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ENJEUX ET PERSPECTIVES DES BIOCARBURANTS POUR L'AFRIQUE

Biofuels in West Africa:

Public Policy Considerations

Authors:
Laurent Dittrick
Edgar Blaustein

Sous le Parrainage de :

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1. Biofuels: a contribution to African Development?

Can expanded production of biofuels[1] help meet the energy and development challenges that the region now faces?

Africa is confronted by multiple challenges. Progress towards development targets, the Millenium Development Goals among others, has been limited. Since Johannesburg, energy access and the contribution of energy to development has been recognised as an essential element for development. Biofuels, a major potential energy resource, could help meet the energy and development challenge in Africa.

This document aims to explore, the pros and cons of increased production of biofuels. What are the different types of biofuels? What can biofuels do? What can't they do? And above all, what can and should West African public authorities do to assure that bio-fuel production makes the maximum contribution to reaching the regions ambitious development objective.

1.1. Biofuels and the energy challenge

The energy challenges in Africa are multiple; they range from access to “modern” energy services, to energy dependence and sustainability.

The power sector is in crisis in several countries: commercial, industrial and household users face blackouts on a daily basis while access itself is very limited. Little progress is being made towards increasing rural populations’ energy access while securing energy supply to existing customers. The electricity sector's dependence on imported fossil fuels is one of the principal causes of the crisis.

Although some Western African countries have oil reserves, the region itself, and even producing countries are oil dependent. Most of the production is immediately exported to fulfil long-term contracts with OECD countries, Due to limited refining capacity, only 9% of oil production is consumed locally[2]. , Furthermore, when products are traded within the region, they are traded at world prices.

This means that African oil producing states can not fulfil demand within their own region. Moreover, as most additional production capacity is situated in the Middle East, *most additional demand will have to be met by this region,* directly exposing Africa and more particularly Western Africa to supply disruptions and price swings due to political instability.

Thus, the energy challenge facing West Africa has two sides. One the one hand, despite rising and volatile oil prices and climate change that has dried up some of the region's hydro-electricity supplies, the reliability and competitivity of power and fuel supplies must be assured for urban users. On the other hand, countries must find ways to expand access to modern energy services to rural and peri-urban users, with low buying power, living in dispersed villages.

As many of the Western African States are highly indebted countries, only a limited amount of public funds can be used to support and influence existing energy trends in the region. Despite a recent recognition of the importance of energy for development, aid budgets have

[1] The term "biofuels" will be use to designate liquid fuels produced from biomass, most often from plant matter. Biofuels are thus a subset of bio-energies, the latter term including solid and gaseous energy vectors produced from biomass.
[2] **AfDB/ OECD**; Overview, **African Economic Outlook, 2003/2004**, AfDB/OECD, 2004

not yet been able to seriously address these issues. Expanding biofuel markets may help address African development challenges, on the condition that public energy/agriculture policies orient market actors towards development challenges.

However, in order to grow, these activities must be supported while avoiding the creation of too many expectations in comparison to other activities. There is a risk of overloading demands on agricultural biofuel production in comparison to other existing cash-crops and activities. This could limit the influx of capital for new developments and indirectly encourage existing activities that have not always contributed to growth...

1.2. The role of public policy

Large scale biofuel production would have a major impact on several important sectors of the economy, and as such could be a factor in attaining diverse public policy objectives relative to energy security, rural development, protection of the environment or macro-economic stability. Optimising the impact of such an important change in land use and in energy supply is of course of great concern to public authorities.

Africa is a major agriculture producer. However, much of this production is directly exported, with little local transformation. Thus, local added value is limited, while African countries are highly exposed to the variability of commodity prices.

Recent World Trade Organisation rulings, aiming to increase market transparency and access, have had adverse effects on Africa. African countries are barred from preferential treatment, while they are required to compete against subsidised production in OECD countries. As a consequence, aid instruments have been put in place to cushion exposed sectors (banana, sugar, cotton..) against the effects of global market reforms. However, direct sectoral support , may have a lock-in effect, increasing investments in a sector and maintaining an activity that may not contribute to development objectives.

As a case in point, the Cotton sector, one of the major export crops in Western Africa, has received significant funds to help it “adapt” to new non-preferential treatment conditions in Europe. At the same time, the large majority of production is exported non-carded and non-treated, with little local added value.

Biofuel market development raises important and complex issues, requiring precise information and analysis to choose the best course from the viewpoint of national welfare. At the same time, given the rapid evolution of markets, countries do not have the leisure to wait years for the results of studies depicting potential benefits and disadvantages.

The purpose of this document is aid public policy decision makers in understanding the issues and in acknowledging possible public policy and policy tools with respect to biofuel production.

2. A bio-fuel primer for West Africa

2.1. What are biofuels.

There are two basic categories of biofuels:
- Ethanol, produced from sugar in all forms, can replace gasoline.
- Vegetable oils and fats can be processed to replace diesel fuel.

This section broadly depicts the different feedstocks, transformation processes and energy products that make up the biofuels market.

2.1.1. Ethanol

Ethanol can be produced from any biological feedstock containing significant levels of sugar or materials that can be transformed into sugar such as starch or cellulose. Sugar beet and cane are the most common sugar-based feedstock. Sweet sorghum is being explored for hot climates. Starch bearing crops such as corn, wheat and other cereals can be converted to ethanol through relatively simple biological or chemical processing. Finally, cellulose from trees and grasses can be used although the conversion process is more complicated.

Ethanol feedstocks: yields and production costs

Feedstock	Yield (m^3 ETOH / ha)	Cost (US \$/m^3)
Sugar cane	3,5 – 5,0	Approx. 160
Sweet sorghum	3,0 – 5,0	200 – 300
Maize	2,5	250 – 420
Sugar beet	2,5 – 3,0	300 – 400
Wheat	0,5 – 2,0	380 – 480
Cassava	1,5 – 6,0	700

Source*:* Microdistillery – LAMNET project ICA4-CT-2001-10106

Several processes are being used or explored for ethanol production. The least complicated directly converts sugar-carrying biomass to ethanol through fermentation (using yeasts and microbes). The main by-product is the remaining material from the crushed plant. In the case of sugar cane and sweet sorghum, the left-over “bagasse” can either be :
- burned in a boiler to produce process heat for the refinery and electricity;
- converted to a replacement for a traditional biomass, in the form of brickets.

Grain to ethanol production only uses the starchy parts of the plants, leaving a significant amount of fibrous remains. Once again, these remains can be burned in a boiler or converted to traditional biomass replacements. However, research now focuses on converting these remains, as well as other cellulosic biomass feedstock, first to sugar and then to ethanol. This process has the advantage of using a much wider range of feedstock, opening the door to higher production levels.

Sugar cane grows in wet-dry tropical and subtropical climates. Higher insolation (sunlight) increases biomass production, sucrose yield, and thus contributes to economic viability. Sweet sorghum, a relatively drought resistant plant with water needs almost 50% lower then

sugar cane, grows in an even wider range of climates including semi arid and warm temperate regions.
The sugar cane/sorghum production process, based on direct sugar transformation, is relatively simple. In contrast, production in Europe and other OECD countries is mostly based on the more complex starch transformation, although sugar beet is also used. Future production in Europe would mostly depend on cellulose-based production with more advanced processing technologies.

Ethanol can be burned in *internal combustion engines* (or "gasoline") engines, either mixed with gasoline[3] in small quantities, for instance 15%, to produce a fuel referred to as E15, or in much larger quantities, for instance up to 85%, to produce E85. In small quantities, as in E15, ethanol improves the octane rating of gasoline. As such it replaces other octane enhancers, such MTBE, that are being phased out in some countries because of they are carcinogens. A major advantage of E15 is that it can be used in all existing gasoline powered vehicles, without modification of the motor.

When used in large proportions, as in E85, ethanol almost entirely replaces petroleum products: the resulting fuel contributes greatly to insulating users from fluctuations in the price or availability of petroleum. Nevertheless, a small modification in motors is required to enable them to run on E85. Very few existing vehicles in West Africa can run on E85.

2.1.2. Vegetable oil or biodiesel

Biodiesel generally refers to methyl esters, made by transesterification, a chemical process using methanol and a catalyst to transform oil or fat feedstocks, such as vegetable oil (soya, sunflower, rapeseed, and more recently jatropha), used cooking oil and animal fat.

The production process also typically yields a crushed bean “cake” (that can be used as an animal feed or as traditional fuel wood replacement) and glycerine. These by-products can contribute to the economic viability and sustainability of the biodiesel process. For example, many African countries are exploring alternatives to traditional biomass use for household applications. Moreover, glycerine is a chemical used in the cosmetic, medicine and food industry. However, although applications are numerous, limited demand may lead to combustion of glycerine as a process fuel in making biodiesel, a low-value application.

Filtered vegetable oil can also be directly used in certain applications. Older generation engines need minimal modification to use this type of fuel. Thus "straight vegetable oil" (SVO) can be of interest in countries where the average age of the vehicle fleet is high. The cost of production and limited technology necessary to press and filter vegetable oil present significant advantages for local use. Finally, ethanol can also be used in the production of biodiesel.

In Europe, the oil and protein plant sectors have developed biofuel markets since the early 1990s to absorb extra additional rapeseed oil production. In Africa and other semi-arid regions, jatropha curcas, a seed-bearing tree which produces inedible vegetable oil is being considered as a feedstock. This plant grows naturally in African countries and has the advantage of growing on non-arable land. In addition, it only requires minimal water and nutrients. However, production would differ from traditional fuel crops such as sugar cane, harvesting and collection of seeds being highly decentralised.

[3] In some countries the term "petrol" is used to refer to the fuel used.

2.1.3. Choice of crops

For a given region, the choice of feedstock will depend on adaptation of crops to agro-climatic conditions as well as production structures. Some crops, like sorghum or jatropha, with low soil and water requirements, offer specific opportunities to marginal rural areas. At global level, crops with very high biomass production potential (best expressed in tropical environments), like sugar cane and maize, grown in low cost structures, show highest competitiveness potential. The future development of lignocellulose based processes will most likely modify these economic parameters. Other crops, although not necessarily the highest yield sources, can be of interest because of their limited use of natural resources and their adaptability to local conditions. Finally, crops may also be chosen or optimized for their by-products. For example, cotton oil is now being considered for biofuel production.

2.2. Biofuel Applications

Biofuels can directly and indirectly contribute to different applications:

- **rural energy access**. Straight vegetable oil can be produced at the village level, with simple mechanical presses. It can be used as a fuel in multi-functional plateforms, in simple generator sets, or in agriculture for mechanisation of field work or for transformation of agricultural products. The solid residues the production process can be used as a replacement for traditional biomass.
- **transport sector**. Ethanol and bio-diesel can be used to contribute to transport sector fuel needs. In this form, biofuels contribute to national objectives for energy independence, and can improve macro-level balance of payments by diminishing petroleum imports. The use of these biofuels also strongly reduces air pollution as they have no sulphur content, and since combustion produces fewer small particulates.
- **export**. Ethanol, refined vegetable oil and bio-diesel, as "green" products, can command premium prices on the international market: refined vegetable oils for biofuel production sell for 450 to 750 450 USD/t, depending on their quality. The export of biofuels can contribute to improving the balance of payments, and provide incomes for rural populations. The more the feedstock is transformed, the higher the local added value for the country.
- **electricity production**. Solid biomass residues can be used to power steam turbines for electricity production. If residues can be obtained at a sufficiently low cost, the electricity produced can be competitive with fossil fuelled power plants. Much of the existing power production capacity in the region is based on heavy fuel oil or diesel electricity power plants. These fuels can either be replaced with refined vegetable oil or biodiesel. Although it may be more interesting to maximise the valuation of biodiesel through use in the transport sector, it can be used to replace diesel fuel in generator sets.

2.3. Current status of bio-fuel production in West Africa

In recent years, many biofuel production projects have been launched in Western Africa. However, due to the time lag between plantation and full-scale production (up to 6 years), many of the new projects and plantations have not yet reached maturity. As a consequence, major projects that could be producing significant quantities of biofuels in the next few years are not yet reflected in production statistics.

However, current data provides an indication of things to come.

In terms of *ethanol* production, little is currently produced in Western Africa. However, short-term opportunities exist. Countries in the SADC (South African Development Community) region are using molasses from the cane sugar industry (a by-product of sugar production) to produce ethanol.

> **The own growth and outgrowth models**
> **Advantages/complementarity**
>
> Two production models can be considered for biofuel production.
>
> - The ***"own growth"*** model supports the development of specific surfaces for exclusive crop production by sector-specific economic actors.
> - The ***"out growth"*** model supports smaller-scale farmers in cash crop production. This can include the provision of seeds and guarantied off-take of production at a fixed price.
>
> Both of these models have advantages. The "outgrowth" model encourages smaller scale production and rural development. However, the limited size of farms and availability of capital to develop them decreases their economic viability. In addition, production levels are lower.
>
> This is why it would be difficult to promote the outgrowth model at the expense of the own growth model. A concerted promotion of both models can provide much more support to smaller scale farming while ensuring sufficient scale and investment in transformation.

Many Western African countries with existing sugar production industries could envisage rapidly converting existing under valued by-products such as molasses into ethanol. Senegal could produce up to 21 million litres of ethanol per year from surplus molasses. An UEMOA study[4] has shown that Benin, Burkina Faso, Côte d'Ivoire, Guinée Bissau, and Mali could be produce around 20 000 m^3/year by using surplus from current production.
Beyond the use of by-products, sugarcane, sweet sorghum and cassava could be grown specifically for fuel production. Increasing current crop production or using 5-10% of current crops for the production of ethanol could significantly increase ethanol production in the very short term without affecting other uses.

While *biodiesel* is not currently produced on a significant scale in Western Africa, widespread experiences are being carried out in many countries. SN CITEC (Dagris) will build a factory to produce 10 000 t/year from existing cotton oil resources in Burkina Faso[5].

The country with the most experience, Mali, has mainly used Jatropha as a hedge. There are currently just under 1 600 linear km of Jatropha hedges in the country, with an overall hedge potential of around 10 000km. Although production from these hedges is significant (reaching 1t/linear km[6]), it is very atomised, and in the absence of other projects, it is not welle adapted to large-scale collection and industrial conversion. . Small-scale individual sized plantations of around 1-2ha reaching a total of 1000 ha in 10-15 sites have already been planted, but only half are sufficiently mature to produce oils[7].

Short-term possibilities, using existing resources and by-products to produce biofuels abound. Some of these by-products are not fully valued, sometimes even creating negative environmental impacts through inappropriate disposal (as can be the case for molasses from sugar production). In other cases, such as cotton, the oil is already used for human consumption after a transformation process. However, plant species can be chosen to not only optimise cotton production but also oil production in consideration of potential additional biofuel production. Finally, part of existing crops or extension of existing crops can provide resources for biofuel production.

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[4] Etude sur le Développement de la filière "Ethanol/gellfuel » comme énergie de cuission dans l'espace UEMOA, 2006, **UEMOA**.
[5] Op Cit.
[6] Rapport projet pourghère, 1994, **Mali**
[7] Information from Mali country profile profile prepared by Denis Gautier, Laurent Gazull, Jean-François Bélières.

2.4. Short term and long term potential

The potential for very short term biofuel production in Western Africa exists, but is in most cases limited by available by-product volumes, cost of collection or by the atomised characteristics of production sites. In addition, there is a risk of competition with local food production. At the same time, preliminary studies show that limited use of existing crops (5-10%) and limited extension of those crops can be used to produce significant volumes - sufficient to cover part of national consumption in the case of mandated biofuel mixes- with very limited effects on crop prices and food availability.

On the other hand, specific crop development for biofuel production can not only produce much more significant volumes, but may also be able to do so at a lower price without necessarily affecting existing production structures. Obviously, this will depend on the availability of land and growing needs for food production to reflect increasing populations. To date, many issues relating to food production can be linked to an extensive, non-fertilized, non-mechanized small-scale farming model. This is an essential characteristic of the agricultural sector in the region. Biofuel crop production may be able to contribute to answering some of these issues without necessarily encroaching on current and future needs.

A production model combining own-growth and out-growth could contribute to answering many issues. While the out-growth model (see previous text box) has the advantage of supporting small-scale farming operations and local development, it also raises issues in terms of productivity, necessary inputs (fertilization, seeds, etc...) and collection/transformation of the feedstock.

Combining the out-growth model with own-growth could help to ensure the development of the necessary transformation capacity, of a centralized collection process, while providing necessary inputs for fertilisation. For example, large own-growth plantations could invest in additional transformation capacity, based on potential out-growth contribution to the production volume. Own-growth projects would also be able to guarantee seed buy-back rates to individual farmers based on market prices. In addition, depending on the transformation process, they could also provide farmers with fertilizer material left over by the transformation process, decreasing pressure on land use.

In conclusion, there is a strong potential for biofuel production in Western Africa. Realising this potential will depend on many factors, including the evolution of agricultural practices for other types of crops. Some of the potential biofuel crops can use uncultivated marginal land, with limited or no irrigation. While much negative publicity has been recently given to biofuel production, analysis has been exclusively based on industrialized country data, with little consideration of specific developing country situations.

3. Biofuel production issues and advantages

Biofuel production and use may contribute to several important public policy objectives, notably: energy security; economic growth; access to energy; protection of the environment.

This chapter will investigate the issues raised by biofuel production.

3.1. Energy security

All African countries, including the oil producing countries, import part or all of their needs for refined petroleum products[8]. Given the instability of oil markets and of oil producing regions, this constitutes a permanent threat for the stability of national economies, particularly for the poorest countries of West Africa who risk being excluded from markets at times of crisis.

In times of increasingly volatile international petroleum markets, insulating national economies from repeated oil shocks is of paramount importance for public authorities. Thus, the energy policies of most countries includes "energy security" as one of the top priorities. Using local energy resources, such as biofuels, can reduce dependency on oil imports by diversifying national energy sources

It must be kept in mind that biofuels contribute to national energy only if they are used to supply national energy needs, for instance if they are used as a transport fuel, or for national energy access programmes. While this might appear obvious, it implies two types of considerations:

- It makes economic sense to use biofuels locally. This issue is further treated in the following paragraph on economic impact.
- The type and quantify of fuel production envisaged is compatible with national energy needs. If biofuel production is meant to improve rural access to energy in the form of Straight Vegetable Oil (SVO), it must be determined if all the links in a local energy chain are in place, notably equipment to extract and refine the fuel (along with the associated skills), and motors that can run on SVO. If ethanol production is under consideration, is the projected production less than what is required for an E15 mixture, compatible with current vehicles, or will there be an excess, to be exported? If biodiesel is under consideration, are all the links in this sophisticated value chain in place.

If it turns out that some of the prerequisites for local use of biofuels are not met, then biofuel production should be considered as an export crop, and evaluated in economic terms (see following para), with full understanding that there will be little improvement in the national energy situation. Countries should consider the by-products and transformation processes in their calculations. Presscake, a residue from the pressing of oily feedstocks, can provide a high-quality traditional biomass replacement. It can also be further transformed into a valuable feedstock for biomass-based electricity plants (pellitization). Presscake and plant residues can be used to produce biogas through anaerobic digestion (AD).

Despite controversy about the energy balance of biofuels, there is an emerging consensus that all common biofuels contain more useful energy than is required to produce them. Corn ethanol has been particularly controversial, but its average energy balance now clearly exceeds one, thanks to improved energy efficiency in both agriculture and ethanol refining. In the future, the type of processing energy used will be more relevant: a biofuel plant that uses biomass energy will contribute far more to reducing GHG emissions than one that uses coal energy.

[8] This is the case for all but a very few countries: the economics of refining and the varying nature of crude oil are such that few countries refine all the products that they need.

3.2. Economic impacts

3.2.1. Employment

Biofuel production can bring significant contributions to employment, especially in rural areas. Beyond direct employment for growth, maintenance and harvesting of crops, transformation and induced employment in other sectors can be significant.

In Brazil, the surgarcane sector has created around 700 000 direct jobs and 3,5 million indirect jobs for the production of 350 million tonnes of cane[9] in 2004, while the ethanol industry is credited with providing more than 200,000 jobs in the United States. The World Bank reports that biofuel industries require about 100 times more workers per unit of energy produced than the fossil fuel industry.

In the absence of additional experience it is difficult to evaluate the full extent of employment opportunities related to biofuels in Africa. However, it is apparent that the choice of production model will affect employment rates. In Africa, producers will most probably choose a labour intensive model, avoiding investments in mechanization in recognition of employment needs and low labour costs.

For example, in the case of Jatropha, producers will typically plan on around 1 person per hectar for planting, maintenance and picking. This number will vary depending on the type of feedstock. In the case of Jatropha, only the seeds are harvested and the tree is maintained, while in the case of sugarcane, the whole crop is harvested once it is mature. Employment is highly seasonal, with high needs during the labour intensive harvest.

3.2.2. Local value added, national economic growth

Economic development is key for African countries. While all economic activities provide a measure of development to countries, some bring more local value added then others. Local transformation of products before use or export increases national value added.

Directly exporting feedstock for biofuel production is not economically viable. The feedstock must be transformed locally in order to minimise transport costs. For example, biodiesel crops would be transformed to refined oil, a more valuable resource on national and international markets. This means that local added value is increased.

Multifunctional Platforms Case study

Use at the village level, for instance Straight Vegetable Oil (SVO) as a fuel for multi-functional platforms, can create a new local productive activity, including local processing of the oil. This could be a welcome addition to rural revenues (unless the biofuel production replaces income from an alternative activity). These new revenues could be a substantial proportion of the value of energy services sold for village use.

Local use of SVO could insulate local energy service provision from an unreliable delivery chain for fossil fuels, or from price variations in fuel due to international market volatility. On the other hand, under current market conditions in West African countries, the production price of SVO would be comparable to the sale price of fossil fuels. As a consequence, use of biofuels will not fundamentally transform the economics of rural decentralised energy services. Biofuels are in no way the miracle solution to provide energy access. Furthermore, the reliability of a local production chain would have to be compared to the reliability of the supply chain for fossil fuels.

[9] **Goldenberg et al**; <u>Ethanol learning curve –the Brazilian experience</u> ; Biomass and Bioenergy, vol 26/3.

In addition, the transformation process produces a number of by-products that can have significant value. This can include residues from pressing that can be used as animal feed or as a replacement for traditional biomass fuels. These by-products can also be transformed through the production of electricity or by using the residues in an anaerobic digestion system to produce biogas, which can be directly used locally or for electricity production. Remaining residues can also be used as fertilizer, for the biofuel feedstock of for other local farming.

Further transformation into a finished product can increase the local added value. This will provide additional by-products which can have an even higher value. As an illustration, the transformation of vegetable oil to biodiesel will produce glycerine, a valuable chemical product.

The degree of transformation and processes chosen will depend on local conditions and needs. This is where public authorities can help to clarify needs and decision making by providing a policy framework with the necessary incentives to encourage optimal public benefits without unnecessarily increasing operational costs.

3.2.3. Balance of payments

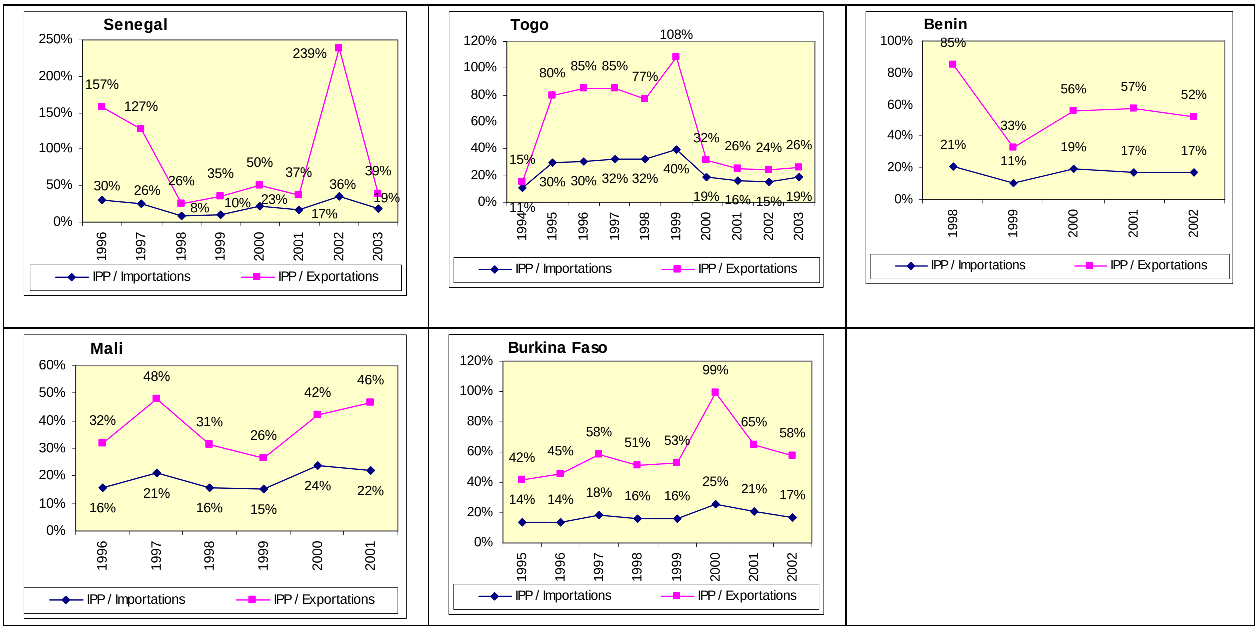
Sub-Saharan African countries pay a high price for fuel imports. The study of a selected number of oil dependent countries' balances of trade (physical exports and imports) shows a number of worrying trends (see "Percentage of export revenues used to pay for fossil fuel imports, percentage of oil in total imports 1993-2003" graphs). Many ACP countries rely primarily on the export of primary, non-transformed goods in the agriculture and mineral sectors. In recent years, terms of trade have deteriorated, with prices for many export commodities decreasing while oil prices have steadily increased. *Many of the worst affected African oil dependant countries spent, on average, 40-50% of their export revenues to import fossil fuel products between 1993-2003 (when oil prices varied between 15-25 $/bl).*

Studies show that the effect of a sustained increase of 10 USD/bl in oil prices can decrease Sub-Saharan country GDP by an average of 1.6%[10]. This does not account for secondary effects on inflation or trade balances. Some countries could suffer an even bigger direct effect loss of up to 3% of GDP.

To put issues in to perspective, the debt relief package agreed by G8 countries during the Gleneagles summit in 2005 was to save African nations about $1 bn a year, but International Energy Agency officials believe the rise in crude prices will cost an additional $10.5 billion a year in oil imports for all Sub-Saharan countries[11]. Up to now, many countries have been partially protected by the Euro effect (i.e: high Euro exchange rates reduce the impact of dollar increases in oil prices).

Cost of fossil fuel product imports vs Total Imports and Exports
(% of export revenues used to pay for fossil fuel imports, % of oil in total imports 1993-2003)

[10] **IEA**; *Analysis of the Impact of High Oil Prices on the Global Economy*; International Energy Agency/OECD, May 2004.
[11] **Financial Times**, *Rising cost of oil counters Africa debt relief*, Financial Times, July 1 2005



Source: UN Balance of trade Statistics,.

The economic savings with biofuels from avoided oil imports can be considerable: between 1975 and 1987, ethanol saved Brazil $10.4 billion in foreign exchange while costing the government $9 billion in subsidies. This investment paid off even more in subsequent years: studies show that from 1976–2004, Brazil's ethanol production substituted for oil imports worth $60.7 billion—or as much as $121.3 billion including the avoided interest that would have been paid on foreign debt (based on debt previously incurred importing oil).

Obviously, it is difficult to compare Brazil's biofuel programme, launched more than 30 years ago, with potential African developments. However, the comparison does give an indication of just how beneficial biofuel production can be if the conditions for growth and development are met. In addition, one must take into consideration that biofuels process by-products can also improve the balance of payments, as exported goods or as a further replacement for energy imports.

3.3. Access to energy

Given the complexity of the biofuel production chain and local production constraints, refined biofuels would rarely be made available on-site at the village level. In most cases, it is necessary to reach a sufficient scale of production to justify local pre-treatment, for example pressing in the case of oil-based plants. Small-scale pressing facilities have been studied. For instance, the "Bagani" jatropha oil press has been designed and manufactured[12] in Mali. Actual small scale biofuel production (trans-esterification process) plants have also been designed although they are not yet commercially available. However, these small-scale facilities are not as efficient as larger ones, designed to optimise production. In addition, the capital cost per unit of transformation is usually higher.

The ultimate choice of production process will be dependent on the goals of the project. If the intention is to produce oil for local populations that can be used as a fuel, then small scale local production can be considered. However, if the intention is to produce, transform and

[12] Note de cadrage pour le Mali ; November 2007 ; **Denis Gauthier, Laurent Gazull, Jean-François Bélières, CIRAD**

distribute the product nationally and internationally, the production process must be optimised to ensure competitivity.

An industrial-scale biofuel production model can also help increase rural access to energy and its sustainable use. In the case of biodiesel, oil-plants will typically be pressed not too far from the production site as long as sufficient resources can be obtained to justify the investment in the pressing units. This means that straight vegetable oil may be made available for local applications within the region. In addition, presscake residues may be available to replace traditional biomass. Residues can also be used to produce biogas in an anaerobic digestion (AD) system. This gas can then be used to power electricity generation or other applications, while the remains of the AD process provide high quality fertilizer to be used locally.

In some cases, part of the residues may be used to produce electricity to fuel the processing facilities. If there is sufficient demand, and a mechanism to redistribute electricity, the electricity production unit can be oversized to permit local redistribution or sale to the grid. Such a facility could also be used for battery charging and other local energy services.

By establishing proper policy frameworks, governments can encourage the development of rural activities, as well as address other policy objectives. Solutions chosen will depend on local situations, needs and possibilities: there is no “one size fits all” solution. Policy frameworks need to promote the “right” solutions for each situation, while avoid disincentives.

3.4. Environment

Although global environmental issues, such as climate change, are often considered to be beyond developing countrys' control, local environmental impacts can have significant negative effects. In addition, many climate-related actions involve measures that make sense on the national level, be it in terms of rational use of energy or possibly replacing volatile high-cost imports with locally produced and transformed products.

Local use of biofuels for transport can help reduce local pollution, especially in urban areas that are exposed to high pollution due to transportation. Although some biofuel crops need fertilization to reach optimal yields, others that are well adapted to local conditions do not require intensive fertilisation. Impacts on water pollution can be minimised with proper fertilisation. Considering the situation and practices in the region, fertilization would need to be optimized, avoiding some of the negative impacts that are mostly a characteristic of large-scale industrialised farming practices in OECD countries.

Major oil crop yields

	Min-Max t/ha	average t/ha	% oil content	oil yield t/ha
oil palm	12.6-32.4	19.2	20	3.84
rapeseed	2.3-3.8	2.9	35	1.02
sunflower	1.7-2.4	2.1	35	0.74
peanut	2.8-3.3	3.1	35	1.09
soybean	2.3-3.6	2.8	17	0.48
jatropha	1.5-2.0	-	30	0.48-0.71

Source: FAO Stat, 2005

Synthesis

		Item	Rainfall	Yield	Energy Input	Energy Ratio	Cost
Bio-Ethanol	Sugar rich crops	**Sugar beet**	1000	14.03	26.6	9.47	43.33
		Sugar cane	1700	59.21	16.6	25.16	48.02
		Sweet sorghum	500	24.9	19.1	7.36	184.08
	Starch rich crops	**Wheat**	1000	3.06	13.47	8.71	207.84
		Corn	975	3.42	18.9	7.9	226.71
		Cassava	800	10.2	27.37	*7.75*	221.73
		Rye	1000	2.43	20.74	7.23	141.68
Bio-Diesel	Oily Seeds	**Palm**	3500	13.06	12.87	3.13	140.2
		Sunflower	950	1.25	19.75	3.07	330.85
		Rapeseed	950	1.93	25	4.84	310.51
		Jatropha	850	9.86	n.a.	n.a.	180
		Soybean	1150	1.62	17.33	3.6	368.71
Combustion Gasification CHP	Lignocellulosic	**Corn + stover**	975	6.84	20.1		
		Wheat straw	1000	*3.06*	4.52	20.71	
		Rye Strraw	1000				
	Lignocellulosic	**Cane bagasse**					
		Wood					
	Lignocellulosic	**Miscanthus**	550	12.59	9.55	29.93	695.3
		Poplar	1300	39.43	6.34	29.32	531.3

Source: Agroils, FAO

In terms of water use, crops should be chosen for their adaptation to local conditions. Those that are best adapted to sahelian conditions are drought-resistant, low water input crops. As can be seen in the table above, feedstocks such as Cassava, Sweet Sorghum and Jatropha are low water input crops that would need very limited irrigation, since they can grow within rainfalls of 500-850 mm/year, common in much of West Africa. To ensure productivity, limited irrigation may be considered in order to provide minimum amounts of water during low rainfall seasons.

Crop water need

Feedstock	**Water mm total/growing period**	**Feedstock**	**Water mm total/growing period**
Melon	400-600	***Jatropha Curcas***	***650-850***
Sorghum/Millet	***450-650***	***Cassava***	***800***
Barley/Oats/Wheat	450-650	Citrus	900-1200
Miscanthus	***550***	Cotton	700-1300
Peanut	500-700	Alfalfa	800-1600
Rice (paddy)	450-700	Banana	1200-2200
Soybean	***450-700***	Sugarcane	1500-2500
Maize	500-800	***Palm***	***3500***

Source: FAO

In addition, some of these crops are *perennial*, in other words, only part of the plant is harvested to produce the biofuels while the rest of the plant remains. This means much lower energy input for preparing, sowing and ploughing land. Another advantage is that perennials retain water in the ground, limiting run-off and helping to replenish local water reservoirs, thus fighting desertification and preserving soil quality.

Although many issues still need to be resolved and experience gained to build a more solid picture, biofuel production may be used, under the right circumstances, to help fight current trends in decreasing agricultural yields and soil quality. With the right policy framework, biofuels could contribute to improving the agricultural model in Africa, by moving to more productive, intensive land, use, while protectingsoil quality.

3.5. Issues

The previous paragraphs detailed the many advantages for West Africa of biofuel value chains. However, many recent reports have stressed the potential adverse effects of biofuel production, (perhaps as a result of increasing public awareness of the existence of biofuels and their potential).

Since all economic activities can have potential adverse effects, it is important to examine biofuels in comparison with the alternative energy source, ie fossil fuels. This section aims to address potential negative impacts that should be considered by public authorities. However, one needs to distinguish between those issues that only relate to biofuel production and those that relate to all agricultural production. Depending on specific national and local circumstances as well as production models, expanding biofuel production can have impacts on food security, national and local economies or the environment. This is also the case for most current crops being grown in the region.

3.5.1. Are biofuels climate friendly?

A priori, the use of biofuels diminishes green house gas emissions, since the carbon in the biofuels was removed from the atmosphere, rather than from fossil underground stocks.

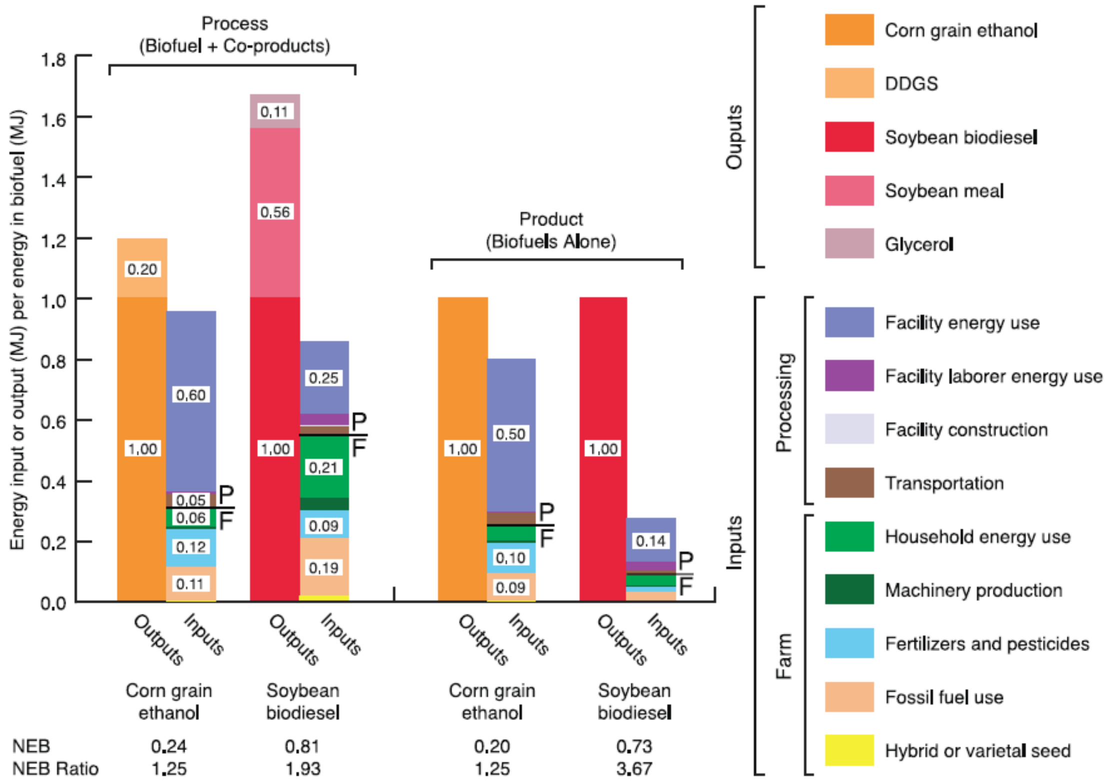
However, reality is more complicated. The climate impact of biofuels must be considered on a life cycle basis, in comparison to fossil fuels.

The production and use of biofuels causes emission of green house gases at several stages:

- **Fertilisation.** Biofuel crops may need fertilising. The production of chemical fertilisers requires energy, responsible for GHG emissions, and can emits nitrous oxide. On the other hand, natural fertilisers (plant residues, etc..) and remains from anaerobic digestion are climate neutral. When the fertilisers are applied to the crop, more nitrogen is emitted to the atmosphere.
- **Land use.** Changes in land use lead to changes in global warming potential emissions. For example, land can act as a carbon sink. Depending on the original state of the land before plantation, the carbon emissions linked to land use will either decrease or increase (forest to plantation: increase; plantation to plantation: stable or decrease, savannah to plantation: decrease, etc..)
- **Water.** If biofuels are irrigated, the pumping of water requires energy, and thus emits green house gases.
- **Mechanised field work.** the fuel for tractors or farm machinery can cause CO_2 emissions.
- **Processing.** Mechanical and chemical processing of biofuels requires energy, thus further CO_2 emissions.

On the other hand, crops sequester carbon, above ground and underground, during their growth.

Biodiesel and Ethanol Energy Balance Comparison



Source: Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels, Jason Hill et.al. 2006 PNAS

Life cycle emissions of biofuels vary greatly from project to project, meaning that analysis must be made on a case by case basis. There is considerable scientific debate on the evaluation of the greenhouse gas emissions of biofuels, most recently with respect to the nitrous oxide emissions[13]. However, one must keep in mind that:

- Analysis up to now has almost exclusively focused on biofuel production in OECD countries. This strongly affects the analysis since the degree of mechanisation and processes are very different from those that would be used in Africa;
- Analysis has, in most cases, focused on existing practices, ignoring efficiency and technology improvements that come from large scale deployment as well as the by-products from production. A small process change, for example using the residues from crops to provide all energy needs can significantly change the energy balance. In the case of Brazil, the exclusive use of bagasse for energy needs completely changes the ultimate energy balance.

Energy crops have the potential to reduce GHG emissions by more than 100 percent (relative to petroleum fuels) because such crops can also sequester carbon in the soil as they grow. Estimated GHG reductions for biofuel feedstock include: fibers (switchgrass, poplar) 70–110 percent; wastes (waste oil, harvest residues, sewage) 65–100 percent; sugars (sugar cane, sugar beet) 40–90 percent; vegetable oils (rapeseed, sunflower seed, soybeans) 45–75 percent; and starches (corn, wheat) 15–40 percent.[14]

As can be seen, there is much latitude for improvement of the climate and environmental performance of biofuel production. Several factors, of specific importance in Africa would tend to decrease greenhouse gas emissions:

- Production would be more labour intensive, reducing mechanisation and related emissions;
- Fertilizing practices would in all probability be less intensive and at least partially based on local plant residues;
- Lack of electricity access would tend to encourage local electricity and energy production based on plant residues.

3.5.2. Are land and labour available? Food vs Energy security?

Biofuel production uses natural and human inputs – principally land, water, and labour – to produce a valuable economic commodity. But these same inputs may already be in use. Thus, increased biofuel production may come to compete with other sectors.

Biofuel production is generally labour intensive, so attention must be given to the availability of a sufficient labour force on the site of production. However, in most West African countries, large populations are under or unemployed. In general, labour shortages should not be a constraining factor on biofuel production. Nevertheless, since the unemployed populations may not live in regions foreseen for biofuel production, adequate consideration must be given to social obstacles to population mobility.

In addition, demand for labour can vary greatly, particularly during the harvest season. This means that seasonal demand must be assessed against current farming practices to determine if existing agricultural labour in the region can be employed during harvesting periods. As harvesting seasons depend on the type of feedstock used, it is possible to choose feedstocks that will not enter into competition with existing labour needs.

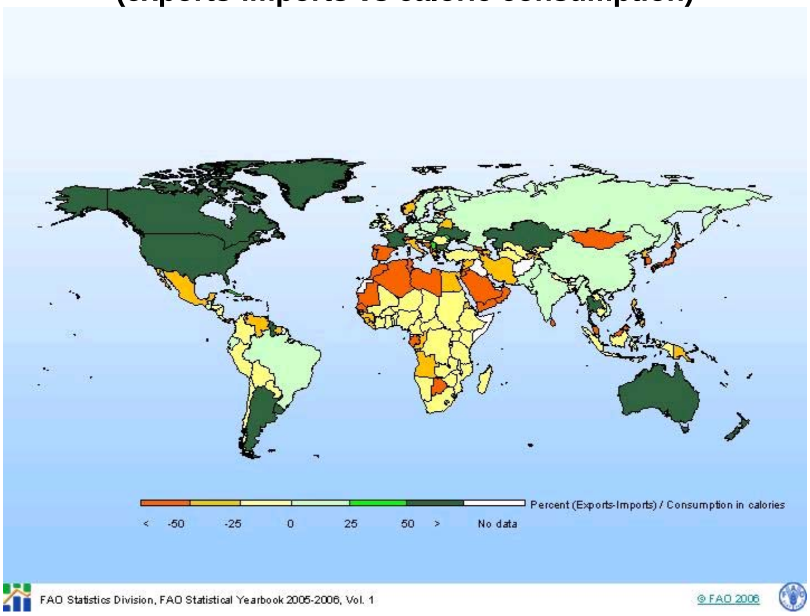
Availability of land is a fundamental constraint for biofuels. Since competitive production will involve large areas of land and industrial farming methods, competition for land would most likely be with current large scale export crops, rather than with subsistence farming. In some

[13] !! ref to Max Planck
[14] FAO, website, biofuels factsheet.

cases, incremental increases in current crops, or optimisation of existing crops to produce biofuels (for example oil from cotton) could provide sizeable biofuel production potential with a limited impact on the existing situation.

However, current trends in Western Africa show the limits of the existing extensive production model with decreasing land productivity and increasing demand for food. Under current conditions, all things remaining equal, Western Africa would have problems meeting its' food requirements in the next 15 years.

Food dependency
(exports-imports vs calorie consumption)



Source: FAO Statistics

However, as the previous illustration shows, Western Africa is already an importer of food. Western African country import needs range from 5% to more than 50% of their food intake: food production can not be considered as being only produced nationally.

The main land issue concerns the current, extensive, low fertilisation model. The current model of land use has led to decreasing yields and increasing soil degradation, increasing the pressure on arable land. Biofuel feedstocks that grow on marginal land could address some of these issues by producing natural fertilizers, and fighting against land degradation. In addition, some biofuel crops are particularly well adapted to "intercropping"[15].

Intercropping

In some cases, intercropping techniques can also be used. This means that other crops can be planted on the same land in between the biofuel crops. Jatropha is particularly adapted to this type of production. In this case, the species planted in between the rows will profit from soil fertilisation for the biofuel crops and may even be partially protected from pests thanks to intrinsic Jatropha plant toxicity. However, capacity for producing these parallel crops must be developed. They can either be directly produced by the biofuel project developer or cooperatives of farmers.

In conclusion, despite recent controversies, there is much potential for increasing the environmental performance of biofuel production. Moreover, African countries may well have a competitive and environmental advantage in biofuel production. This will depend on their

[15] Growth of different crops

choice of crops and the way they choose to develop their production, once again a factor of the policy framework that they put in place.

Food security or energy security: the case of Senegal

As explained above food production and biofuels production depend on the same resource base: land, water and labour. While in some cases, there may be ways to stimulate biofuel production without reducing food production, in many cases, a choice must be made. How might public authorities choose between food security and energy security? A priori, there is consensus that food is more important than energy: food is a vital need. But is energy not also a vital need, albeit of a different nature?

The case of Senegal offers an interesting example. Agricultural policy in Senegal during the colonial period and during the first two decades of independence actually created a situation of food dependency. Senegalese farm output was oriented towards ground nut ("peanut") production, a product for which Senegalese agronomic conditions constitute a comparative advantage. Ground nut production displaced staple food production – notably millet – and the food gap was filled through the importation of low cost rice from Southeast Asia (at the time also under French colonial rule). This shift is so fundamental that the Senegalese national dish, cheb u jien, is based on imported rice. While this import-export system made economic sense at the time, changing climatic conditions and the declining price of peanut oil on world markets has led to a sharp decline in rural income from ground nuts: exports declining from 252 955 tons in 2001 to 37 467 tons in 2005.

But does the high level of food dependency of Senegal, 52% of food is imported, constitute more of a danger than the high level of energy dependency (98% of energy needs outside traditional biomass are based on imported fossil fuels)? In fact recent history, and projections of possible crisis scenarios in energy markets, might lead public authorities to consider that possible disruption of energy supplies is more likely than disruption of food supplies, and thus constitutes a greater danger for Senegal.

The situation is further complicated by another, indirect, link between food and biofuel. The rising price of fossil fuels has destabilised the up till now successful Senegalese "butanisation" programme. State subsidies on LPG, necessary to support consumption, are becoming too much of a load. But a shift back to traditional wood based domestic fuels would increase the load on Senegalese land, and might pose a threat to food production. The fundamental question is how to optimise the satisfaction of different needs – liquid fuels, food, traditional domestic fuels – all based on the same resource base.

Conclusion. The best solution to balance food production and energy production would of course be to increase agricultural productivity and to improve management of forests. The actions needed, in terms of soil conservation, soil enrichment, and forestry practices, are in any case essential to stop and reverse the declining fertility of Senegalese lands.

source of data: "Stakes and perspectives for biofuels in Africa: Case of Senegal"; Papa Nouhine DIEYE

3.5.3. Soil Fertility, Water pollution, Biodiversity.

As with any other large scale commercial crop, biofuel production would have an impact on soil fertility, and could be a source of water pollution (from fertilisers or insecticides). The precise impact depends greatly on the crop itself and the farming methods.

Similarly, if biofuel production requires deforestation or similar removal of natural habitat, there may be negative impact on biodiversity.

On the other hand, planting of biofuel crops on degraded land may enhance soil quality, and avoid erosion. In some cases it might provide an enriched habitat, thus increasing biodiversity. Other issues to be considered are access to water points for animal husbandry and land used for grazing which is not necessarily accounted for.

There is much potential for biofuel production in Western African countries. The types of feedstock that can be used for this are quite varied and in some cases particularly well adapted to Western African pedological conditions. The local production of biofuels can bring many development and economic benefits to countries in the region. However, as for all activities, if the sector is not properly structured, it will not bring expected development benefits, will not be profitable and may even have negative environmental effects. This is why public authorities must take an active stance in supporting the development of these activities, within a framework encouraging their sustainable development.

Availability of land: the case of Mali

Mali is a country with a huge surface area – 122 million hectares – of which only 6.5 million are currently cultivated. A priori, this would seem to indicate that there should be no difficulty in identifying lands for use in biofuel production. A detailed analysis shows that the situation is more complicated.

1) Current situation
Desert areas not suitable for agricultural activities account for 71 million hectares. Much of the remaining land is used for animal husbandry, a very important activity, both for local consumption and for export. Some estimates of land availability do not take into account fallow lands, although leaving lands fallow is essential under current agricultural methods. Taking into account these factors, biofuel production could use: :

- Marginal lands with access to water: 250 000 ha.
- Pourghère hedges, estimated at between 10 000 and 22 000 linear km, although they are dispersed and collection of production would be costly and difficult to organise.
- Intercropping, but the impact on agriculture (shading of plants, water consumption) is not yet fully understood.

2) Trends and future potential

- Irrigated areas are decreasing, in part because of decreased flow in the Niger river.
- The sahelien and sub-desert regions have probably reached the point of saturation for grazing. Furthermore, desertification is pushing the desert South, encroaching on grazing lands.
- Climate change. Rainfall is decreasing, and zones of agricultural production are being pushed South.
- Expansion of cultivated zones is one of the main factors leading to deforestation. An estimated 200 000 ha of forest disappear each year. This in turn threatens the availability of wood fuel, essential for cooking.
- About 7 to 15% of arable lands have been abandoned to due declining fertility.

Furthermore, cultivated land areas have increased by a factor of 2.5 in the last 20 years, while population has grown by only a factor of 1.5. The two causes are increased consumption (a good thing) and decreased soil fertility (a bad thing). It is estimated that the population of Mali will grow to 23 000 000 by 2025 (double the 2000 population). Land use for food would thus more than double, under current trends. As a consequence, food production in 2025 would occupy all arable land (including lands currently considered as marginal), and might start encroaching on grazing and forest lands.

Conclusion. There is currently a considerable potential for biofuel production, that would not enter into competition with food production. Nevertheless, in the medium term, viability of biofuels production, and well as of food production, would necessitate major efforts to modernise agriculture, in order to move towards more intensive, higher productivity use of lands.

4. What can public authorities do?

Although biofuel production is not the panacea – it can not provide an answer to all African problems - it does show much potential in the region. African countries are already large agricultural producers and the climate and environmental conditions in Western Africa are well adapted to many biofuel feedstocks. In addition, the resource can be transformed locally, conserving a greater part of the added value in country.

> ***Time is short, the world is evolving quickly!***
>
> Outside forces - unstable oil markets, energy crisis, etc – are powerful drivers pushing the market forward at a rapid pace. In the absence of timely public action, private actors will take decisions that may pre-empt public decision making. Thus, public authorities must at the same time engage long term decision processes, and take short term actions with respect to ongoing projects by clarifying their own goals and expectations while building their experience.

However, policy makers must temper their expectations: although there is much potential, biofuel production is currently unproven in Africa. Furthermore, there is very little experience with commercial production of most of the feedstocks that are well adapted to the region.

In addition, significant capital will need to be injected into projects to develop the sector. Although local actors have shown a certain will to invest, limited sized projects may not have the capacity to fulfil expectations. Thus, scaling up production will require Foreign Direct Investment (FDI) to accompany local investments and investors. International capital can only be raised if investors have sufficient confidence in future market development, in country support, as well as in existing and planned policy frameworks. In most cases, projects require large initial investments, as well as operational cost funding for significant periods, since many projects do not start producing any cash flow for more than five years. Considering typical investor outlooks, this means that large efforts must be made in making conditions sufficiently attractive and secure to ensure the necessary scale of investment.

Careful consideration must also be given to optimizing local benefits and limiting environmental impacts.

Finally, decision-makers need to acknowledge that projects are already being developed and plans being made to increase capacity. Thus, governments. must act rapidly to encourage the development of ongoing projects, while carefully assessing impacts and accompanying project developers to ensure success and to optimise benefits for the country.

This calls for:

- Consultations with stakeholders;
- Evaluation of available options in view of public priorities;
- Definition of policy objectives and putting into place appropriate policy tools.

The following paragraphs aim to set out the biofuel production specific aspects of the public decision process.

4.1. Consult

Biofuel activities in Westen Africa are evolving rapidly. Since significant long-term investments are being prepared, it is important to provide a stable framework for development with a long-term vision of goals and objectives. In the same way, all decision-making must be made as transparently as possible in order to increase confidence in the market and the security of investments to be made. On the other hand, if public policy makers take unilateral decisions, they risk creating a climate of uncertainty.

In order to favour confidence, public policy makers should use engage in a participatory process, including all market actors, to *accompany* the development of local biofuel production. Although this will take time and effort, the reward can be significant, ensuring that decisions made are directly applicable, specifically targeted at the issues relevant to the sector.

Beyond limited consultations, policy makers should consider the creation of a lasting platform for information exchange and policy determination. In order to avoid multiplying time-consuming and budget hungry committees, countries should strive to work through existing structures for consultations, for instance existing multi-sectoral energy committees with a few additional stakeholders:

- Small and large scale operators and investors in the biofuel value chain. In some cases, these will be large trans-national companies whose viewpoint will be made known to public authorities;
- Rural farmers are perhaps the largest group of people concerned by biofuel production, but are not always well represented in public decision making.
- Given that everyone uses energy, and that biofuel production may affect the reliability or cost of energy services, the populations' needs should also be considered. In principle, these are summarised in national energy and development policies.

Policies can not be defined in a vacuum: their success will depend on stakeholders' adoption of the policy vision, that must be relevant, focused and applicable.

4.2. Evaluate

Evaluating options in the field of biofuels involves both financial and non financial public policy criteria. However, countries must first define their public policy priorities in order to define their evaluation criteria. This will mean re-examining existing development objectives in the light of possible biofuel activities.

As energy issues are seldom fully covered in national development planning documents, countries will also need to develop their understanding of these issues. Current exercises being carried out within "multisectoral energy committees", examining the conditions for implementation of the regional white paper on energy access, should be able to contribute.

Considering the level of experience with biofuel development in Western Africa, it is premature to evaluate existing and proposed projects. Actors have only recently started launching projects and in most cases these projects are far from reaching maturity. Although promising, their economic viability is not proven. In addition, although some are plants species are endemic to the region, there is insufficient experience with "new" species being introduced for large-scale biofuel production. Finally, much progress can be made in agricultural performance, in choice of species or in transformation processes.

In cases where biofuel feed stocks come from existing species that are commercially exploited, partial evaluation can be made based on agricultural experience. However, policy makers must take into consideration that these species have not been optimised for their energy potential when evaluating them. For example, it is entirely possible that oil production from cotton could be significantly higher if species were chosen for their oil content as well as the quality and quantity of cotton in recognition of the potential value from biofuel production.

By establishing platforms for exchange between all actors, Governments will be able to collect information in order to benchmark current and future performance. In addition, stakeholders will be able to provide their input and experience on the most important needs, helping policy makers to increase the relevance of their work.

4.3. Decide and act

Many of the fundamental decisions with respect to biofuels production are in the hands of private actors, who decide:

- what crops to plant;
- what production model to use,
- where to sell their produce.

However, these decisions are made in relation to existing conditions and constraints in the country. In the absence of existing goals, private sector operators are obliged to interpret current legislation and policy objectives to determine the most beneficial policy for development. Considering the time horizon of investments involved, this creates much uncertainty. Actors may even go as far as suggesting and discussing possible national objectives with government authorities

Providing a clear and transparent framework for national policy objectives will constitute a first step in engaging project proponents on country-specific development goals. Nevertheless, public authorities have a wide range of tools at their disposal to influence the choices of private economic operators.

Governments can *set the scene* by adopting goals for local consumption. However in the absence of incentives to launch production or to distribute products locally, producers may need to export their production to ensure sufficient economic viability. Governments may wish to examine the opportunity of setting mandatory fuel mixes, including biofuels, as has been done in Europe and is being considered in Eastern Africa.

Incentive frameworks can also be examined. Although these may have a cost in terms of national budgets, they may also be offset by induced economic activities, employment and avoided foreign currency imports. As has been shown, Western African countries are highly exposed to fossil fuel import prices and in some cases are already spending significant amounts to support fossil fuel prices.

Indirect financial incentives may also be relevant. Taxation regimes can be adapted to express financial and economic benefits related to biofuel consumption in country by completely or partially foregoing taxes on biofuels distributed locally. Corporate taxes can also be adapted to increase incentives.

Finally, governments can *set the framework* for development in order to encourage the emergence of projects answering national priorities without necessarily encroaching on public budgets. For example, marginal land may be put at the disposal of projects on a free basis on the assumption that this may help redevelop soil quality and local economies. Some feedstocks have shown their ability to grow on this type of land while helping fight against erosion. As large scale production will tend to encourage increased productivity, operators will apply fertilisers, be they chemical or natural. This can help to increase soil fertility.

Governments can also consider encouraging local employment and development. This can include encouraging projects that will combine own-growth with out-growth by guaranteeing a certain price for independent farmer production.

Whatever the policy framework, public policy and public action must be carried out in a pragmatic manner, taking into account the limits to public action and budgets. The role of governments is to set the scene for development with general conditions for development, employment, environment.