Facility (GEF). GEF was established in 1991 and helps developing countries fund projects and programs that protect the global environment. GEF grants support to projects related to climate change, land degradation, biodiversity, international waters, the ozone layer, and persistent organic pollutants. In the climate change area, GEF supports both mitigation and adaptation projects that would be of potential interest to UEMOA member countries. Climate change mitigation projects reduce or avoid GHG emissions in the areas of renewable energy (including grid electricity from renewable energy and promotion of renewable energy for rural energy services), energy efficiency, and sustainable transport. In terms of renewable energy, the GEF seeks to expand the markets for renewable energy by removing barriers to the large-scale application, implementation, and dissemination of renewable energy technologies. Climate change adaptation funding supports interventions that increase resilience to the adverse impacts of climate change on vulnerable countries (including the UEMOA), sectors (including agriculture and rural development), and communities. Moreover, it manages two special funds under the UNFCCC—the Least Developed Countries Fund and the Special Climate Change Fund. The GEF represents a major source of financing for renewable energy projects in developing countries, having invested over \$1 billion in these technologies to date, including bioenergy. GEF financing leveraged an additional \$5 billion in co-financing, comprised mostly of public financing as well as loans and grants from the GEF implementing agencies—the World Bank, UNEP, and UNDP—and GEF executing agencies. These include the AfDB, the International Fund for Agricultural Development (IFAD), FAO, and UNIDO.

Over the period 2007 to 2010, GEF's Strategic Focus¹⁰ regarding biomass will be to focus on sustainability issues, ensuring that biomass feedstocks for GEF climate change mitigation projects do not threaten biodiversity or contribute to further deterioration or water misallocation. Global benefits from the program are expected to come primarily from the energy value of biomass, not the value of residual carbon sequestered. In GEF-4 a dedicated program has been created to focus on the sustainable energy production of biomass. Activities will ensure that biomass projects do not contribute to deforestation, reduced soil fertility, or increased GHG emissions beyond project borders. This program will also provide additional support to biomass that is planted for dedicated energy purposes, provided it meets sustainability criteria. As the conversion of cellulosic biomass to liquid fuels becomes more feasible—technically and economically—GEF support in this areas is expected to grow to include targeted research. In general, GEF activities include technical assistance, capacity building, and investment.

Currently, GEF is preparing a proposal for its Board to conduct a major initiative on renewable energy and energy efficiency for West Africa. Subject to the confirmation by countries in the region, GEF funds in the range of US\$45 million will be earmarked under the proposed energy program. It is expected that co-financing in the range of US\$80 to 100 million will be mobilized through various multilateral/bilateral agencies, national counterparts, the private sector, and NGOs. Preliminary discussions with a few donor agencies including UNF and The Netherlands, and countries in the region, have yielded an encouraging response. The proposed GEF program,

¹⁰ GEF's Fourth Replenishment Period

which will be developed through a participatory and consultative process, would specifically focus on practical interventions and projects on the ground that will demonstrate the technical and economic viability of promising renewable energy and efficient energy technologies and measures, and promote private sector involvement in stimulating energy markets in the region. The program would also aim at mainstreaming renewable energy and energy efficiency policies and measures into regional cooperation frameworks and national development plans. The proposal, which will be submitted at the GEF Council Meeting in November 2008, could provide an opportunity for UEMOA member countries in sustainable agriculture and energy development.

UN Agencies. A number of UN agencies actively provide support in the bioenergy area, as outlined below.

- **United Nations Conference on Trade and Development.** UNCTAD coordinates policy dialogues on trade and economic policy in the UN system. It provides interested countries with access to sound economic and trade policy analysis, capacity-building activities, and consensus-building tools. UNCTAD works closely with the private sector to develop the business and sustainable development case for increased production, domestic use, and trade in biofuels.
- **United Nations Development Programme.** UNDP places priority on expanding energy access in the poorest countries and is working to incorporate bioenergy and biofuels into country programs. A key program of UNDP in West Africa has been its Multifunctional Platform Project (MFP), which promotes an integrated, multidimensional approach to reducing rural poverty, focusing on women. The program uses diesel engines (increasingly fueled by biodiesel) to power a range of tools and provide electricity. In 2007, UNDP received a grant of \$19 million from the Gates Foundation to expand this program in West Africa, including bioenergy.
- **United Nations Environment Programme.** UNEP brings expertise in sustainable energy finance and is developing assessment tools for clean energy investments. For example, UNEP, along with the UNF and others, was instrumental in creating a financing facility for clean energy in Africa—the Africa Rural Energy Enterprise Development (AREED)—to address the critical financing barriers confronted by SMEs in the marketplace (see Box 9-3).
- **United Nations Industrial Development Organization.** UNIDO has been developing and implementing projects involving bioenergy technologies for decades, including liquid biofuels. UNIDO focuses primarily on industrial processes and quality control of bioenergy production. UNIDO also tracks new technology advances; provides field-level technical assistance; and supports bioenergy program development and implementation. In July 2007, UNIDO sponsored the first high-level Biofuels Conference in Africa in Addis Ababa, Ethiopia with the African Union (AU) and the Government of Brazil. The meeting brought together stakeholders to formulate a common strategic vision for the development of

biofuels throughout the continent and facilitate the establishment of viable policies and strategies for the African biofuels industry.

Box 9-3: Supporting Small and Medium Energy Enterprises in Africa

AREED provides early-stage funding and enterprise development services to entrepreneurs, helping build successful businesses that supply clean energy technologies and services to rural and peri-urban African customers. AREED services include training and hands-on business development assistance. For the enterprises that show the best commercial potential, AREED also provides early-stage investment and assistance to secure additional finance.

The AREED initiative works to broaden the skills of organizations involved in the energy and investment sectors to help them nurture energy entrepreneurs. This includes African NGOs and development organizations, helping them to identify potential energy projects and provide follow-up business support services to entrepreneurs. Resource tools are also available that focus on business planning, management structuring, and financial planning for the rural energy sector. AREED also works with financial institutions, to help them assess and integrate the rural energy business sector into their portfolios. AREED provides workshops and specific hands-on tools centered on rural energy markets and enterprises, appropriate project finance models, financial analysis, and risk management issues. Opportunities for co-financing are also explored. Currently, AREED is active in five countries: Mali, Senegal, Ghana, Tanzania, and Zambia.

- *Food and Agriculture Organization.* FAO is in the forefront of devising standards and policies for balancing food and fuel production. FAO also provides detailed technical assistance in the formulation of detailed and well-informed technical strategies and programs in the bioenergy area as regards potential impacts on food security and natural resources. It hosts the Global Bioenergy Partnership (GBEP) and leads the implementation of the International Bioenergy Platform (IBEP), which serves as a mechanism for technical and policy collaboration between international, regional, domestic, and civil stakeholders. In June 2008, FAO hosted the landmark High-Level Conference on World Food Security: The Challenges of Climate Change and Bioenergy, which brought together 42 heads of state and government, 100 high-level ministers, and 60 non-governmental and civil society organizations from 181 member countries to discuss the challenges that climate change, bioenergy, and soaring food prices pose to world food security.
- *The International Fund for Agricultural Development.* IFAD is a specialized agency of the UN that was established as an international financial institution in 1977 as one of the major outcomes of the 1974 World Food Conference. IFAD is dedicated to eradicating rural poverty in developing countries. IFAD's new strategic framework (2007–2010) recognizes biofuels as an energy market opportunity

for the poor. Activities include research grants for the poor to examine biofuels market opportunities, establishment of private sector links and promotion of biofuels crops, global consultations on issues such as jatropha and sweet sorghum development, and partnerships with bilateral and multilateral organizations.

9.5 GLOBAL PARTNERSHIPS AND FOUNDATIONS

Alliance for a Green Revolution in Africa (AGRA). A partnership initiated by the Bill and Melinda Gates Foundation and the Rockefeller Foundation in 2005, AGRA is designed to support “African” solutions to the challenge of improving agricultural productivity throughout the continent. The partnership was a direct response to the Comprehensive Africa Agriculture Development Plan developed by the African Union in 2002. Since its inception, AGRA has developed cooperative arrangements with a number of bilateral donors, including the UK’s Department for International Development, the U.S. Agency for International Development, and the new U.S. Millennium Challenge Account. AGRA’s priorities focus on development of more productive crops; soil improvements; water availability, quality, and access; and national, regional, and international policies that mirror the priorities of the UEMOA member countries. While AGRA’s focus extends to the entire agricultural sector, the Gates and Rockefeller Foundations are already researching the potential of bioenergy and other energy alternatives, given the vital role energy access plays in developing agriculture. AGRA currently manages over \$300 million in grant programs.

A number of partnerships are active in agriculture and/or renewable energy programs that include bioenergy. The following partnerships concentrate specifically on renewable energy.

- *The Renewable Energy and Energy Efficiency Partnership.* REEEP offers financial support to projects involved in policy and financing issues in the promotion of renewable energy and energy efficiency. Since 2004, REEEP has supported 58 such projects and invested over \$6 million.
- *The Global Village Energy Partnership.* GVEP International is working to provide a range of products and services to partners on the ground, including access to finance, training, and technical assistance; development of knowledge and skills through information sharing; and support for adaptation within the context of climate change. GVEP also works with stakeholders to promote an enabling working environment for GVEP International Partners; to strengthen and promote energy SMEs, enabling wider market outreach by building local energy supply chains; and to achieve measurable and quantifiable results and to communicate these to all partners. In the near future, GVEP has plans to open a finance facility for SMEs in West Africa, which could include bioenergy.
- *The UN Foundation.* UNF builds and implements public–private partnerships to address the world’s most pressing problems, and broadens support for the UN through advocacy and public outreach. UNF is a public charity. It seeks to strengthen and support the UN and its causes through a blend of advocacy, grant

making, and partnerships. In the bioenergy area, UNF supports the International Bioenergy Initiative (IBI). Launched by UNF in 2005, IBI integrates in-country resources and international markets to create economic opportunities for rural communities and developing nations. It identifies the nexus of sustainable energy and development—providing innovative, effective strategies to increase rural incomes, improve energy access, and reduce GHG emissions. Access to clean affordable energy for all is vital to the achievement of the MDGs. To achieve these objectives, the IBI focuses on four priorities: expanding energy access, promoting new trade opportunities, advocating cross-sector sustainability, and financing investment in biofuels and bioenergy.

Other foundations include the Fact Foundation, which is providing support in Mali for bioenergy development, the Program for Rural Electrification (AMADER), and Shell Foundation.

9.6 PRIVATE SECTOR

At the regional level, the private sector has organized itself under the auspices of the UEMOA with the creation of the African Association for the Promotion of Biofuels (AAPB) in November 2006 in Dakar. The association brings together more than 50 private operators involved in bioenergy development, representing all elements of the value chain. A key focus of AAPB is the ECOWAS Investment Bank Fund for biofuels and renewable energies that is currently in development. Additionally, several large foreign investment projects have been announced in certain countries of the UEMOA region.

9.7 SUMMARY

- Financing for bioenergy projects and programs in UEMOA member countries, particularly those targeting smallholders, remains a challenge.
- Access to start-up capital is a major obstacle to be overcome for entrepreneurs and small producers and financing of the agricultural sector remains weak in the West Africa subregion.
- There are a number of entities to potentially collaborate with on bioenergy development. These include UEMOA government agencies, local financial institutions, multilateral and bilateral agencies, international organizations, global partnerships and foundations, the private sector, etc.

10. Blueprint for Bioenergy, Agriculture, and Rural Development in the UEMOA — 2009 to 2011

Building upon the inputs of the report, this chapter sets forth a Blueprint for Action in the field of bioenergy for the period 2009 to 2011. This Blueprint was established by the UEMOA, under the framework of its Biomass Energy Regional Program (BERP), in conjunction with the Rural Hub for West Africa. Key activities are organized into five pillars: capacity building, policy, finance, market development, and technology transfer and research and development (R&D).

10.1 KEY ACTIVITIES

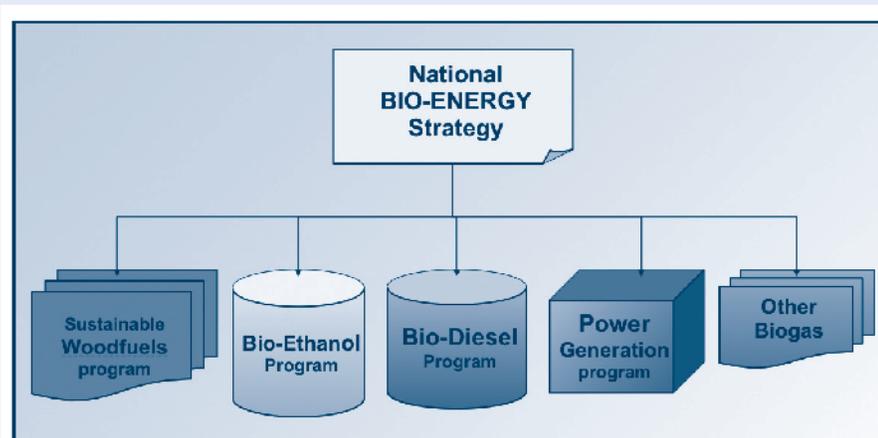
The primary activities of the three-year Blueprint are organized into five pillars:

- Capacity Building
- Policy Support
- Finance
- Market Development
- Technology Transfer and Research and Development (R&D)

Box 10-1: UEMOA Biomass Energy Agenda

The UEMOA BERP has set forth an ambitious strategy to pursue bioenergy in five areas: sustainable wood fuels, bioethanol, biodiesel, power generation, and biogas. This report provides input to the program, with the Blueprint laying out an action plan for delivering results.

UEMOA/AFRICA: Moving
Toward an Integrated
"Biomass Energy" Agenda



PILLAR 1: CAPACITY BUILDING

For bioenergy markets to develop and deepen, capacity building is required in all areas of project and program design, development, implementation, and operation. This entails a long-term commitment, with activities focusing on individuals, institutions, and systems, and aimed at public, private, and non-government organizations. Capacity-building activities include:

- Train policymakers on policies and programs for accelerating adoption of bioenergy by small landholders.
- Integrate bioenergy into national development strategies in agriculture, forest conservation and sustainable use, poverty alleviation, energy, and rural electrification.
- Strengthen enterprises to source, integrate, install, operate, maintain, and service bioenergy systems; provide business training and incubation support.
- Train the finance and banking sectors (senior management/loan officers) on the risks/rewards of financing bioenergy projects, through pilot projects and programs that minimize initial investment risks.
- Provide training and technical assistance on standards for bioenergy development, drawing on international efforts in this area (e.g., the European Union, the Global Bioenergy Partnership, and the Roundtable on Sustainable Biofuels, among others).
- Provide training to governments and the private sector on the CDM and official and voluntary carbon markets.
- Conduct communications and outreach on bioenergy benefits/challenges, including consumer awareness campaigns.

PILLAR 2: POLICY SUPPORT

Government support, in the form of policy, regulations, and/or incentives, has been instrumental in driving bioenergy markets worldwide. Key policy areas to address in the UEMOA are provided below; these should give due consideration to food security issues (see Box 10-2):

- Identify and develop pragmatic policy instruments, building upon lessons learned and experience from the UEMOA and other countries/regions. These should emphasize policies that promote local value-added, rural development, gender equity, community forestry, sustainable agriculture, etc.
- Consider establishment of national/regional targets and timetables for bioenergy development, to include issues of small farmers.
- Help establish regulatory frameworks at the national level to accelerate bioenergy development.
- Work with policymakers to link energy and agricultural priorities.

- Establish a lead organization in each national government to coordinate bioenergy activities across the interested ministries (e.g., agriculture, energy, rural development, finance, commerce/trade, and environment).
- Increase coordination and cooperation across Africa (e.g., the New Partnership for Africa's Development (NEPAD), ECOWAS).
- Establish guiding principles for land use development.
- Foster a regional market for sustainable bioenergy, to include cross-border trade.
- Engage the private sector in policy/regulatory development, including producer organizations, SMEs, cooperatives, etc.
- Address water rights.
- Monitor and evaluate the impact and performance of bioenergy activities at the national and regional levels.
- Apply the Bioenergy Evaluation Tool in assessing various bioenergy policies at the national and regional level (see Box 10-3).

Box 10-2: Local and Regional Bioenergy Markets

UEMOA member states can speed this process by adopting new, common standards for modern biomass and bioenergy products—and promoting more efficient technologies. Charcoal, the most common form of biomass apart from firewood, is energy inefficient, creates toxic particulates, and is a potent contributor to GHGs. Developing new, cleaner cooking fuels using sustainable biomass offers the opportunity to create employment in rural communities, raise incomes, and improve health. Combining this initiative with clean-burning, locally produced stoves offers even more benefits. Several pilot projects have focused on using combinations of agro-forest residues and/or animal wastes and have proven the viability of this approach. These programs should be scaled up.

Incorporating some portion of existing bio-oil production into diesel fuel through establishing a blending requirement (e.g., 2 to 10%) is a standard approach to reducing fossil fuel consumption and creating an additional market for local production. Lower-quality groundnut, palm, and cottonseed oils might be options for this practice. Pilot programs that use jatropha oil—a common hedging shrub with non-edible oilseeds—offer the most promise for village energy use, as the high-quality oil can run generators and small engines with minimal processing. Improving yields per hectare of this perennial plant holds promise for increasing oil production. Senegal is experimenting with mandating that a certain portion of cropland in each village be dedicated to jatropha production for local use.

Box 10-2 (continued): Local and Regional Bioenergy Markets

Ethanol is already produced in the region, primarily from sugarcane. As diesel is the most common fossil fuel in the region, substituting ethanol for other oxygenates—including lead—could create a cleaner fuel and reduce petroleum demand. As Côte d’Ivoire produces and sells much of the refined product in the region and produces bio-oils and ethanol, it could work with its UEMOA partners to 1) establish blending mandates for diesel and gasoline that would incorporate biofuels into the new formulations; 2) identify the best blending levels for the present—and work to increase them over time; and 3) jointly undertake market studies to determine how additional biofuel supplies could be produced in the region and used in the refining and blending processes.

Currently, all UEMOA countries subsidize petroleum products and electricity. The long-term objective would be to phase out such subsidies and reduce petroleum imports. This objective is achievable, but it demands a strategy and a commitment to use efficiency and conservation in combination with alternative fuels to achieve economic sustainability.

Box 10-3: Example of BEET Application

Ethanol Potential in Four West African Countries (Benin, Côte d’Ivoire, Senegal, and Togo)

The BioEnergy Evaluation Tool (BEET) Project, sponsored by the UNF, is a user-friendly decision support tool to evaluate country- and regional-level energy security, economic, agricultural, and environmental impacts of bioenergy policies and strategies on a quick-turnaround basis. An alpha version of BEET was recently developed and demonstrated for analysis of E10 policy in El Salvador as a case study—a beta version of BEET is currently underway. The BEET analytic capability provides insights into how bioenergy policies and investments can play an important role in contributing to sustainable economic development. BEET was also used to assess the potential for ethanol, produced from domestically grown crops, in four West African countries (Benin, Côte d’Ivoire, Senegal, and Togo) collectively as a single region. In the future, a more rigorous analysis of biofuels potential and implications in West Africa using BEET could be conducted as needed.

The table below illustrates the amount of land required to domestically produce ethanol for the four countries. The left column indicates the type of crop grown, and the data columns show the available arable requirement by crop type necessary to meet demand for ethanol under an E-10, E-25, or E-85 policy. Ethanol demand is based upon gasoline consumption in the transport sector for the four countries (IEA, 2005). For all of the scenarios, ethanol can be produced using currently available arable land and would not displace food produced from permanent crop land.

Total Land (in hectares) Required for Ethanol Crops (Benin, Côte d’Ivoire, Senegal, and Togo)

	E-10	E-25	E-85
Sugarcane	18,813	47,032	159,910
Maize	180,094	450,235	1,530,800

Box 10-3 (continued): Example of BEET Application

Potential Impacts of Ethanol Policy Options (Benin, Côte d'Ivoire, Senegal, and Togo)

	E-10	E-25	E-85
Reduction in Oil Imports (gallons/year)	25,208,040	63,020,100	214,268,340
Balance of Trade Impact (million US\$)	\$84.7	\$211.7	\$719.9
Investment in New Ethanol Production Facilities (million US\$)	\$62.6	\$164.8	\$573.1

The table above shows some of the key impacts of the alternative ethanol options using BEET. As can be seen in the first two rows, producing ethanol from domestically grown crops contributes significantly to reducing oil imports and improving the balance of trade collectively for the four countries. The upfront capital costs to achieve these impacts are shown in the third row. Comparing the balance of trade impacts with the investment costs for ethanol production facilities suggests that the payback times of these two ethanol options are relatively short for all of the ethanol production options. This example focuses on a domestic ethanol policy. Another option may be to export some or all of the ethanol produced within the UEMOA region. A more rigorous application of BEET would include evaluating the trade-offs between and impacts of exporting ethanol versus domestic consumption.

PILLAR 3: FINANCE

Finance and investment are key to the growth and development of bioenergy in UEMOA countries. As the industry expands and develops, the scope and breadth of financing sources and instruments, both locally and internationally, must be increased. More creative leveraging of public and private sector resources will be needed to meet the financing requirements of the bioenergy industry, including from a variety of public and private sector sources. Activities to be conducted include:

- Engage local financial institutions and micro-credit agencies on bioenergy; conduct banker training workshops to increase awareness of bioenergy risks/rewards by investment officers and managers.
- Establish risk mitigation facilities to spur local financing for bioenergy projects, particularly at the small-scale level.
- Foster development of “bankable” project portfolios in bioenergy; offer assistance to entrepreneurs in areas such as R&D, seed capital funding, pre-feasibility and feasibility assistance, reimbursable grants, etc.
- Develop a Bioenergy Regional Fund to provide investment support, in conjunction with the ECOWAS Bank of Investment.
- Conduct donor coordination roundtables to brief current and prospective donors on UEMOA bioenergy activities and secure their participation.
- Explore opportunities for carbon finance at the national/regional levels.
- Engage the private sector in project identification and development and understand its issues/requirements with respect to financing projects in the UEMOA member countries.

PILLAR 4: MARKET DEVELOPMENT

A number of near-term project and program opportunities exist for bioenergy development in UEMOA member countries and should be explored in more detail. Examples are provided below. Pursuit of these efforts however, will require assessment of technical, institutional, financial, environmental, social, and economic considerations, as well as a review of related experience in other countries. The Regional Bioenergy Center proposed in Pillar 5 below is envisioned to serve as a source of information on these topics.

- **Wood, Waste, and Residues.** Forests comprise a major natural resource in UEMOA, covering 44.5 million ha. Due to deforestation and degradation, this resource is under severe pressure. Traditional biomass in West Africa includes fuelwood, wastes from timber processing, agricultural and other forest residues, and animal waste. These products comprise the largest source of primary energy consumption (73%) in the UEMOA area. Modern stoves and low-tech processing systems are key to make this resource sustainable and more efficient.
- **Combined Heat and Power.** CHP, or cogeneration, plants have considerable potential for application throughout UEMOA member countries. As CHP plants are relatively large-scale operations, they require a significant and reliable source of crop residues and sustainable woody biomass. This can be met through plantations, but could also be sourced from rural areas where the CHP facility could serve as a hub for rural electrification schemes.
- **Small-scale Biomass Gasification** is already being demonstrated successfully in several countries and could have applications in the UEMOA.
- **Sugarcane.** Bioethanol production from sugarcane is highly developed worldwide, making bioethanol the main biofuel used today. UEMOA has potential for expansion of production and use of bioethanol in sugarcane-producing countries. Programs can be designed to advance economic and social development, and increase jobs and raise income. Much can be learned from the experiences of other countries such as Brazil; research is needed to determine the best crop varieties given the unique needs, conditions, and resources in the UEMOA.
- **Biomass for Clean Cooking Fuels.** Improved cookstoves and feedstock programs (e.g., biogas, ethanol gel) can potentially free valuable time of women and children in collection of traditional biomass, while reducing health impacts and slowing deforestation. Widespread dissemination of improved cookstoves should be a priority.
- **Sweet Sorghum.** Sweet sorghum is a promising crop offering several benefits. Most notably it provides fuel (ethanol), power, food (grains), and fodder (leaves) and has a variety of rural, industrial, and commercial applications. Sweet sorghum is widely grown in the region.
- **Biomass for Rural Electrification,** to include agricultural processing and electricity generation. Liquid biofuels such as vegetable oils and biodiesel provide opportunities for power production at a relatively small scale and, in particular, for small and medium-size

electricity grids at the village and community levels. There are large numbers of oilseed-bearing trees and shrubs available that do not compete with food production or land use and generate fewer environmental impacts. Solid biomass — from sustainable forest programs — can also be used. Effort is needed to organize grassroots organizations for collection, grading, and oil processing.

- **Diesel Displacement.** Adaptation of existing diesel engines to use biofuels has significant potential. Biodiesel lends itself to small-scale agriculture because it can displace diesel in both transport and electricity generation. Examples exist where women's groups, cooperatives, communities, and others have collaborated on biodiesel development for local applications.

PILLAR 5: TECHNOLOGY TRANSFER AND R&D

Support is required for all aspects of technology research, development, demonstration, deployment, marketing, financing, operation, and maintenance. Further, continued emphasis on accelerating renewable energy R&D is critical to reduce costs, improve performance, and enhance competitiveness with fossil energy sources. Proposed activities include:

- Strengthen local data availability. Access to reliable timely data for bioenergy decision making—including policies, projects, and programs—is a major issue in UEMOA member countries and regionally. An inventory of data services and needs should be conducted and a “prioritized” listing of requirements compiled. The UEMOA member countries should coordinate on this effort with groups like FAO, IFAD, OECD, and others that are also looking at strengthening agricultural data systems in Africa and elsewhere.
- Establish/implement a Regional Bioenergy Center with information on policies, markets, technologies, costs, business models, applications, finance sources, standards and certification, etc. The Center should study traditional biofuels, new crops, including trees, and establish priorities for expanding sustainable use, where and when appropriate.
- Develop tools and toolkits to assist the public and private sector in bioenergy decision making.
- Conduct joint research efforts between local research institutions and industry, aimed at renewable energy applications and collaborative efforts to carry out renewable energy resource assessments.
- Combine efforts with industrialized countries to promote knowledge transfer and the development of appropriate bioenergy technologies for the UEMOA.
- Facilitate South-South collaboration and cooperation on sustainable bioenergy development and forest management.
- Conduct research on current/potential biomass supply and value chains, including forests, in the UEMOA member countries.
- Continue research on local issues related to bioenergy development such as land use, land tenure, soil conditions, socio-economic issues, etc.

10.2 SCHEDULE

The proposed schedule of activities over the three-year program time frame is provided in Figure 10-1.

Figure 10-1: UEMOA Bioenergy, Agriculture, and Rural Development Strategy Proposed Schedule of Activities—CY 2009–2011

	2009	2010	2011
Capacity Building			
Train policymakers			
Develop/implement standards/quality assurance			
Integrate bioenergy into national/regional strategies			
Conduct communications and outreach on bioenergy benefits/risks			
Perform enterprise development training			
Provide banker training			
Conduct carbon training (CDM, voluntary)			
Policy Support			
Establish regional targets/timetables for bioenergy development			
Identify appropriate policy instruments			
Work with policymakers to link energy/agricultural priorities			
Identify national organization to coordinate bioenergy across ministries			
Create national regulatory frameworks			
Establish guiding principles for land use development & water rights			
Foster regional market for bioenergy			
Engage private sector in policy/regulatory development			
Monitor and evaluate performance on bioenergy activities			
Finance			
Develop project preparation facilities			
Conduct donor coordination			
Engage local financial institutions & micro-credit agencies on bioenergy			
Establish risk mitigation facility(ies) to spur local financing			
Develop a Bioenergy Regional Fund (with ECOWAS Bank of Investment)			
Explore opportunities for carbon finance at the national/regional level			
Market Development			
Assess near-term project/ program opportunities in UEMOA countries/ region			
Implement viable projects			
Technology Transfer and R&D			
Establish/operate Regional Bioenergy Center			
Develop tools/toolkits			
Conduct joint efforts with industrialized countries and South-South collaboration			

10.3 MANAGEMENT AND IMPLEMENTATION

The UEMOA BERP would have lead responsibility for Blueprint coordination, working in close cooperation with member countries on design, development, and implementation. This effort will include a consultation process conducted at the national and regional levels, engaging policymakers, agricultural producers, the private sector, and civil society. The need for these consultations on bioenergy has been strongly voiced by the UEMOA member countries. Also engaging in the consultation process would be a number of external organizations, to include the international financial community, private companies, research organizations, bilateral/multilateral organizations, etc. The technical and financial support of these organizations will be key to success.

As part of the Blueprint management effort, a Bioenergy Advisory Task Force will be formulated. The Task Force will be comprised of experts representing key stakeholder groups across the region and internationally, to advise on sustainable bioenergy development in the UEMOA region.

11. Where Do We Go From Here? Making the Transition to Greater Prosperity Through Bioenergy

Over the last eight years, the UEMOA member states have started to chart a course to change their future. In this endeavor, they face a number of obstacles: endemic poverty, rapid population growth, low agricultural productivity, limited natural resources, and little capital. Reversing these conditions will require an integrated strategy that involves economic, social, and environmental policy choices.

The agricultural sector provides the largest share of employment and output for most UEMOA member countries, yet it is critically dependent on imported inputs, including energy and fertilizer, for its productivity. The energy sector is characterized by power-generating stations that serve modern centers in urban areas; yet, there is significant dependence on traditional biomass by the rural and urban poor. For more than 70% of the population this means no access to electricity and limited modern energy services. In light of these circumstances, policymakers are asking what role modern bioenergy can play in transforming this situation, and what steps must be taken to change the current paradigm that compromises sustainable economic progress.

Knowledge is central to addressing these questions, and this report has served to highlight both what we know and do not know about the situation. The Blueprint highlights where data collection and information sharing are needed. It is imperative to also highlight the opportunities and issues that need to be addressed as the UEMOA adopts regional policies to expand the use of modern bioenergy.

- Traditional biomass use is accelerating deforestation and compromising the health of women and children. Phasing out the use of traditional charcoal through new systems that provide alternative fuels which rely on a combination of feedstocks, including agricultural and forest residues, should be a high priority.
- Redressing deforestation is central to any bioenergy strategy in the UEMOA region. Reforestation strategies need to incorporate protection and conservation, with the production of fast-growing species that can be harvested sustainably and processed into cleaner cooking fuels and/or biochar for soil conditioning. Improved production of these crops can position the UEMOA region to take early advantage of new, cellulosic conversion technologies which promise much higher energy returns when they come on stream.
- Where large-scale reforestation is not possible, incentives that encourage multi-cropping of fast-growing trees (such as in Niger) are another possible option.

- Water scarcity and adequate rainfall are likely to become increasing constraints on agricultural productivity. Strategic conservation, community engagement, and reforestation can help offset this problem and protect watersheds. Given the vulnerability of any agricultural production to water availability, investments in watershed restoration and sustainable community forestry are important both now and in the future.

The region produces some first-generation crops and is experimenting with other crops that show potential in rural areas. This production and experimentation offer a platform for expanding the use of sustainable bioenergy with policies that encourage good practices.

- Bioenergy development depends on fully integrated policies in agriculture, energy and rural development programs. The organization of the UEMOA Commission reflects this need which must be reinforced within national and local policies.
- The UEMOA needs to assess whether some of its current production of first-generation fuels—palm oil or sugarcane ethanol—can be more economically utilized by blending them into petroleum-based transport fuels and/or cleaner cooking fuels.
- A positive assessment would likely encourage the adoption of new, regional transport fuel standards that incorporate more locally produced bioenergy into products, reducing import demand and adding local value to the energy sector.
- This analysis would further examine whether expansion of either palm oil or sugarcane production is warranted, given land and water availability in suitable areas.
- Sweet sorghum should be assessed as a possible additional feedstock for ethanol production.
- Both sugarcane and sorghum production systems should take steps to incorporate bioenergy into their processing systems and cogeneration of electricity for nearby communities.
- Pilot investments in jatropha are increasing, given the high quality of the oil produced. The UEMOA should establish systems for monitoring and reporting the results of these schemes as soon as feasible. Local research and plant breeding will be needed for this and other crops (including tree crops).
- Jatropha yields to date limit its contribution to the larger energy sector, but policies should provide incentives for its use at the village level to reduce dependence on imported oil and to expand rural employment and incomes.
- Regional collaboration on plant breeding is particularly important in the case of jatropha—given public investments in its production and use.

- Perennial crops—like sugarcane, trees and shrubs that can be pruned for wood-based feedstocks, and ultimately some grasses—offer major advantages in this region. The UEMOA Commission should explore with FAO, the Consultative Group on International Agriculture Research, and possibly the Global Crop Diversity Trust on how best to identify crops that can contribute to a renewable energy base.

The UEMOA Commission and its member states are actively engaged in determining their next steps. Early actions should include:

- An inventory of bioenergy projects in the region and a common methodology for evaluation.
- Consultations with producer organizations and farmers are needed to assess what policies will best support their efforts to produce food, fuel, and fiber. Each country will have specific opportunities to pursue; but the goal is to undertake complementary actions that will produce local, renewable energy and expand energy access.
- Early investment in pilot programs to reduce use of traditional charcoal and develop production systems that support local processing of cleaner fuels from agriculture and forest residues.
- A priority reforestation plan.
- Exploration with the World Bank, the GEF, and other donors on how a regional sustainable forestry and watershed plan can be financed.
- These consultations will help identify how to prioritize the introduction of new crops—and help determine when marginal and degraded land offers important opportunities for bioenergy investments.
- Throughout the above activities, it will be critical for UEMOA governments to work in close partnership with the private sector (e.g., Public–Private Partnerships, PPP).

Bioenergy has the potential to contribute to economic growth in UEMOA member countries through reducing oil imports, driving rural development, creating jobs, expanding food production, and reducing poverty. Locally produced bioenergy can increase access to affordable, renewable, modern energy services in West Africa while broadening the base for socio-economic development. Realizing this vision demands careful attention to several social factors and trends.

- **Land tenure.** Current policies put small land holders at a disadvantage, by not ensuring their access to defined perimeters and supporting their investments. Early bioenergy investments have focused on “plantation” operations that further limit the holders’ chances of producing a new, higher value crop and getting predictable support for their efforts. For social benefits to be achieved, policies will have to focus on creating opportunities for smallholders—and supplies of seeds,

plant materials, fertilizer, and water access will have to be consistent. Micro-credit institutions in rural areas are likely to be essential in supporting small land holders.

- **The gender gap.** Women play vital roles in agriculture and need support. It is vital that new agriculture policies recognize this and that extension and micro-credit programs incorporate women into their efforts and advance their empowerment.
- **Rapid population growth.** This trend holds the most potential for undermining the UEMOA efforts to increase agriculture productivity and chart a course for sustainable development. Recent social surveys in some UEMOA countries have underscored women's interest and need for access to health services, including family planning and their desire to space births. As more and more agricultural labor is provided by women—as men migrate to urban areas and abroad—keeping women healthy and productive is an essential strategy for improving productivity. Family planning programs were an essential component of East Asia's development strategy and will be needed here.
- **Climate change.** Maintaining the health of soils, watersheds, biodiversity, and the human population in an ecosystem is a strategy for both mitigating the effects of and adapting to climate change. The UEMOA region is uniquely vulnerable to this phenomenon. It is clear, however, that the political leadership is committed to pursuing more sustainable strategies and improving the resilience of the ecosystems and the communities that depend on them. Bioenergy can be a component and an entry point for a broader sustainable development plan that offers a better future.

APPENDIX 1:

Results of Ethanol Assessment for the UEMOA

Table 1: Prices per megajoule (MJ) of Ethanol and Household Fuels

Country	Raw material	Ethanol (FCFA/MJ)	Real price of butane (FCFA/MJ)	(%) ^a	Non-subsidised price of butane (FCFA/MJ)	(%) ^a
Benin	Cassava	17.8	8.7	103%	130	37%
Burkina Faso	Sugarcane	17.7	6.3	183%	127	39%
Côte d'Ivoire	Molasses	9.1	55	67%	130	-30%
Guinea Bissau	Cashew tree, apples	25.2	117	117%	117	117%
Mali	Molasses	14.4	70	106%	120	20%
Senegal	Molasses	11.7	60	94%	126	-7%

^a Price gap. The percentage shows how much more expensive (or cheaper) ethanol is.

Table 2: Price per MJ of Anhydrous Ethanol, Biodiesel and Fossil Fuels

Country	Raw material	Product	Price (FCFA/MJ)	Gasoline price (FCFA/MJ)	(%) ^a
Benin	Cassava	Anhydrous ethanol	150	136	11%
Burkina Faso	Sugarcane	Anhydrous ethanol	151	182	-17%
Côte d'Ivoire	Molasses	Anhydrous ethanol	93	186	-50%
Guinea Bissau	Cashew tree, apples	Anhydrous ethanol	226	222	2%
Mali	Molasses	Anhydrous ethanol	122	186	-34%
Niger	Jatropha	Biodiesel		15.2 ^b	-11%
Senegal	Molasses	Anhydrous ethanol	102	195	-48%
Togo	Jatropha	Biodiesel		14.1 ^b	-5%

^a Price gap. The percentage shows how much more expensive (or cheaper) ethanol (or biodiesel) is.

^b Diesel

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