

## 6. Bioenergy Resources in the UEMOA

A number of resources in the UEMOA could potentially be used for bioenergy development.<sup>8</sup> 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).

<sup>8</sup> 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
<b>Cassava/ Manioc</b>	<ul style="list-style-type: none"> <li>Range, prefer porous</li> <li>Prefer ph 6-7, no saline</li> </ul>	<ul style="list-style-type: none"> <li>Drought resistant</li> <li>Will not survive water log</li> </ul>	<ul style="list-style-type: none"> <li>High nutrient absorption</li> </ul>	<ul style="list-style-type: none"> <li>Tropical, subtropical</li> </ul>	<ul style="list-style-type: none"> <li>Important for food supply (carbohydrate)</li> <li>High productivity; labor intensive</li> </ul>
<b>Coconut</b>	<ul style="list-style-type: none"> <li>Sandy soil</li> <li>Salinity tolerant</li> </ul>	<ul style="list-style-type: none"> <li>Prefer high humidity</li> </ul>		<ul style="list-style-type: none"> <li>Tropical</li> </ul>	<ul style="list-style-type: none"> <li>Excellent production yield</li> <li>Many productive applications beyond energy</li> </ul>
<b>Hemp</b>	<ul style="list-style-type: none"> <li>Deep soil, good water supply, pH 6/7</li> </ul>	<ul style="list-style-type: none"> <li>Some moisture the entire season</li> </ul>	<ul style="list-style-type: none"> <li>Moderate, no pesticide needed</li> </ul>	<ul style="list-style-type: none"> <li>Varied, preferably warmer climates</li> </ul>	
<b>Jatropha</b>	<ul style="list-style-type: none"> <li>Undemanding, does not require tillage</li> </ul>	<ul style="list-style-type: none"> <li>Can be cultivated under irrigated and rain-fed conditions</li> </ul>	<ul style="list-style-type: none"> <li>Low-fertility sites and alkaline soils</li> <li>Better yields with fertilizers</li> </ul>	<ul style="list-style-type: none"> <li>Tropical and subtropical but also arid and semiarid</li> </ul>	<ul style="list-style-type: none"> <li>Does not compete with food</li> <li>2 harvests per year; able for village use</li> <li>Yield determinants of wild seed not known</li> <li>Labor intensive</li> </ul>
<b>Maize/corn</b>	<ul style="list-style-type: none"> <li>Soil should be well-aerated and well-drained</li> </ul>	<ul style="list-style-type: none"> <li>Efficient user of water</li> </ul>	<ul style="list-style-type: none"> <li>High fertility</li> <li>Continuous maintenance</li> </ul>	<ul style="list-style-type: none"> <li>Temperate to tropic conditions</li> </ul>	<ul style="list-style-type: none"> <li>Important for food supply</li> <li>High energy need</li> <li>Produces less ethanol than sugarcane</li> </ul>
<b>Miscanthus/ perennial grass</b>	<ul style="list-style-type: none"> <li>Brown soils with high humus %</li> <li>pH 5.5 – 7.5</li> </ul>	<ul style="list-style-type: none"> <li>Crucial during the main growing seasons</li> </ul>	<ul style="list-style-type: none"> <li>Low</li> </ul>	<ul style="list-style-type: none"> <li>Adapted to warmer climates but fairly cold-tolerant</li> </ul>	
<b>Oil Palm</b>	<ul style="list-style-type: none"> <li>Good drainage</li> <li>pH 4 – 7</li> <li>Soil flat/rich/deep</li> </ul>	<ul style="list-style-type: none"> <li>Even distribution of rainfall</li> </ul>	<ul style="list-style-type: none"> <li>Low</li> </ul>	<ul style="list-style-type: none"> <li>Tropical, subtropical</li> <li>Temperature 25 – 32°C</li> </ul>	<ul style="list-style-type: none"> <li>Excellent yield</li> <li>Less manual labor to harvest</li> </ul>
<b>Rapeseed</b>	<ul style="list-style-type: none"> <li>Mild, deep loamy</li> <li>Medium texture, well-drained</li> </ul>	<ul style="list-style-type: none"> <li>600 mm minimum yearly precipitation</li> </ul>	<ul style="list-style-type: none"> <li>Similar to wheat</li> </ul>	<ul style="list-style-type: none"> <li>Sensitive to high temperatures</li> <li>Best at 15 and 20°C</li> </ul>	

Table 6-2: Key Feedstock Characteristics (continued)

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

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.

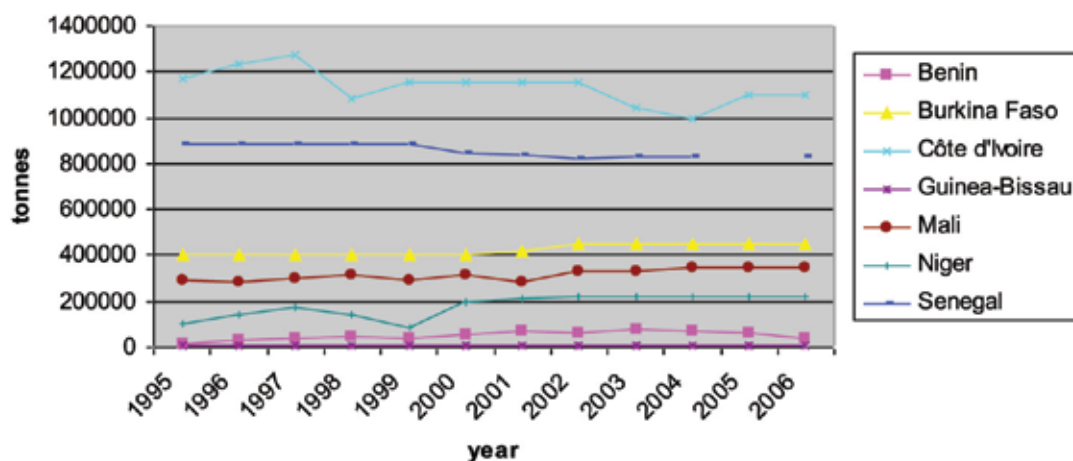
Practically all UEMOA member countries produce sugarcane that could be used for making ethanol. In many countries, molasses, a byproduct of cane, is already being used to supply factories (see Figure 6-1).

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 m<sup>3</sup> of industrial ethanol (96%) and 10,000 tonnes (12,500 m<sup>3</sup>) 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.

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## 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.

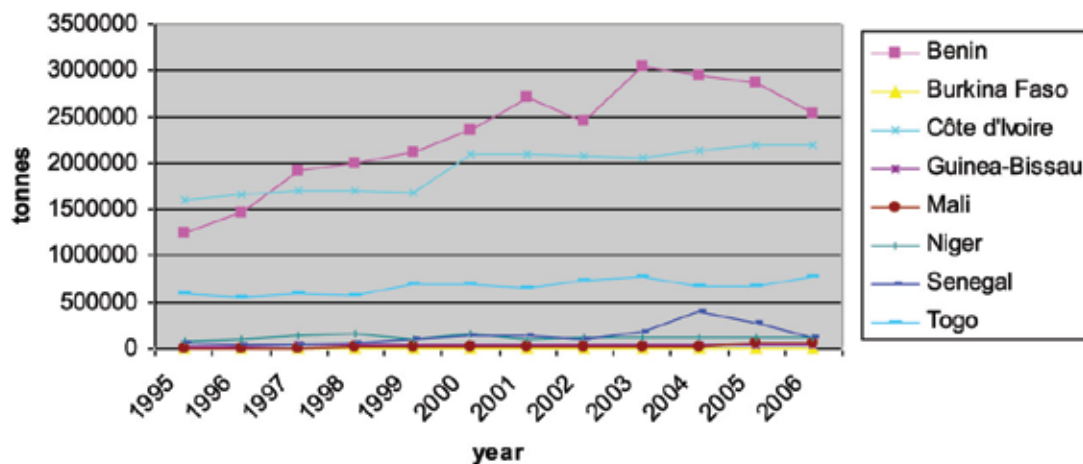
### 6.2.3 CASSAVA

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
<b>Total</b>			<b>85,923</b>

#### 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 m<sup>3</sup> 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

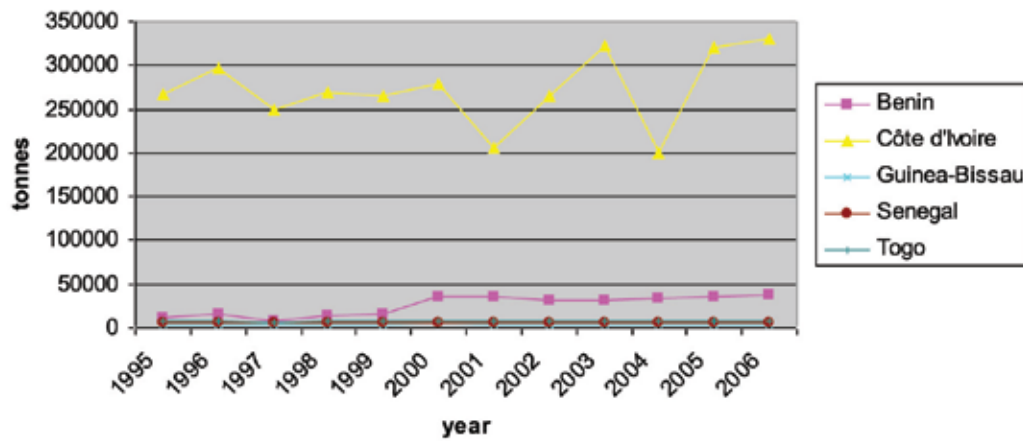
Palm oil provides excellent yields. It had been used primarily for domestic applications, but exports have been increasing due to growing biodiesel demand.

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

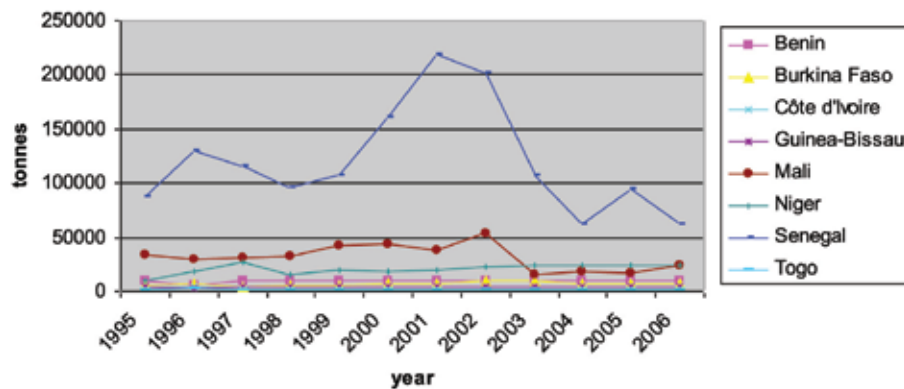
Groundnut production in the UEMOA has been decreasing rapidly over the last few years, with production in 2006 at approximately the same levels as it was 10 years ago (see Figure 6-4). Supply and demand trends do not seem to encourage this prospect in the short term.

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

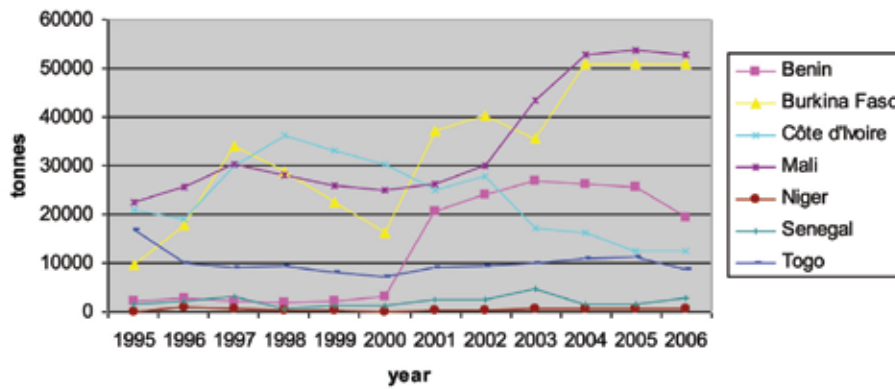
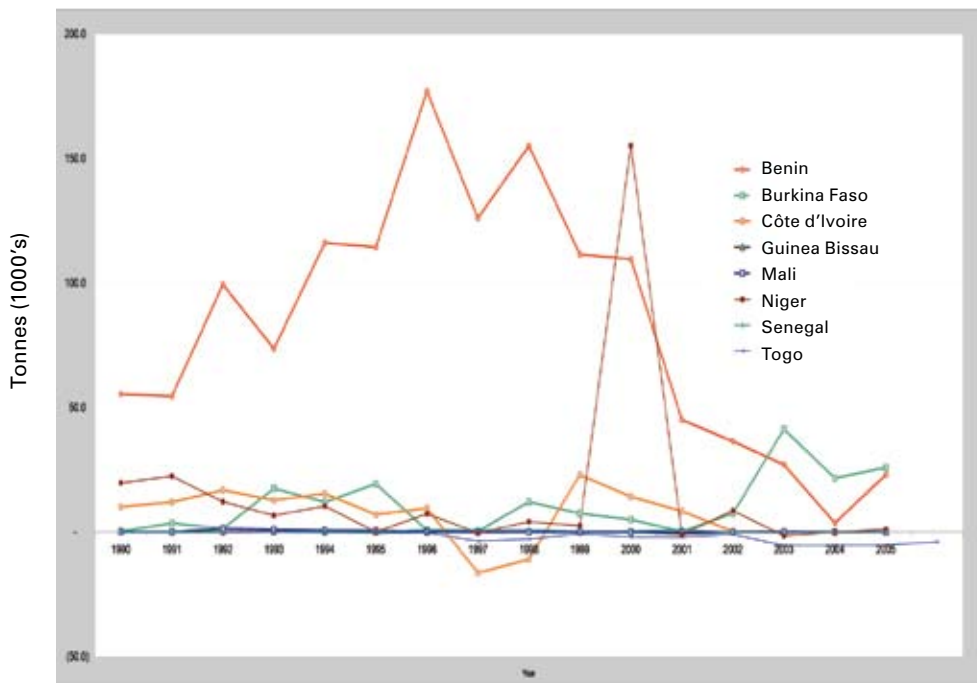


Figure 6-6: Net Exports of Cottonseed in the UEMOA: 1990 to 2005



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.