Biofuels: Strategic Choices for Commodity Dependent Developing Countries

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Cover photo's rape seed and sugar cane

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Foreword

Increasing energy costs, environmental impacts of fossil fuels, uncertainty regarding future energy supply and the need to reduce the energy import bills in both developing and developed countries, have given incentives to encourage the production of petroleum substitutes from agricultural commodities.

First generation biofuel technologies are already well developed and are available in many countries. The current and rising high oil prices make biofuels economically competitive when sourced from the most efficient producer countries.

Ambitious biofuels targets set by many countries in recent years reflect the new optimism about the potential of biofuels. To date, the participation of commodity-dependent developing countries in this new biofuels market has not been significant, mainly limited to sugar-producing countries in the Caribbean and Africa and some very early experiences with cassava, jatropha, oil palm and coconut in Africa, Asia and the Pacific islands.

The issue of bio-fuels, therefore, has become of paramount importance in world commodity markets and, in this respect, it is important that the Common Fund for Commodities should be cognisant of this rising importance of biofuels and adopt a clear policy on this strategic matter. This includes not only the benefits but also the costs associated with the development of the biofuel industries. The multi-dimensional nature of biofuel production raises critical issues including policy dilemma of food security or what is now being referred to as "Grain Drain". Challenges come in many forms, including production capacities and scarce resources diverted from food production, disruption of established production systems, as well as the overall lifecycle costs of substituting biofuels for traditional energy sources.

This is why the CFC has chosen the issue of bio-fuels as the feature topic of its Commodities Issues Series study for this year. The study attempts to highlight the strategic choices facing commodity-dependent developing countries in the wake of new opportunities and challenges related to the development of biofuel markets.

In particular, in this study, the Fund looks at the lifecycle costs and benefits of intensified biofuel production, while providing future outlook; and attempting to identify the likely challenges and opportunities for commodity producers in developing countries in the coming years. While maintaining neutrality in the biofuels debate, the study in particular focuses on the impact, opportunities and challenges of biofuels for the target beneficiary groups of the CFC.

We hope that the study will stimulate informed policy debate among Members of the Fund, as well as in the international development community on the impact of biofuel sector growth on the sustainable development of commodity dependent developing countries.

Amb. Ali Mchumo
Managing Director

Executive Summary

The aim of this document is to provide commodity-dependent developing countries (CDDCs) with a framework for strategic decision-making on entry into production and use of biofuels.

Key Trends

Biofuels are fuels produced from biomass for purposes such as transport, heating, electricity generation and cooking. Bioethanol is produced from carbohydrate-rich plants (e.g. sugarcane, maize, beet, cassava, wheat, sorghum). A "second generation" of bioethanol under development is based on cellulose rather than sugars. Biodiesel is produced from oily crops or trees (e.g. rapeseed, sunflower, soya, palm, coconut, jatropha), but also from animal fats, tallow and waste cooking oil. The second generation of biodiesel relies on a number of different technologies. For example, Biomass to Liquid (BTL) uses the Fischer-Tropsch process, which involves gasification of wood, straw or municipal waste to produce biodiesel.

First generation biofuel technologies are already well developed and available in many countries. The current high in oil prices makes biofuels economically competitive when sourced from the most efficient producer countries. Ambitious biofuels targets set by many countries in recent years reflect the new optimism about the potential of biofuels. To date, the participation of commodity-dependent developing countries in this new biofuels market has not been significant, mainly limited to sugar-producing countries in the Caribbean and Africa and some very early experiences with cassava, jatropha and coconut in Africa and the Pacific islands.

Bioethanol accounts for 93% of global biofuel production. Global bioethanol production has shown an average annual growth of 20% since the year 2000 and makes up about 3% of global gasoline use in 2005. Large countries with strong biofuel policies already in place dominate biofuel production – Brazil and the US together account for more than 70% of global production – but other countries are developing significant and growing industries. About 40% of global bioethanol production comes from sugarcane and maize respectively, while the remaining 20% comes from other crops.

Biodiesel production, on the other hand, is fairly small compared to bioethanol, accounting for less than 0.2% of the diesel consumed for transport. The EU is responsible for 90% of global production of the biodiesel end product. While rapeseed oil is the main feedstock used in the EU, soy is used in the US, Argentina and Brazil, palm oil in Asian and Latin America and coconut oil in several Asian and Pacific islands.

Although the bulk of the global production is still consumed domestically, international trade in biofuels is expected to grow very rapidly in the coming years, as the global increase in consumption will not coincide geographically with the scaling up of production. The expected mismatch between global demand and supply presents export opportunities for low-cost producer developing countries, especially those located in tropical areas that have comparative advantages in feedstock production.

Brazil is the main global bioethanol exporter, increasing its exports considerably over the last few years and today supplying about 50% of international demand. Other emerging exporters include Caribbean countries, China, the EU, Pakistan, Peru, Ukraine, Zimbabwe and Swaziland. The US, in spite of major increases in domestic production, remains as the main bioethanol importer, accounting for 31% of global imports, with increasing demand too from the EU, Japan, Korea and Taiwan. Trade in biodiesel is at a less developed stage. For feedstocks the picture is different: trade in bioethanol feedstocks is relatively stable, but it is growing rapidly for biodiesel feedstocks, notably palm oil from Malaysia and Indonesia to the EU.

Policy Goals for Biofuels Development

Four key policy goals are associated with current impetus among governments to promote development of biofuels industries in their countries:

Energy security: Increasing energy costs, uncertainty regarding future energy supply and the need to reduce the energy import bill are prime incentives to encourage the production of petroleum substitutes from agricultural commodities, in order to increase energy security at both national and local level.

Rural development: Biofuels generate a new demand for agricultural products, reducing commodity surpluses and improving commodity prices. This provides opportunity for more value-added agricultural output and to improve agricultural employment and livelihoods, especially when the cultivation involves small-scale farmers and the conversion facilities are located near the feedstock sources in rural areas.

Export development: Many countries see in biofuels an opportunity to develop a new export market for their agricultural produce and to increase export revenues. This stems from the fact that the main international consumers (northern countries) will not have the domestic capacity to supply their entire domestic demand, while many developing countries located in tropical and subtropical areas have, or may develop, advantages in biofuel production.

Climate change mitigation: Awareness of the adverse environmental impacts of fossil fuels and international commitments assumed under the Kyoto Protocol are increasing motives, especially for industrialised countries, to introduce alternatives such as biofuels within their energy portfolios. In developing countries, the prospect of attracting investment in the biofuels sectors, for example through carbon trading systems (e.g. the Clean Development Mechanism) is also generating significant interest in biofuels.

Decision Tree for Country Governments

Adoption of biofuels production and consumption can deliver any of these policy goals singly or in combination. Nonetheless, there are several challenges and trade-offs that CDDCs will need to confront. A careful identification and analysis of the opportunities, risks and trade-offs becomes essential before countries embark upon biofuels production to allow countries to identify a suitable role for biofuels within their development strategies and implement adequate comprehensive policies to increase the opportunities and minimise the risks and trade-offs involved.

To help guide such a process, a decision tree is given below. The decision tree can be worked through stepwise to assess first whether biofuels are an appropriate development pathway and then to map out key elements of the strategy for development. The first step is to make policy goals explicit, necessary because many of the later policy choices will depend on a clear understanding of the primary and secondary goals for biofuels development. The second step is determination of the possible array of feedstocks appropriate to the country.

Following these two preliminary steps, four key areas for analysis need to be covered: food security, environment, social and economic issues. For each of these, there is a central critical question for each of the four areas, with corresponding "red lights" for biofuels development – indicative conditions that are important enough to bring the wisdom of biofuels development into serious doubt for that country.

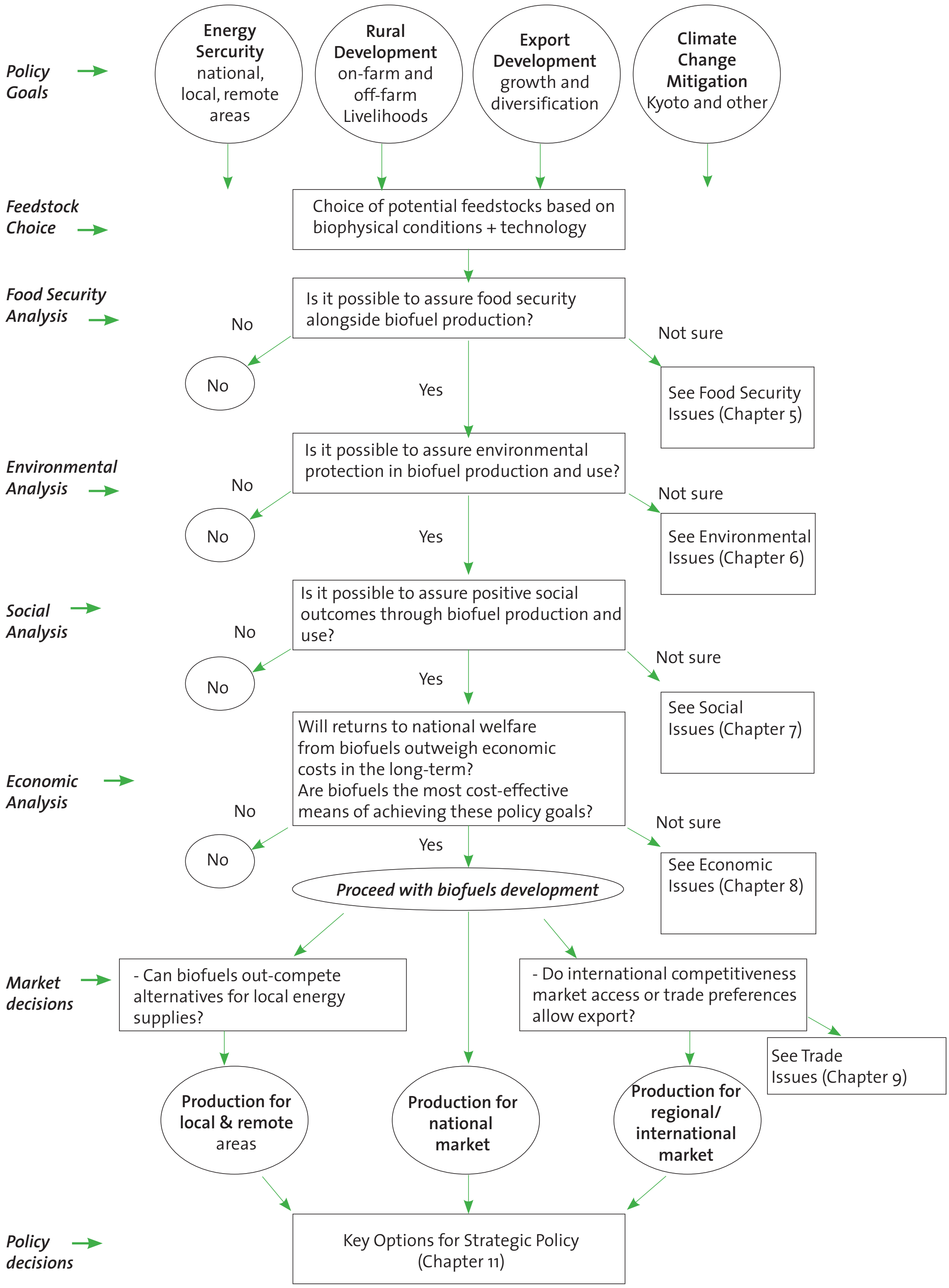
Once decision-makers have achieved an acceptable level of certainty that positive impacts will outweigh negative impacts in food security, environment, society and economics, a decision can be made to go ahead with biofuels development. The next key area for decision-making is around market options, particularly what combination of local, national or international production, delivery and consumption is most suitable, depending on policy goals. These decisions should be informed by clear understanding of the value chain as a whole, to ensure fair ownership of processing as well as production to maximise benefits to rural development.

Choice of Feedstocks

Since cultivation and harvest of feedstocks accounts for 50-75% of the total costs of biofuel manufacture, feedstock choice is critical Sugarcane is currently the most significant feedstock, for bioethanol, supplying 40% of global production. Sweet sorghum is a promising alternative, due to its low production costs, drought resistance and suitability for small-scale farmers. For biodiesel, feedstocks include palm oil, soy, jatropha, sunflower and castor oil. Biodiesel feedstocks in general require less extensive tracts of land for efficient production than do bioethanol feedstocks, and may be grown in combination with other crops. Water supply is a key determinant of feedstock choice. For example, while jatropha may be grown on marginal agricultural land, irrigation can quadruple yields. Rainfall variability has strong impacts on emerging biofuel industries. Greater efficiencies in feedstock production are expected to come from higher yields per hectare, through technologies such as fertilisers, pesticides, herbicides, mechanisation and genetic improvement of planting stock.

The economic viability of manufacture of biofuels from feedstocks will also be driven by technological change. For first generation bioethanol and biodiesel, the chemical processes are well established and most

Decision tree for strategic national choices on biofuel development



expense is associated with achieving purification to transport-fuel standard. Countries that have already established sugar refineries for the food industry have a strong headstart in bioethanol manufacture. Second-generation biofuels require more complex technologies, but can be manufactured from a much wider range of feedstocks: almost any kind of plant biomass, or agricultural and urban wastes. Second-generation biofuels are expected to achieve an energy balance of 5 (energy produced = 500% energy required for production), similar to the current energy balance for palm oil and lower than for bioethanol from Brazil.

Regarding feedstock choice, policy makers need to be cognisant of likely returns to investment for specific geographic regions or types of agricultural system (small-scale versus large-scale; irrigated versus dryland). Different kinds of feedstock may benefit different groups of producers, maximising either land-based or labour-based potential. A major opportunity comes through building on existing industries and "pathway" technologies, buying in South-South regional expertise in technology and management as appropriate.

Food Security Issues

Threats to food security are recognised as the primary drawback of large-scale biofuels development. Biofuel production stands to impact on both of the major dimensions of food security: availability (food supply from production and imports) and access (entitlements and distribution among society). At the international level, the growing demand for biofuels is expected to reverse the long-term downward trend in global prices of agricultural commodities. However, recent significant increases in global prices for several feedstocks have been more associated with weather-related shortfalls in agrifood markets in tandem with increasing demand for agricultural crops from newly industrialising economies rather than increased biofuel demand.

Historically, domestic food prices have not been tightly linked to international food or energy prices, but growing international trade in biofuels may see food prices becoming more directly driven by energy prices. In the longer term, a gradual end to subsidised overproduction of food in developed countries should remove market distortion and stabilise prices. Future development of second-generation biofuels will reduce the interdependency of agricultural and energy prices and the competition between food and fuels. Second generation biofuels are compatible with food production, using for example the non-edible parts of food crops, and so do not compete for land.

Hunger is largely a matter of relative access to food rather than overall supply. Higher agricultural commodity prices are good news for agricultural producers, but higher food prices have an adverse impact on poorer consumers. For rural households that are net producers of food, overall gains in welfare and food security are expected due to rising revenues from biofuel crops and food crops. But most rural households are actually net buyers of food. Rising prices of maize, and potentially of cassava, are hence a major concern. Concurrent rises in prices of all staples and agricultural produce will prevent consumers from substituting cheaper foodstuffs, leading more quickly to reduced variety and quality of diet. The impact of biofuel production on food security is of particular concern in countries, including a number of CDDCs, where chronic under-nutrition is already a major problem.

Indications that costs to food security will outweigh energy savings and export earnings from biofuels, or indications that food security will be compromised for specific social groups (e.g. poor urban and rural consumers, small-scale producers) should be taken as red lights to investment in bio -fuels development. In countries where a biofuels industry is under development, policies to maintain food security might include early warning systems for prices and distribution of staple foods, provisions for food production for local supply within biofuels areas, and continued or enhanced investment in research and development for agriculture, with an emphasis on multi-purpose cropping and small-scale farming systems.

Environmental Issues

Over their full life cycle ("well to wheel"), biofuels produce a complex mix of positive and negative environmental impacts. Demand for biofuels will be met through a combination of yield increases, displacement of other crops and expansion of the total agricultural land area. It seems unlikely that increased biofuel production will come through agricultural efficiency alone, so further land use conversion away from natural and semi-natural vegetation can be expected.

Large-scale estimates have been made for the future expansion of biofuel production without damage to existing agricultural systems or natural ecosystems, based on the use of "marginal" lands, but these do not take into account the current uses and functions of these areas for poor people's gathering of wild products for subsistence and cash, livestock grazing, wildlife corridors, maintenance of water quality, shifting agriculture, maintenance of soil fertility and biodiversity conservation. Biofuels also displace other economic and land use activities which then take place elsewhere – such "displacement issues" are not often well understood, or ignored. However, water rather than land may be the key limiting factor to biofuels production and processing in many localities.

Biofuels can reduce carbon emissions by absorbing and releasing carbon from the atmospheric pool without adding to the overall pool (in contrast to fossil fuels) and by displacing fossil fuels. However, production of biofuels does in most cases involve consumption of non-renewable fuels. While sugarcane-based bioethanol and second-generation biodiesel may achieve 70-100% reduction in greenhouse gas emissions relative to gasoline, cereal-based bioethanol shows lower reductions or even increases. Higher use of mechanisation and fertilisers, transport of fuels and land use changes away from natural forest are further contributing factors. In general, over their life cycle, biofuels are associated with lower levels of soil, water and air pollution than fossil fuels.

Second-generation biofuels will be produced from surpluses, wastes and by-products of agriculture and forestry, reducing environmental impacts relative to monoculture annuals used for first-generation biofuels and other cash crop purposes. However, second-generation biofuels generated through enzymatic breakdown are likely to be highly dependent on genetic modification. Several of the short-cycle woody plants that hold promise for second-generation biofuels are also known as invasive species.

Red lights for investment in biofuels development include movement of agricultural frontier into biodiversity-rich areas and protected areas, major diversion of water from production of food crops or other key uses, and predicted high risks to biosafety or biodiversity. Policy measures for environmental protection include appropriate systems of tax-based and regulatory incentives to counter economically and environmentally perverse incentives to convert natural landscapes, development of "best practice" regulations or incentives for on-farm production, and strategic use of opportunities in the carbon market at international level.

Social Issues

One of the key policy decisions for governments is the balance between large-scale and small-scale systems for production and processing of biofuels. In general large-scale systems are more globally competitive and export-oriented, while small-scale systems offer greater opportunities for employment generation and poverty alleviation. However, the two systems are not mutually exclusive and can interact successfully through outgrower schemes, cooperatives, marketing associations, service contracts, joint ventures and share-holding in the value chain.

Export-oriented biofuels production favours large-scale, mechanised agribusiness and concentrated land ownership, raising the threat of landlessness, deprivation and social upheaval for displaced small-scale farmers. The strength and nature of land rights will be a key determinant of patterns of land ownership under biofuel production. While biofuel production is expected to generate more employment per unit of energy than conventional fuels, it is not clear that job opportunities will compensate for losses to land. Furthermore, most jobs will be unskilled and seasonal, with decreases in labour demands as the industry becomes more efficient. More positive impact of biofuels on rural employment is likely to be oriented around local small-scale production and processing for local consumption. Similarly, social and economic multiplier effects from biofuels are expected to be highest under local investment, production and consumption.

Biofuels have the potential to increase access to affordable energy for isolated communities through small-scale decentralised biofuel programmes. Use of processed liquid biofuels for household cooking and heating could also help to reduce respiratory disease and death associated with burning solid biomass fuels indoors, to which women and children are especially vulnerable.

A predicted threat of serious disruption to rural areas – undermining of land rights, resulting landlessness, few alternative livelihood options and social upheaval – should be taken by policy makers as a red light to biofuels development. Policy measures to maximise social benefits include protection of communal and individual land rights, incentives for inclusion of smallholders in production, incentives for revenue sharing at all stages of the value chain, regulation of monopolies, and support to decentralised production and use of biofuels.

Economic Issues

Economic costs of biofuels differ widely depending on the type of biofuel, feedstock, the country of provenance and the technology used. Sugarcane-based bioethanol from Brazil is by far the most cost-efficient. The global price of fossil fuels is another key factor: if world oil prices remain high for a prolonged period of time, biofuel programmes have a better chance of becoming financially viable without sus tained government support in a larger number of countries.

Feedstock costs are critical as they account for the majority share of total costs of production, so that any changes in feedstock costs or prices can have an enormous impact on overall biofuel costs. Labour, other inputs, environmental compliance costs involved in the production process, the cost of conversion (including investment needs) and the revenues generated by the associated by-products also need to be included into the equation. The costs of biofuel production are scale-dependent, with higher costs for small-scale operations. An important implication of all this is that the economics of biofuels can be improved. Improvements not only crucially depend on increases in feedstock productivity and advances in technology, but also on the existence of suitable infrastructure for transport and distribution of both the feedstocks and the biofuel. Lack of infrastructure is a major constraint in many CDDCs and as such is an important factor undermining the commercial viability of biofuel production.

Experience to date suggests that the biofuels sector is not commercially viable without assistance, at least in the initial phases of sector development. Therefore long-term policy support is required, which exerts pressure on government revenues. Key lessons from experience suggest: policies need to lead from the specific policy goals for biofuel production in that country; policies need to be designed so as to reach the desired target group; governments tend to get higher returns on their public spending by fostering small-scale production due to the lowered demand for social welfare spending and greater economic multiplier effects; and the benefits and costs of these policy measures need to be carefully weighed against equivalent costs of the energy being replaced and those of other available alternatives.

The development of a biofuel sector requires channelling investment for feedstock production, processing and distribution – a major challenge in the context of CDDCs that have poorly developed financial systems and a high risk associated with investment. Governments play an important role in channelling the required investment. They need not only to provide the fundamentals of an enabling environment, but also to support access to credit especially for smaller rural producers, to facilitate policy and technical support to reduce the perceived sectoral risk, and to identify and facilitate new potential source of funds. Governments do not have to work in isolation, as other institutions (e.g. international financial institutions) also have a role to play in reducing political risk in developing countries.

Trade Issues

The different policy goals associated with biofuels highlight the strategic nature of the product and therefore the existence of some degree of protectionism in almost any producer country. Protectionism can be especially acute where energy security is associated with self-sufficiency or where biofuels are being promoted to help domestic farmers in high-cost producer countries.

Tariffs on bioethanol exports are especially high, but tariff escalation seems to be more pronounced in biodiesel trade. Tariff escalation favours processing and value-addition in the importing country. On the other hand, the level of the applied tariffs varies widely due to bilateral or regional trade agreements involving the US or the EU, which provide preferential market access for biofuels (especially bioethanol) imported from many developing countries. These trade preferences exert a large influence on the current patterns of trade.

Subsidies are another key concern. Probably every producing country, especially in the industrialised world, has some form of domestic support for the biofuels industry, including support to feedstock production, biofuel processing and commercialisation. Available experience with agricultural subsidies suggests they can have very harmful effects on developing countries' competitiveness and therefore hamper their efforts to build a successful biofuels sector. Last but no least, while technical and sustainability standards are certainly needed for the good performance of the industry and to assure the accomplishment of minimum levels of sustainability, their proliferation and divergence without mutual recognitions pose a major obstacle to CDDCs.

Trade opportunities for biofuels exports from CDDCs come not only from traditional Northern markets. Many exporting countries are increasingly targeting South-South or regional trade, taking advantages of their proximity to large Southern markets or to increase opportunities for energy regional cooperation. South-South cooperation can help to build domestic capacity for biofuels development. CDDCs can benefit from countries more experienced in biofuel production such as Brazil, China and India, which can help with technology transfer and developing global markets.

Overall, the development of a successful export-oriented biofuels sector involves more than land availability, good climate, cheap labour and preferential market access. It crucially depends on countries' domestic capacity to expand biofuels production efficiently, to have access to the required technology, to produce in compliance with relevant standards, to develop suitable transport infrastructure to reach exports markets, and to build sufficient capacity in policy implementation and project management to run biofuels production and processing effectively.

Value Share and Rural Development

In common with other bulk commodities, the rural development opportunities of biofuels will be realised through control over the value-added parts of the production chain and its economic multiplier effects. The potential for value to be created and retained in rural areas depends strongly on whether biofuels are being developed for local and sub-regional markets with small-scale production, or for large-scale commercial production for national or global markets, and also on the pattern of ownership. Community-level production may be particularly appropriate for fuel-importing land-locked regions where poor infrastructure and high transportation costs can make biofuels competitive with imported petroleum fuels.

Economies of scale tend to favour larger producers and land concentration, but policies to promote farmer ownership of links in the value chain such as transport and processing will do much to secure sustainable benefits to society. But for farmers to retain a stake in emerging commercial biofuels markets requires finance and organisation. To produce high-quality biofuel, commercial value chains are designed around consistency, reliability and traceability of supply, both significant barriers to market entry for small producers and their organisations.

Community-level production may be resilient in the face of changes in national and global markets. But large-scale production for national or global markets, which have been producer-driven and have had significant producer ownership, will likely short towards buyer-driven chains. Just because the biofuels industry is agri-based and job intensive does not necessarily mean that it will link smallholders and the informal economy effectively with the formal economy. Therefore public policies and mechanisms are necessary to encourage competition, reward local ownership, and promote revenue sharing.

Key Options for Strategic Policy

Once policy makers have examined the pros and cons of biofuels development associated with feedstock choices, food security, environmental, social, economic, trade and value chain issues, giving particular attention to the red lights for embarking on development of the industry, some more detailed aspects of policy may be considered.

Development of a strong biofuels industry is a long-term task. It requires a sustained commitment from governments in terms of budget allocation, inter-sectoral coordination and adaptive policy to provide an appropriate set of incentives for producers, processors and consumers. This will have a sizable impact on government's revenues. Long-term costs will need to be weighed against the net benefits of biofuels promotion to national welfare and also compared against of the costs of other policy options to achieve a specific policy goal Due to the dynamism of biofuels markets, governments also need to be prepared for constant review and adaptation, providing a flexible policy environment. Coordination and coherence among sectors (Ministries of Agriculture, Energy, Environment, Industry and Trade) and at the international level are crucial

In some cases there is potential for reaching synergies and win-win-win opportunities among the different policy goals associated with biofuels development. For example, it is possible for governments that are pursuing a biofuels programme for export development to shape the set of incentives and regulations to encourage participation by smaller producers and processors and hence to achieve rural development goals in tandem with export development.

The three broad types of market channels – biofuels for local-remote-landlocked areas, for the national market and for the international market – are best promoted through specialised sets of policy incentives. These include promotion and access of biofuels technologies, removal of constraints to sector development, underpinning of micro-finance and farmer organisations, incentives for broad-based ownership of the value chain, investment in infrastructure, negotiation of trade terms, strategic international partnerships for development of technology and management, and participation in international standards setting. These policy options focus on the supply side, and need to be supplemented by demand-side interventions such as national targets for biofuels or tax exemptions for biofuel consumption.

1. Overview

The biofuels industry got underway on a large scale in the early 1970s, within the PROALCOOL Programme in Brazil. But it is only in the last five years that biofuels have started to be taken seriously as an alternative to oil worldwide. Today we are witnessing a rapid expansion of global biofuel markets as many countries introduce ambitious policies to increase the proportion of biofuels in their energy portfolio.

Countries are introducing biofuels to achieve a range of different policy goals: to improve national or sub-national energy security, to promote rural development, to develop exports, to improve the balance of trade by reducing oil imports, and to pursue climate change mitigation policies. In some cases there might be synergies between the achievement of these different policy goals, but there may also be risks and tough trade-offs to confront for food security, society, environment and the economy. Strategic decision-making about the adoption of biofuels requires a careful and integrated analysis of all these issues.

The aim of this document is to provide commodity-dependent developing countries (CDDCs)[1] with a framework for strategic decision-making on entry into production and use of biofuels. It provides an overview of key issues, opportunities, risks and trade-offs in the development of a biofuel sector. Chapter 2 provides a brief introduction to biofuels and presents the key global trends in the market development, production and trade in biofuels. Chapter 3 explains the four main policy goals associated with the development of a biofuels sector and introduces a decision-tree tool to guide countries their decision-making regarding the biofuel sector. Chapter 4 gives an overview of feedstock choices. The next four chapters cover food security, environmental, social, economic and trade aspects associated with biofuel development, identifying for each the key issues and policy implications. Chapter 10 describes how value is created and captured within biofuels value chains, highlighting the implications for rural development. Finally, Chapter 11 provides key options for strategic policy on biofuels development.

1 *Defined by the CFC (2006) as "developing countries for which 50% or more of all merchandise exports are made up of non-oil commodities"; full list in Annex 1*

2. Biofuels: An Emerging International Market

2.1 What are biofuels?

Biofuels can be defined as fuels produced from biomass for purposes such as transport, heating, electricity generation and cooking[2]. They can be produced from agricultural and forest products and the biodegradable portion of industrial and municipal waste. This paper focuses on liquid biofuels: bioethanol and biodiesel, which account for more than 90% of global biofuel usage. The main use of liquid biofuels is in the transport sector. Biofuels can also be used for purposes such as domestic lighting, cooking and heating, especially in poor rural communities in remote or land-locked developing countries where the costs of fossil fuels transportation makes them prohibitive. Their performance for these other uses, however, needs to be assessed against that of other technologies such as biogas, micro hydro, wind and solar.

Bioethanol is alcohol produced by fermenting and then distilling sugars from sugar-rich plants (e.g. sugarcane, maize, beet, cassava, wheat, sorghum). The alcohol is then purified to remove water. Both anhydrous bioethanol (<1% water) and hydrous bioethanol (1-5% water) can be used pure as fuels, but they are usually blended with gasoline[3]. Blends of 5% or 10% of bioethanol in gasoline, denominated E5 and E10 respectively, do not require any modification to the vehicle engine.

Work is now underway to develop a "second generation" of bioethanol, based on cellulose rather than sugars. This technology will allow almost any plant biomass to be used for biofuels, including forestry products (e.g. short rotation coppices), sawmill wastes, crop residues (e.g. stalks, leaves and hulks) and energy grasses (e.g. switch grass), as well as waste paper and other industrial and domestic wastes. The most promising second-generation technology for bioethanol is enzymatic hydrolysis.

Biodiesel is produced from the reaction of vegetable oil with alcohol in the presence of a catalyst to yield mono-alkyl esters and glycerine, which is then removed. The oil comes from oily crops or trees (e.g. rapeseed, sunflower, soya, palm, coconut or jatropha), but also from animal fats, tallow and waste cooking oil. Some types of biodiesel can be used unblended or in high-proportion blends with modification to the vehicle engine. A blend of 5% of biodiesel is denominated as B5.

The new second generation of biodiesel involves a number of different technologies to produce biodiesel directly from non-fat biomass. For example, Biomass to Liquid (BTL) uses the Fischer-Tropsch process, which involves gasification of wood, straw or municipal waste to produce biodiesel.

Table 2.1 Selected examples of biofuel targets for transport around the world

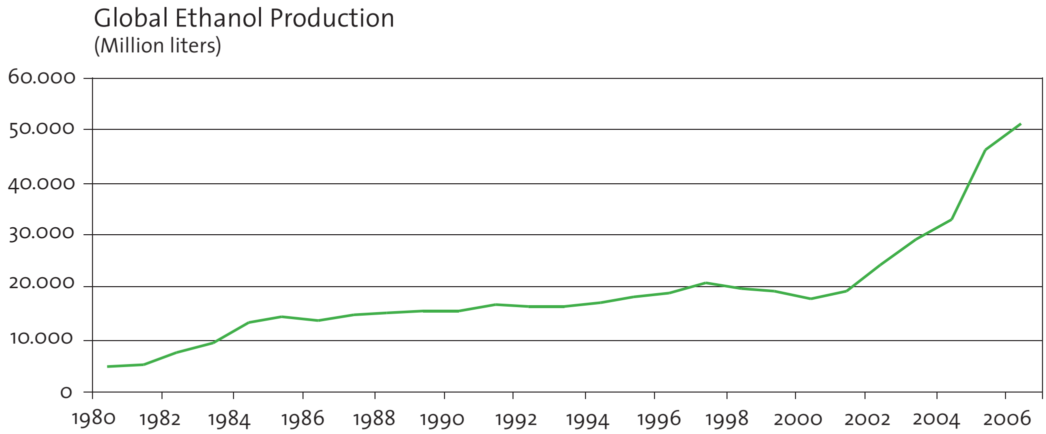
Country	Biofuels Target	Country	Biofuels Target
Argentina	B5 mandatory by 2010	Indonesia	
Bolivia	B20 mandatory by 2010	Japan	10% biofuel blend proposed; voluntary B5
Brazil	Minimum bioethanol blend (20-25%) B2, B5 and B20 by 2007, 2013 and 2020, respectively	Malaysia	Biodiesel act (proposed)
China	15% by 2020 (total renewables)	Mexico	Biodiesel legislation
Colombia	10% by 2009, with gradual increases to 25% in 15 to 20 years	Peru	B5 mandated 2010
Canada	5% biofuels by 2010	South Korea	Mandatory blending
Ecuador	10% bioethanol and 5% biodiesel in the near future	Thailand	10% biofuels blend by 2012
EU	5.75% "indicative" biofuels target by 2010;	US	Target of 28.4 billion litres by 2012 (5% gasoline consumption); January 2007: "20 in 10" promise (20% fuel from renewable sources in 10 years). 10% "binding" target by 2020
India	B5 biofuels in use in several states;	South Africa	3.4% of total liquid fuel by 2013 (4.5% of transport fuel) B20 by 2012

Source: Authors' elaboration from country data

2 *Note the difference between processed biofuels and unprocessed biomass fuels, such as firewood, charcoal, animal dung and crop residues that are burned directly for cooking, heating and industrial use*

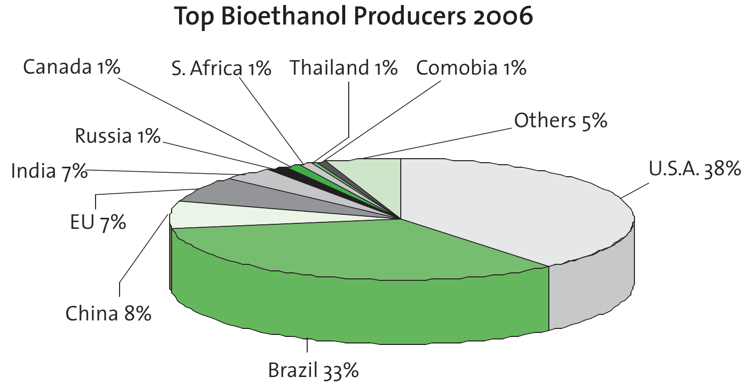
3 *Sometimes in a derivative form of ethanol, known as ethyl-tertiary-butyl-ester (ETBE)*

Figure 2.1 Global ethanol production



Source: Authors' elaboration based on data in Earth Policy Institute (based on F.O Licht data)

Figure 2.2 Top bioethanol producers in 2006



Source: Authors' elaboration based on data in Earth Policy Institute (based on F.O Licht data) boration from country data

2.2 Development of the global biofuels market

For transport, biofuels can compete with oil compared to alternatives such as hydrogen, because biofuel technologies are already well developed and available in many countries. Bioethanol and biodiesel can be mixed in low-blends with gasoline and diesel respectively, without engine modifications. Flexi-fuel vehicles (FFVs) can run with any type of fuel blend from pure gasoline to up to 85% biofuel blend. Fuel, infrastructure and vehicle technologies are now sufficiently well developed to allow the gradual introduction of biofuels into any country. Moreover, the current level of oil prices makes biofuels from the most efficient producing countries economically competitive.

The ambitious biofuels targets set by many countries in recent years reflect the new optimism about the potential of biofuels (Table 2.1).

2.3 Trends in biofuel production

Global biofuel production in 2006 was estimated to be over 55 billion litres. This figure is however very small considering that, only in terms of gasoline, some 1,200 billion litres are produced annually worldwide. Bioethanol made up 93% of global biofuels production in 2006, while the remaining 7% was biodiesel. Although bioethanol is produced around the world its production and consumption is strongly concentrated in the Americas. Biodiesel production and consumption is still strongly concentrated in the EU. Almost all biofuels are used in cars and trucks, though small quantities of bioethanol are used for aviation purposes (IEA 2006).

In terms of land use, it is estimated that by 2004 about 14 million hectares were being used for the production of biofuels – about 1% of global available arable land (IEA 2006).

Trends in bioethanol production: Bioethanol is by far the most widely used biofuel for transportation worldwide. Global production reached 51 million litres in 2006, with an average annual growth of 20% since the year 2000 (Figure 2.1). Bioethanol accounted for about 3% of global gasoline use in 2005 (UNCTAD 2006b). Brazil and the US together account for more than 70% of global production, but other countries also have significant and growing industries (Figure 2.3; Box 2.1). In 2006, the US overtook Brazil for the first time as the leading producer with 38% of global production.

Box 2.1 Bioethanol production around the world

Brazil produced 15 billion litres of sugarcane-based bioethanol, equivalent to 33% of worldwide production in 2006. Prompted by oil prices, Brazil began to produce bioethanol from sugarcane in the 1970s (through the PROALCOOL Programme) and is considered the most successful example of a commercial application of biomass for energy production and use. Extensive experience in bioethanol production, suitable natural conditions for sugarcane and low labour costs have made Brazil the most efficient bioethanol-producing country. Production is mainly destined for the domestic market, where bioethanol accounts for 41% of Brazilian gasoline consumption (Dufey 2006). Over recent years, exports have started to expand, but they still account for less than 15% of domestic production.

The US produces 38% of world output. Bioethanol started to be produced in the US from maize in the early 1970s. Thanks to recent introduction of aggressive policies to promote the bioethanol industry (e.g. introduction of a target through the Renewable Fuel Standard (RFS) and heavy tax incentives) production capacity increased from 4 billion litres in 1996 (Dufey 2006) to some 20 billion litres in 2006, and currently accounts for over 3.8% of national gasoline consumption (GMF 2007).

Other Americas: Canada contributes 1.1% of bioethanol global production, mainly produced from wheat and straw. In South America, sugar producing countries like Colombia, Peru and more recently Paraguay are taking measures to stimulate production and consumption of sugarcane-based bioethanol but also experimenting with high-sugar content crop varieties such as cassava. Traditional sugar producers in Central America and the Caribbean such as Costa Rica, Guatemala and Nicaragua and other Caribbean Islands are also taking measures to scale up bioethanol production.

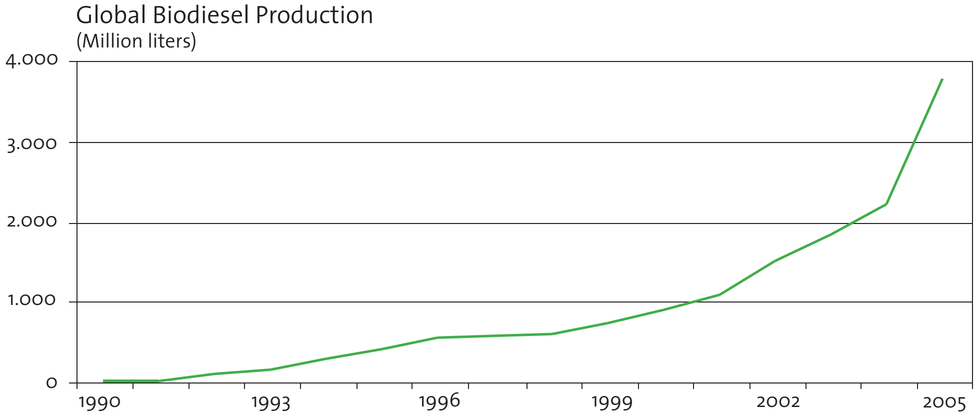
East Asia: China is the third largest producer in the world and accounts for 7.5% of global bioethanol production. About 80% of the bioethanol is grain-based, mainly derived from maize, cassava and rice. India accounts for 3.7% of global bioethanol production, largely based on sugarcane and cassava. Thailand, the world's second largest sugar exporter, produces 0.7% of global bioethanol production.

Europe produced 7% of the world's bioethanol in 2006. France is currently the front-runner in the EU's attempt to boost bioethanol, accounting for 2% of global production, mainly from sugar beet and wheat. France is followed by Germany (1.5%) and Spain (1%).

Africa: In Africa, traditional sugar-producing countries, such as South Africa, Kenya, Malawi, Zimbabwe, Mozambique and Ghana, are investing in increasing bioethanol production capacity. In addition to sugarcane, African countries are also exploring the use of other energy crops such as sweet sorghum and cassava.

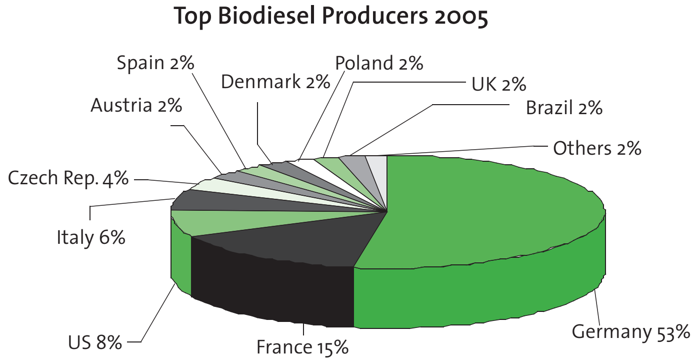
Oceania: Australia already contributes 0.3% of world bioethanol production and is also introducing measures to increase its production on the basis of sugarcane.

Figure 2.3 Global biodiesel production



Source: Authors elaboration based on data in Earth Policy Institute (based on F.O Licht Data)

Figure 2.4 Top biodiesel producers in 2005



Source: Authors' elaboration based on data in Earth Policy Institute (based on F.O Licht Data)

Bioethanol feedstocks: About 40% of global bioethanol production comes from sugarcane (notably Brazil, India) and maize (US and China) respectively, while the remaining 20% comes from other crops. In temperate countries, the latter mainly include beet, barley, wheat and wine residues (in the EU). Tropical countries, including some CDDCs, are experimenting with other high sugar content crops such as cassava and sweet sorghum. Feedstocks are described further in Chapter 4.

Trends in biodiesel production: While biodiesel technology has been established for some time, large-scale production began only in the 1990s. Since then production has increased steadily, reaching a record 3.7 billion litres in 2005, with an average annual growth of 33% since 2000 (Figure 2.3). Biodiesel production, however, is still fairly small compared to bioethanol and accounts for less than 0.2% of the diesel consumed for transport (UNCTAD 2006b). The biodiesel market is also strongly concentrated. Of the 2005 production, 90% was in the EU, with Germany alone accounting for 53% of global production (Figure 2.4). Other biodiesel producers include the US, Brazil and several other countries with biodiesel programmes in early commercial or research phases (Box 2.2).

Box 2.2 Biodiesel production around the world

Europe Biodiesel demonstration plants opened in Europe in the 1980s as a means to sustain rural areas while responding to increasing energy demand. The main feedstock was and is rapeseed, grown locally. After a decline in the early 1990s due to falling oil prices, production has dramatically increased led by strong policy incentives. Biofuels currently account for about 1.8% of EU transport fuel supply, of which biodiesel contributes 80%.

The Americas: in addition to the US (mainly soy-based) and Brazil (soy, palm oil, castor oil), countries such as Colombia and Ecuador are introducing measures to produce biodiesel from palm oil. Argentina is producing biodiesel from soy and expects to become one of the key global producers in coming years. These countries' interest in producing biodiesel not only focuses on fulfilling domestic demand but also on exploiting export opportunities.

Asia: Palm oil producers, notably Malaysia and Indonesia but also Thailand (palm oil and jatropha), are setting ambitious targets and channelling investment into biodiesel production, targeting both the local and international markets. India has also initiated an ambitious large-scale biodiesel programme based on jatropha for the domestic market.

Oceania: Pacific island nations are experimenting with both palm oil and coconut as biodiesel feedstocks, potentially highly competitive given the costs of transporting oil by sea. Coconut oil producers such as the Philippines and several Pacific nations are scaling up biodiesel production.

Africa: African countries including Burkina Faso, Cameroon, Ghana, Lesotho, Madagascar, Malawi and South Africa are exploring the potential of jatropha as a large-scale biofuel source. South Africa, Swaziland and Zambia have already set plantations at a commercial level.

Biodiesel feedstocks: Between 80 and 85% of EU production comes from rapeseed oil, which is equivalent to 20% of the total EU rapeseed production (Dufey 2006). However fierce competition within the food sector has dramatically increased the price of rapeseed oil, and it has begun to be replaced by soy, sunflower and palm oil, although in small quantities (GMF 2007). Elsewhere, soy is gaining preference in the US, Argentina and Brazil. Palm oil has the highest energy content of current biodiesel feedstocks and is the preferred choice for biodiesel in some Asian and Latin-American countries. There are a few early experiences with coconut oil in South East Asia (Philippines and other Pacific islands). Several dry tropical countries are experimenting with jatropha (some of them with plantations at the commercial level) and pongamia (India). Recycled oil and fats from the food industry can also be used for biodiesel, but this application is limited so far. Overall, biodiesel accounts for about 2% of global vegetable oil production (Johnston et al 2006). Feedstocks are described further in Chapter 4.

2.4 Trends in biofuel trade

The increased production and use of biofuels have led to a growing international trade, although the bulk of production is still consumed domestically. However, international trade is expected to grow very rapidly in the coming years, as the global increase in consumption will not coincide geographically with the scaling up of production.

Bioethanol: Bioethanol trade has shown a strong growth rate since early 2000. Brazil is the main global exporter, increasing its exports considerably over the last few years and today supplying about 50% of international demand for bioethanol. The main destinations for Brazilian bioethanol exports in 2004 were India (20%), the US (18%), Korea (10%) and Japan (9%). The Brazilian government expects that by 2015 about 20% of the national production (8.5 million litres) will be exported (Ministerio da Agricultura et al 2006). Other exporters include Caribbean countries, China, the EU, Pakistan, Peru, Ukraine, Zimbabwe and Swaziland. While in EU countries exports are destined to other European countries, in countries from the

Caribbean Basin Initiative (CBI) such as Guatemala, Costa Rica, El Salvador and Jamaica, bioethanol is reprocessed in the region and then re-exported to the US, where they enjoy preferential market access.

Worldwide the US is the main importer of bioethanol, accounting for 31% of global imports (Dufey 2006). Indeed, in spite of the dramatic increase in production, bioethanol consumption has been outpacing production in the last few years, leading to increased bioethanol imports. During 2006, the US imported the equivalent to 13% of the domestic production of bioethanol, a dramatic increase from 3% in 2005. Main sources were Brazil (62%), Jamaica (9%), China (6%), Costa Rica (5%) and El Salvador (4%).[4] The EU, Japan, Korea and Taiwan are also bioethanol importers and their dependence on imports is likely to increase in the future due to their ambitious targets for biofuels and their limited land for domestic production.

Developing countries such as Ghana, Sri Lanka, and Myanmar are also importing bioethanol, though in small quantities (UNCTAD 2006a). Even though the final use of the bioethanol is not known, this may show the potential of bioethanol in developing countries, including CDDCs.

The bioethanol feedstocks trade, on the other hand, seems not to be strongly affected by the development of the bioethanol market. In the case of sugarcane, for instance, UNCTAD (2006a) states there are no signs the increased bioethanol production has had any impact on feedstocks trade, which suggests that sugar and sugarcane are not traded for bioethanol production purposes. The main reason is that bioethanol production from sugarcane is a widely available cheap process, whereas the cost of transporting raw sugar is prohibitive. Trade in other feedstocks such as maize and molasses have also remained stable.

Biodiesel: Trade in biodiesel is at a less developed stage than trade in bioethanol, and data is therefore even patchier. Biodiesel trade statistics are not exact since biodiesel was only included within the Harmonised System in 2005 and there is no strictly defined HS code[5]. However, trade in key feedstocks shows early signs of impacts. According to UNCTAD (2006a), trade in all uses of vegetable oils has increased significantly, especially for two types of oils: soya bean oil and palm oil. However, while recent developments on the biodiesel market have not had a marked impact on soya bean oil trade, there are more pronounced signs of impacts on the palm oil trade. For instance, the EU, the main biodiesel producer, currently imports rapeseed from the Black Sea region, soy from Argentina, Brazil and the US, and palm oil from Malaysia. Although the majority of the imported palm oil is used by the food industry (as a substitute for rapeseed oil), the share of imports of palm oil for industrial use increased by a factor of 3.4 between 2001 and 2006, accounting for about half of vegetable oil imports (GMF 2007).

Beyond the EU, Malaysian biodiesel is also targeting a regional demand – notably China (IEA 2006) – but also preparing to export to countries such as Colombia, India, South Africa and Turkey. In addition, the US recently started to import small amounts of palm oil-based biodiesel from Ecuador. It intended to import 170 million litres in 2006, and more than 379 million in 2007, exceeding therefore the 284 million litres produced by the entire US biodiesel industry in 2005 (Pioneer Press 2005).

2.5 Biofuels markets: looking ahead

Production and consumption: World biofuel production is set to increase rapidly in the coming years driven by greater demand for road-transport fuels. IEA (2006) in its reference scenario predicts that by 2030 global energy use in this sector will be 55% higher than in 2004. According to the same source, world biofuel production will grow between 7% and 9% every year, reaching between 4% and 7% of the world road fuel use by 2030. The final rate of biofuels penetration would depend on whether countries' policies enacted or adopted by mid-2006 remain in place (reference scenario) or whether new policy measures to encourage production and use of biofuels are introduced (alternative scenario). Bioethanol is expected to account for the lion's share of the increase in biofuels global use, as production costs are expected to fall faster than those of biodiesel. Lichts (2005) predicts that bioethanol will make up 4% to 5% of gasoline use by 2010. These estimations do not include the role of the second-generation biofuel technologies being developed

4 Author's estimations based on data from RFA 2007
5 The most commonly used is HS 3824 9099

today, which could allow biofuels to play a much bigger role in the long term.

The biggest increases in biofuels consumption are expected in the US, already the biggest global consumer, and in the EU, which will overtake Brazil as the second largest consumer. Biofuel use outside of these regions is expected to remain modest, with the largest increases in Asian developing countries, notably China and India. In terms of land use, according to the IEA scenarios, the share of the world's available arable land devoted to biofuels is expected to reach between 2.5% and 3.8% (from 1% in 2004). Land availability and the impacts on the food market will be the key issues limiting growth in the first generation of biofuels.

Trade: International trade in biofuels is expected to expand significantly, but the bulk of biofuels consumed worldwide will continue to be domestically produced, given the existing trade restrictions. Brazil is expected to remain the largest bioethanol exporter. However, low cost producers from Asia (e.g. Thailand), Africa (e.g. Malawi, Zimbabwe, Mozambique and Zambia) and Latin American and Caribbean countries (e.g. Guatemala and Colombia) may also emerge as significant exporters. Regarding biodiesel, countries such as Malaysia, Indonesia and the Philippines are set to become significant exporters, especially of biodiesel derived from palm oil.

In spite of the policy measures to increase its self-sufficiency, the US is expected to continue being a key importing country. Indeed, the stronger demand will be served both by internal production and imports, mainly from countries that benefit from preferential market access (e.g. CAFTA-CBI countries) and Brazil. In the EU, given internal land constraints and pressure on feedstock prices, meeting the biofuel targets (an indicative 5.75% for 2010 and a mandatory 10% by 2020) will require significant volumes of both imports and locally produced biofuels. EC (2007a) suggests that by 2020 imports would serve about 20% of the EU biofuel production –about half of them would be form first generation feedstock and mainly oilseeds and vegetable oils. Other promising import markets are likely to be Asian countries like Japan, Korea and Taiwan, which have very little land available for increased production. In Japan, for example, biofuel demand is set to grow rapidly. Almost all the country's biofuel will need to be imported (Dufey 2006). China and India are also set to become net biofuel importers.

2.6 Prospects for biofuel development in CDDCs

As the above analysis suggests, so far the participation of CDDCs in this new market has not been significant. Biofuel production is dominated by the largest countries that have strong biofuel policies already in place. CDDCs' participation is mainly limited to sugar-producing countries in the Caribbean and Africa and in some very early experiences with jatropha and coconut in some CDDCs in Africa and the Pacific islands. However, it should be noted that in some CDDCs such as Malawi, biofuel production is not new. Malawi initiated its bioethanol programme in 1982 and has a current production capacity of 18mn litres per year. The government of Malawi, like many other governments in Africa including Mali and Burkina Faso, is also encouraging the planting of jatropha for biodiesel production.

On the trade side, with the exception of Brazil, which exports to several countries around the world, most exporting countries concentrate on consumer countries, such as the EU, the US and Japan, where they enjoy preferential trade access. However, the expected mismatch between global demand and supply also presents export opportunities for other low-cost producer developing countries (including CDDCs), especially those located in tropical areas that have comparative advantages in feedstock production. Many countries can also find benefits in developing a regional market for their biofuels.

3. Strategic Choices for Biofuels: Four Policy Goals and a Decision Tree

Development of biofuels in the early 1970s was motivated by concerns over world oil prices and hence the need to increase national energy security and reduce the import bill, although rural development appeared in a later stage. The end of the oil crisis in the late 1970s diminished interest in biofuels. Current high oil prices imply that the goals of greater energy security and reduction of oil import bills are still at the heart of the policy agendas behind the renewed global interest in biofuels. Nonetheless, many of the new biofuels programmes are being conceived and driven as part of farm-support policies or ways to provide new end markets for agricultural products, reducing global stocks and therefore providing new opportunities for rural employment and income. A further new driving force behind this renewed global interest in biofuels is their alleged role in reducing greenhouse gas emissions. This would help countries to combat the global warming problem and would enable them to comply with commitments under the Kyoto Protocol.

Countries are likely to have different combinations of policy goals when considering development of a biofuels industry. To be able to make strategic choices and trade-offs, it is important to start the process with a careful consideration of the policy goals applicable in a particular country. The four main policy goals behind biofuels adoption are outlined below.

3.1 Four main policy goals for biofuels production

Policy Goal 1: Energy security

Enhanced energy security has become a universal geopolitical policy concern and is the key policy driver behind the first attempts to introduce biofuels at a massive scale in the mid-1970s (e.g. Brazil). Today, the increasing energy costs and uncertainty regarding future energy supply are giving many governments incentive to encourage the production of petroleum substitutes from agricultural commodities. Indeed, the volatility of world oil prices, uneven global distribution of oil supplies, uncompetitive structures governing the oil supply and a heavy dependence on imported fuels are all factors that leave many countries vulnerable to disruption of supply, imposing serious energy security risks (Dufey 2006).

Energy diversification makes countries less vulnerable to oil price shocks, which can compromise macro-stability, and affect variables such as the exchange rate, inflation and debt levels (Cloin et al 2007). Biofuels are a rational choice in those countries where feedstocks can be produced at reasonable cost without adverse social and environmental impacts.

For remote places, biofuels that are locally produced can offer a highly competitive alternative to other fuels. This is relevant to CDDCs such as Pacific island nations and land-locked countries in Africa where the high costs of fossil fuel transportation and the related logistics make them prohibitive. For instance, in Buka town in Papua New Guinea, the petrol pump price for diesel in Port Moresby was K2.68 a litre, while coconut diesel was selling at K2 a litre (Kokonut Pacific 2006).

Energy security at the local level as well as the national level can be a motive for biofuels development. Biofuels offer a promising alternative to traditional biomass fuels and fossil fuels for domestic uses and small-scale industries. This is especially true where transport costs for fuels are high, such as remote land-locked regions or small islands.

Closely linked to the policy goal of energy security is the goal of reducing the oil import bill. At least two-thirds of the 43 CDDCs are net oil importers. Oil import dependency is especially acute in Sub-Saharan and East Asian countries, where 98% and 85% of their oil needs are met by imports, respectively (ESMAP 2005a). Changes in oil prices have devastating effects in these countries. For instance, the 2005 oil price surge reduced GDP growth of net oil importing countries from 6.4% to 3.7%, and, as a consequence, the number of people in poverty rose by as much as 4-6%, with nearly 20 countries experiencing increases of more than 2% (ESMAP 2006). Domestic biofuel production offers oil importing CDDCs an opportunity to replace oil imports and improve their trade balance. The experience in Brazil, for instance, suggests that replacing imported gasoline by bioethanol saved the country some US$ 43.5 billion between 1976 and 2000 (US$1.8 billion/year) (Dufey 2006).

Policy Goal 2: Rural development

A primary motivation for the promotion of biofuels is rural development. Biofuels generate a new demand for agricultural products that goes beyond traditional food, feed and fibre uses. This may reduce the volatility of commodity prices while reducing commodity surpluses. It also provides an opportunity for more value-added for agricultural output. All of these aspects enhance rural development, especially in developing countries. For instance, the Colombian Government estimates that sugarcane-based bioethanol production will increase the country's GDP by 3% with most positive effects accruing in rural areas (Dufey 2006).

Biofuel production can be used to improve agricultural employment and livelihoods, especially when the cultivation involves small-scale farmers and the conversion facilities are located near the crop sources in rural areas. For instance, 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 case of the Brazilian bioethanol industry, it has provided more than half a million direct jobs. Most bioethanol-related jobs involve low-skilled and poor workers in rural areas.

Biofuels can also provide opportunities for agricultural diversification. For instance, the reform of the EU sugar regime implies that biofuel production could provide an opportunity for diversification for many traditional sugar-producing CDDCs in Africa and the Caribbean whose sugar exports enjoy preferential access to this market. In the case of the Caribbean, the preferences erosion would mean a 40% reduction in sugar revenues. Biofuels are also being promoted as production alternatives to less desirable crops such as coca in Colombia and tobacco in Malawi.

It must be noted however, that large-scale production of biofuels will have complex effects on development, with both positive and negative social outcomes likely in rural areas. These issues are explored further in Chapter 7.

Policy Goal 3: Export development

Many countries see in biofuels an opportunity to develop a new export market for their agricultural produce and to increase export revenues. This stems from the fact that the main international consumers (northern countries) will not have the domestic capacity to supply their entire domestic demand, while many developing countries located in tropical and subtropical areas have, or may develop, advantages in biofuel production. On average, biomass in tropical and subtropical areas is five times more productive, in terms of photosynthetic efficiency, than biomass produced in temperate regions (Johnson et al 2006).

Countries with large land endowments and with significant cost advantages in agricultural commodity production, those with long experience in feedstock production and trade but facing strong pressures to diversify their industries, and those enjoying from preferential access to key consumer countries are already expanding production or seizing the opportunities from supplying biofuels to the international market. Targets may not only involve traditional North-South trade but also regional South-South trade (see Chapter 9 for more information).

Policy Goal 4: Climate change mitigation

Climate change is considered the most serious environmental threat facing the world. The transport sector, including emissions from the production of transport fuels, is responsible for about one-quarter of energy-related greenhouse gas (GHG) emissions, and that share is rising (Worldwatch Institute 2006). According to the International Energy Agency, biofuels in transport are expected to enable a 6% global GHG reduction. However there are mixed views among the scientific community regarding the actual GHG reductions associated with biofuels.

The growing global awareness of the adverse environmental impacts of fossil fuels, and the international commitments assumed under the Kyoto Protocol are motivating a growing number of countries, especially industrialised countries, to introduce alternative energy options, including biofuels, within their energy portfolios.

In developing countries, the prospect of bilateral or multilateral aid transfers for climate change mitigation is also generating significant interest in biofuels. Developing countries do not currently have binding GHG reduction targets under the Kyoto Protocol and are typically more concerned with potential climate change impacts than with reducing their own GHG emissions (Kojima et al 2005). The Clean Development Mechanism (CDM), however, offers to developing countries an opportunity to benefit directly from investment in mitigation technologies that generate GHG reduction credits for industialized (Annex I) countries.

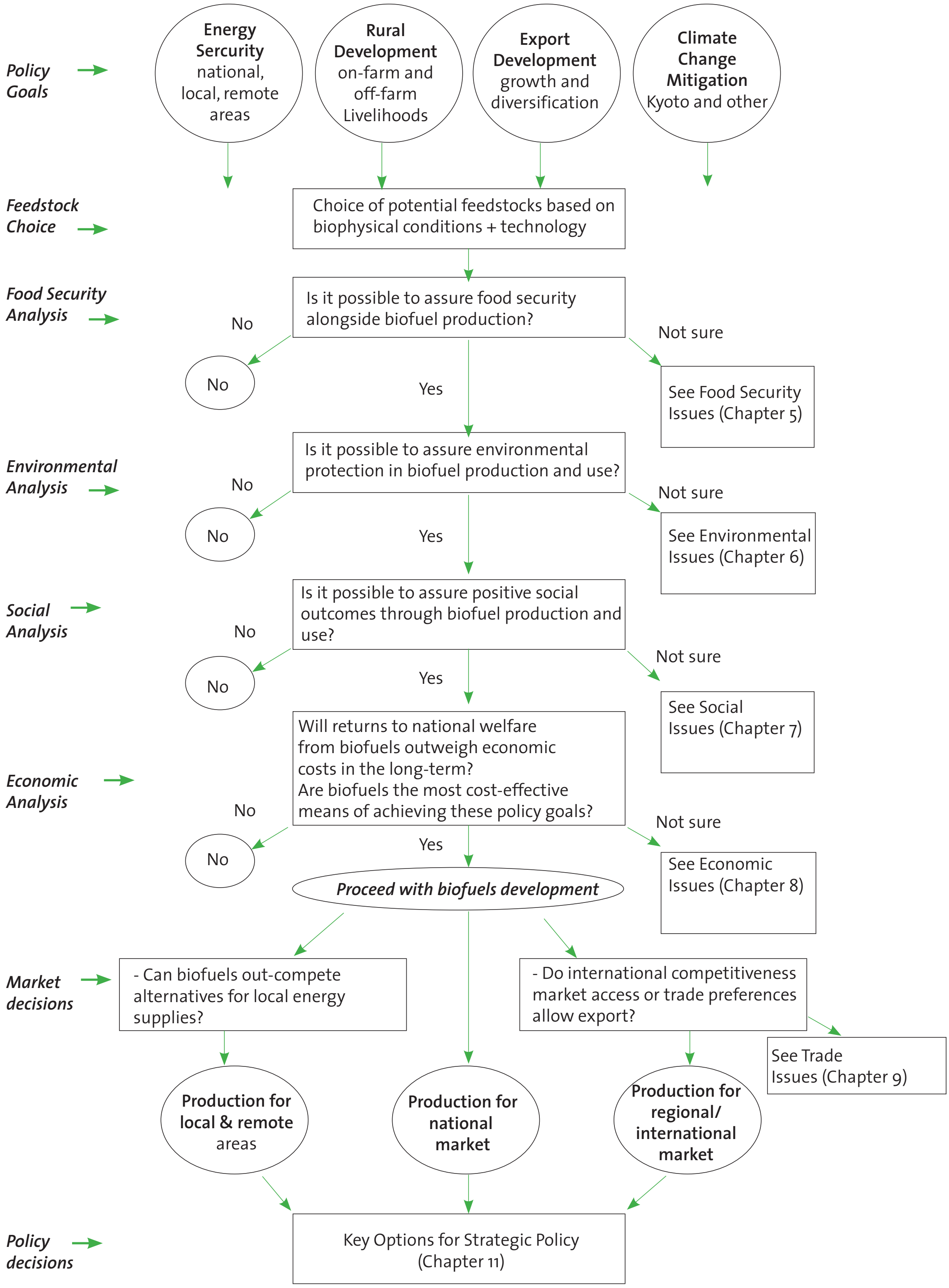
3.2 Decision Tree

Biofuel benefits are anything but straightforward. While biofuels can certainly serve to achieve several of the aforementioned policy goals, there are a number of challenges and trade-offs that CDDCs will need to confront. These challenges and trade-offs vary largely depending on the type of policy goal to be achieved, the type of biofuel technologies, feedstocks used and the country's conditions. A careful identification and analysis of the opportunities, risks and trade-offs becomes essential before countries embark upon biofuels production. Such an analysis will allow countries to identify a suitable role for biofuels within their development strategies and to implement comprehensive policies to increase the opportunities and minimise the risks and trade-offs involved.

To help guide such a process, a decision tree is given below to lay out in sequence the issues and critical questions that need to be covered in determining the suitability of biofuels development and the elements of a biofuels strategy (Figure 3.1). The decision tree can be worked through step by step, as follows:

1. The first step is delineation of the policy goal, or mix of policy goals, that decision-makers hope can be achieved through development of biofuels – necessary because many of the later policy choices will depend on a clear understanding of the primary and secondary goals for biofuels development (see the earlier part of Chapter 3 for a summary of the main policy goals).
2. The second step is determination of the possible array of feedstocks appropriate to the country – necessary because many of the details of social, economic and environmental impacts will depend on whether production is geared towards bioethanol or biodiesel, and the specific feedstock in use (see Chapter 4 for a discussion of feedstock choice).
3. Following these two preliminary steps, four key areas for analysis need to be covered: food security, environment, social and economic issues. For each of these four areas there is a chapter within this text that lays out the key issues and policy implications (Chapters 5 through 8). Note that the decision tree presents a central critical question for each of the four areas. Corresponding to the critical question is one or more "red lights" for biofuels development – indicative conditions that are important enough to bring the wisdom of biofuels development into serious doubt for that country. As well as the "red lights", each of these four chapters presents a set of promising options to maximise benefits from biofuels.
4. Once decision-makers have achieved an acceptable level of certainty that positive impacts will outweigh negative impacts in food security, environment, society and economics, a decision can be made to go ahead with biofuels development. In addition, much of the strategy for appropriate biofuels development will have become clear through the process of sequential analysis.
5. The next key area for decision-making is around market options, particularly what combination of localised, national or international systems is most suitable. This decision should be informed both by trade issues (Chapter 9) and by a careful consideration of how value accrues along the chain (Chapter 10).
6. Finally, once it is clear that biofuels industry development is an appropriate pathway for achieving policy goals, there are a number of more detailed policy decisions to be taken (Chapter 11). These include both overarching considerations, such as the long-term nature of investments and policy coherence, and scale-specific policy considerations that differ among localised, national and international market options.

Figure 3.1 A decision tree for strategic national choices on biofuel development



4. Choice of Feedstocks

4.1 Biophysical considerations

Cultivation and harvest of feedstocks accounts for 50-75% of the total costs of biofuel manufacture (OECD 2006). Thus the choice of feedstock and careful management of the production process are "make or break" considerations in biofuel production.

Sugarcane is currently the most significant feedstock, for bioethanol, supplying 40% of global production (see Section 2.3). It requires extensive land areas and plentiful water (Table 4.1), though new varieties such as "energy cane" are productive at much lower levels of rainfall or irrigation. Among the alternatives suitable for CDDCs, sweet sorghum is a particularly strong contender, due to its low production costs (about 40% of costs for sugarcane) and suitability for small-scale farmers. Sweet sorghum is a multi-purpose crop, potentially yielding both bioethanol (from the cane) and food (grain) and is suitable for cultivation in dryland areas such as the 23.4 million hectares of Africa currently used for production of grain sorghum (ICRISAT 2007).

Meanwhile, for biodiesel, the primary feedstock is rapeseed, largely grown and processed in Europe (see Section 2.3). The future may see greater reliance on tropical feedstocks for biodiesel. Of these, palm oil provides particularly high yields per hectare, but is only suitable for lowland areas with a high water supply (Table 4.1). Jatropha, sunflower and castor oil offer promising alternatives. Biodiesel feedstocks in general require less extensive tracts of land for efficient production than do bioethanol feedstocks, and may be grown in combination with other crops (e.g. in Madagascar, jatropha is already grown alongside vanilla to provide physical support).

The importance of water to feedstock production should not be underestimated. It is well known that jatropha can grow on marginal lands – but a farmer can expect yields too to be marginal under these conditions. Irrigation can quadruple yields (Table 4.1). Rainfall variability has proven to have strong impacts on emerging biofuel industries, such as when drought caused a major dip in sugarcane supply in Thailand in 2005 (ESMAP 2005b). Achieving target yields through reliance on irrigation will have corresponding effects on water reserves and aquifers (see Chapter 6 on Environmental Issues).

4.2 Technological considerations

Current thinking is that the best way to reduce the costs of production of feedstocks is to increase yields per hectare while keeping additional costs down (ESMAP 2005b). The technologies to achieve such gains include fertilisers, pesticides, herbicides, mechanisation and genetic improvement of planting stock, particularly through GM. All of these options

Table 4.1 Rainfall requirements and yields of major biofuel feedstocks

Crop	Rainfall requirements	Crop Yield	Potential fuel yield (high end)
Biodiesel crops			
Palm oil	2000 mm/yr upwards	5 t/ha fruits from young plants, rising to 21 t/ha with mature plants under good management	6000 l/ha
Jatropha	500 mm/yr upwards Can survive at 250 mm per annum but does not produce seed	2 t/ha seed rainfedup to 12 t/ha seed under irrigation at rainfall equivalent of 1500 mm/yr	700 l/ha
Sunflower	600-1000 mm/yr	0.8-1.5 t/ha seed rainfed / 2.5-3.5 t/yr seed irrigated	1000 l/ha
Castor oil	400 mm/yr upwards	0.6-1.5 t/ha seed rainfed / 2.2-4.0 t/ha seed irrigated	1400 l/ha
Soy	450-700 mm/yr	1.5-2.5 t/ha beans rainfed / 2.5-3.5 ton/ha beans irrigated	700 l/ha
Bioethanol crops			
Sugarcane	1500-2500 mm/yr	50-150 t/ha cane (10-12% sugar)	6500 l/ha
Maize	500-800 mm/yr	6-9 t/ha grain with irrigation, much lower without	3100 l/ha
Sweet sorghum	450-650 mm/yr	0.8-1.3 t/ha grain rainfed / 3.5-5.0t/ha grain irrigated	3700 l/ha (cane + grain)
Cassava	600mm/yr upwards	3-8 t/ha tubers in Africa (potential yields are as much as 80 t/ha)	5000 l/ha

Note: These figures are indicative and do not highlight the continuing development of high-yielding low-input crop varieties. Sources: For rainfall and crop yield data, jatropha from *Jatrophabiodiesel.org* & other crops from FAO; for fuel yield data, castor oil from *journeytoforever,org*, sweet sorghum from ICRISAT 2007, cassava from *www.cassava.org* & other crops from Worldwatch Institute 2006 carry environmental costs and risks (see Chapter 6 on Environmental Issues) and may also require capital investment beyond the scope of small-scale farmers in particular.

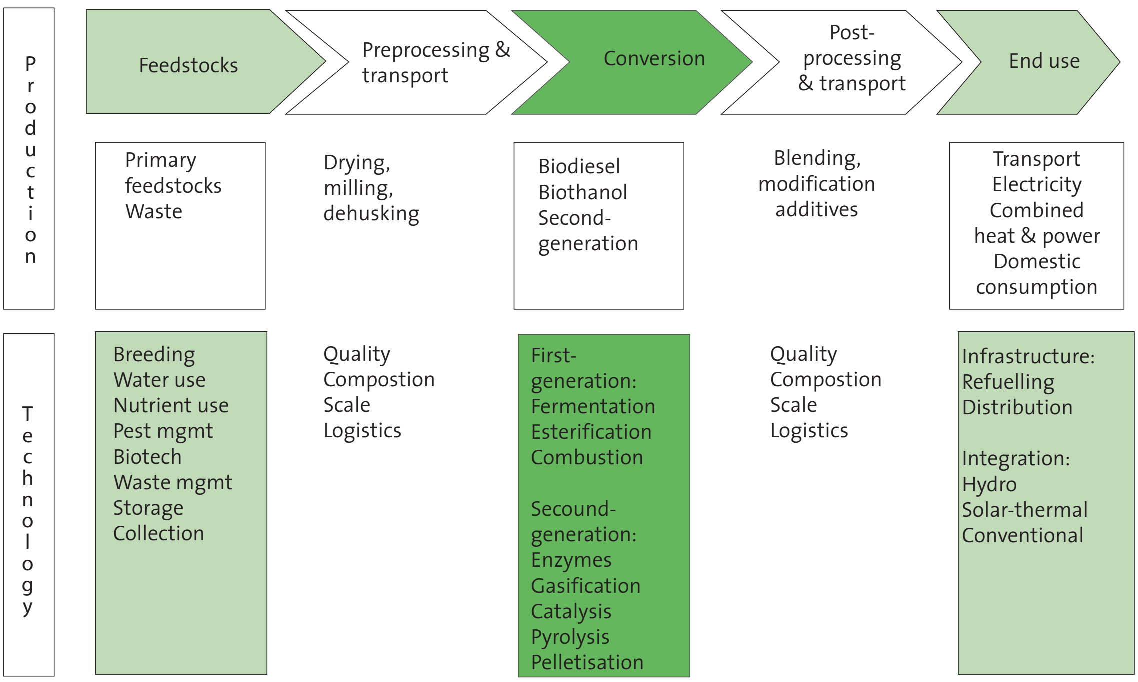
Biodiesel manufacture relies on a fairly simple esterification process that has remained much the same for the past two decades (Turner et al 2007). At present, most biodiesel manufacture occurs in Europe, meaning that other feedstock-producing countries export unprocessed or partially processed oil rather than biodiesel itself. (Worldwatch Institute 2006). Technologies for second-generation biofuels, which entail the manufacture of biodiesel directly from cellulose, are developing rapidly. A number of different chemical engineering options are under development, including gasification (Fischer-Tropsch), pyrolysis (heating in the absence of oxygen) and enzymatic breakdown (Figure 4.1).

For bioethanol, the manufacturing process involves fermentation, distillation and drying. Traditional technologies exist all over the world for manufacture of bioethanol (e.g. *alcohol brulée* distilled from sugarcane in villages in Madagascar, or *cachaça* in Brazil), but manufacture to transport-fuel standard requires almost complete removal of water from the final product and is thus a more complex process. Processing occurs locally and international trade is in bioethanol rather than in unprocessed or semi-processed feedstocks (see Chapter 2). Sugarcane deteriorates rapidly after harvesting, which limits the time between harvest and preliminary processing and hence the catchment area of the processing plant or biorefinery (this is also true for palm oil).

The costs of establishing biorefineries for bioethanol and biodiesel are discussed in Chapter 8 on Economic Issues (see also ESMAP 2005b). From a technological perspective, the existence of "pathway" technologies will do much to enable development of a biofuels industry – it is considerably easier to establish bioethanol plants if refineries for the food industry are already functional (Worldwatch Institute 2006). Nonetheless, considerable and protracted support is required. Brazil's ability to reduce the cost of processing to be able to produce the world's cheapest unsubsidised bio-ethanol was a result of sustained government investment from the 1970s (UNCTAD 2006).

Efficiency of energy production is also an important consideration in choice of feedstocks. Calculation of the overall energy balance of any biofuel relative to oil or other fuels is a complex procedure that must take into account the full lifecycle of the fuel ("well to wheel"). Current estimates suggest that sugarcane in Brazil has the

Figure 4.1 Technology requirements in the biofuels value chain



Source: Adapted from Woods 2006

most positive energy balance (mean ratio of 8.3, i.e. 8.3 joules produced for every joule of fossil fuel used), with a ratio for maize-based ethanol of around 2, palm-based biodiesel 5.6, castor-based biodiesel 4.2 and soy-based biodiesel 1.4 (Dufey 2006). Jatropha is expected to have the best energy balance among the biodiesel feedstocks. Second-generation biofuels could achieve an energy ratio of around 5.

4.3 Second-generation and other feedstocks

Second-generation biofuels are based on extraction of energy from cellulose rather than from sugars (bioethanol) or fats (biodiesel). Second-generation biofuels are more difficult to extract than first-generation (via processes such as enzymatic breakdown and gasification; Figure 4.1) but have several advantages. As well as much greater resilience during processing, storage and transport, and use of a much higher proportion of total plant biomass, second-generation biofuels are obtainable from a wider variety of feedstocks, which can be grown under a wider range of biophysical conditions. Almost any plant matter is an appropriate feedstock, including fast-growing scrub and shrubs from marginal lands. Second-generation biofuels are also an effective use of wastes, e.g. from forestry industries, crop residues and urban refuse.

Other than cellulosic second-generation fuels, other potential feedstocks include some already grown widely in some CDDCs, such as groundnuts and coconut, as well as wastes from other industries, such as used vegetable oil from the catering industry or animal fats from the meat packaging industry (Worldwatch Institute 2006).

4.4 Policy implications

Red lights for production of a specific feedstock:

- Mismatch of feedstock to prevailing biophysical conditions
- Any clear indication that returns are unlikely to outweigh costs for a particular geographic region or type of agricultural system (e.g. South Africa has rejected biofuel feedstock production as a viable development for small-scale farmers)

Policy measures to select and develop appropriate feedstocks:

- Weigh up both the costs and returns of alternative feedstocks – and the likelihood of benefiting different groups of producers (e.g. wetter versus drier regions of the country; agrifood industry versus individual farmers; richer farmers versus poorer farmers)
- Weigh up land-based and labour-based potential, such as the high available areas and labour forces for biofuel feedstock production in the SADC countries of Africa (Johnson and Rosillo-Calle 2007) against the necessary investments in technology, management and regional trade cooperation
- Build on existing industries and "pathway" technologies – for example the most potential to develop a strong bioethanol industry is in countries that are already major exporters of sugar (two CDDCs, Peru and Cuba, are currently among the world's top 20 sugar exporters)
- Buy in South-South regional expertise in technology and management (e.g. Caribbean countries are recommended to invest in advice from the Brazilian industry – see Bauen et al 2006; India has important experience with jatropha development – see www.jatrophabiodiesel.org)
- Track developments in second-generation biofuels to enable early adoption if appropriate

5. Food Security Issues

Threats to food security are recognised as the primary drawback of large-scale biofuels development. Hence we recommend that the first step in strategic analysis of the potential for biofuels in a particular country is to consider possible effects on food security (see Decision Tree in Chapter 3). Empirical data remain limited and hence much discourse around food security impacts depends on models rather than experience.

5.1 Key issues

On a global basis, increased biofuel production will lead to higher food prices, benefiting producers and disadvantaging consumers. Biofuel production stands to impact on both of the major dimensions of food security: *availability* (food supply from production and imports) and *access* (entitlements and distribution among society).

Impacts of biofuel production on food availability: In terms of availability, the key question at national level is whether the savings and gains from biofuels will outweigh additional food costs. Biofuels compete with food crops for land and for water, potentially reducing food production where new agricultural land or water for irrigation are scarce. For biofuels that are manufactured from food crops, there is also direct competition for end-use (e.g. cereals, soy, sugarcane, palm oil). Thus, rising demand for biofuels is expected to push up food prices, as far as biofuel expansion occurs at the expense of other crops and crop end-uses, rather than through expansion of the agricultural frontier (see Chapter 6 on Environmental Issues).

At the international level, the growing demand for biofuels is expected to reverse the long-term downward trend in global prices of agricultural commodities. Several studies predict that increased global biofuels production will drive up agricultural commodity prices (see for example FAPRI 2006, FAPRI 2007, OECD-FAO 2007, OECD 2006, FAO 2007, USDA 2007 and ESMAP 2007).[6] Higher prices are expected both for the commodities used as biofuel feedstocks and for other agricultural commodities (though more moderate increases for the latter) . There have already been real, significant increases in global prices for several feedstocks. World prices rose much more strongly in 2006 than anticipated for cereals, and to a lesser extent for oilseeds, but weakened markedly for sugar[7] (OECD-FAO 2007). However, these trends are strongly related to short-term factors such as weather-related shortfalls, reduced global stocks and increased demand from main economies (e.g. Asia). Higher demand for biofuel feedstocks merely increased pressure on an already tight supply. For instance, the combined cereal supply shortfall in North America, Europe and Australia in 2006 of over 60 Mt was nearly four times larger than the 17 Mt increase in cereal use for bioethanol in these countries (OECD-FAO 2007).

At the domestic level, historically, domestic food prices have not been tightly linked to international food or energy prices, as price transmission mechanisms are not straightforward (Hazell et al 2005). Growing international trade in biofuels may see food prices becoming more directly driven by energy prices. At first this may lead to higher price volatility, but over the longer term a gradual end to subsidised overproduction of food in developed countries should reduce market distortion and regularise international prices (UN-Energy 2007). Tighter coupling of energy and food prices is expected to prevent the collapse in national food security and widespread starvation feared by some commentators (Schmidhuber 2007). Additionally, feedstock production is currently the largest proportion of biofuel production costs and hence the area in which most efficiencies are likely to be made, further pushing down prices in the longer term (Peskett et al 2007).

Future development of second-generation biofuels will reduce this interdependency between agricultural and energy prices and the competition between food and fuels. Second generation biofuels are compatible with food production, using for example the non-edible parts of food crops, and so do not necessarily compete for land. However, the timeline, availability and production economics of these technologies are not yet clear.

Impacts of biofuel production on access to food: The issue of access – how the gains and costs of biofuels to food security will be distributed across society (producer/consumer; rural/urban; poor/rich) – is more nuanced and less explored in the literature than the issue of overall food availability, but requires

6 Note that there may be opposite effects for biofuel by-products: oversupply and hence depression of prices for both the by-products and the alternatives with which they compete

7 Sugar prices surged between late 2005 and early 2006 but fell back again later in the year particular attention on the part of CDDCs. FAO and other commentators agree that hunger is largely a matter of access rather than supply, so that a focus on rural development and livelihoods makes more sense that trying to maximise global food supply, which for now at least is adequate for global needs (Murphy 2007).

Higher agricultural commodity prices are good news for agricultural producers, but higher food prices have an adverse impact on poorer consumers. For rural households that are *net producers* of food, overall gains in welfare and food security are expected due to rising revenues from biofuel crops and food crops (Peskett et al 2007). But despite being producers of agricultural crops, most poor farming households in rural areas are *net buyers* of food. Rising prices of maize, and potentially of cassava are hence a major concern. Maize is the preferred staple food of more than 1.2 billion people in Latin America and Africa (Global Crop Diversity Trust 2006, cited in ESMAP 2007), while cassava provides one-third of calorific needs in sub-Saharan Africa and is the primary staple for more than 200 million poor people. Concurrent rises in prices of all staples and agricultural produce will prevent consumers from substituting cheaper foodstuffs, leading more quickly to reduced variety and quality of diet. This may be offset to some extent by lower energy costs where supported by appropriate policy (UN-Energy 2007), though many poorer consumers may be expected to bear simultaneous increases in food and energy prices (Schmidhuber 2007). In addition to higher feedstock prices, biofuel producers' incomes will also be affected by changes (expected reductions) in prices attainable for biofuels by-products.

Biofuel production has the potential to shift small-scale farmers off the land (see Chapter 7 on Social Issues), so that a smaller proportion of the rural population are net food producers. In palm oil producing countries such as Papua New Guinea, small-scale producers note food security as a major concern, especially where government or corporate land use policy promotes large oil palm plantations without any set-aside for food crops (Vermeulen and Goad 1996). Bioethanol feedstocks are typically grown more extensively than biodiesel feedstocks and thus stand to impact even more severely on local food security.

The impact of biofuel production on food security is of particular concern in countries where nutrition is already a major challenge, as in those CDDCs where more than a fifth of the population is chronically undernourished, or where more than a fifth of children under five are underweight (Table 5.1). Importantly, these problems of under-nutrition are related to differential access to food among different households and individuals, as well as food availability at the national level and other factors. Hence the solutions are institutional as well as technical, requiring not only investments in raising agricultural productivity and processing efficiency, but also in improving access to these gains by different groups in society. To benefit food security, biofuels need to be developed within an integrated and diversified framework for rural development (including e.g. microfinance, market information, gender provisions).

Table 5.1 CDDCs surpassing thresholds of 20% population chronically undernourished and 20% under-five-year-olds underweight

Chronically undernourished people		**Underweight under five years olds**	
> 20 % of population	**>33% of population**	**>20% of population**	**>33% of population**
Armenesia	Burundi	Benin	Burkina Faso
Botswana	Central Africa Rep.	Central African Rep.	Burundi
Guinea	Eritrea	Ghana	Eritrea\
Honduras	Ethiopia	Guinea	Ethiopia
Kenya	Madagascar	Kenya	Madagascar
Mali	Mozambique	Malawi	Mali
Mongolia	Rwanda	Maldives	Niger
Namibia	Sierra Leone	Mozambique	Papua New Guinea
Nicaragua	Tanzania	Namibia	
Niger	Zimbabwe	Rwanda	
Panama		Sierra Leone	
Togo		Tanzania	
		Togo	

Source of data: Human Development Report 2006

5.2 Policy implications

Red lights for biofuels development:

- CDDC national governments, particularly those that are currently net food importers, will need to assess the balance between biofuels earnings and food costs, based on comparative advantage and trade conditions and taking into account likely trends in yields per hectare, expansion of total agricultural land and transition to second-generation biofuels. Any indications that biofuel production might have severe impacts on food security, nationally or locally, should be taken as a "red light" to further development of the biofuels industry. These include both:
- Indications that costs to food security will outweigh energy savings and export earnings from biofuels at national level.
- Indications that food security will be compromised for specific social groups (e.g. poor urban and rural consumers, small-scale producers).

Policy measures to maintain food security:

- Better understanding of impacts on domestic food prices and incomes of changes in international agricultural prices (feedstocks, substitutes and by-products).
- Set-aside land for food production e.g. allocation of food crop areas within biofuel plantations
- Analysis of the links between food and energy policy, particularly with a view to maximise household savings among poorer sectors of society. FAO is currently developing a framework for policy makers?
- Water allocation systems among food, fuel, fodder and fibre crops and other land uses
- Continued or enhanced investment in technology and R&D for agriculture and for water management, with an emphasis on multi-purpose cropping and small-scale farming systems
- Support to local systems for biofuel production and use (e.g. cultivation of sugarcane for village-level manufacture of *alcohol brûlé* for household end-uses in cooking and heating)
- Early warning systems on prices and distribution of staple foods

A common rationale for promotion of biofuels is their environmental performance relative to fossil fuels. Evidence suggests, however, that over their full life cycle, biofuels produce a complex mix of positive and negative environmental impacts, as outlined below.

6. Environmental Issues

6.1 Key issues

Land use: Meeting demand for biofuels will depend on a combination of yield increases, displacement of other crops and expansion of the total agricultural land area. The advance of the agricultural frontier into natural habitats is an international environmental concern, particularly the massive expansion of soy and palm oil in the rainforests of the Amazon and South-East Asia respectively (Biofuelwatch 2007), though some business and political interests view conservation efforts in these areas as counter-economic and neo-colonial (Rohter 2007). Certainly, it seems unlikely that increased biofuel production will come through agricultural efficiency alone, so further land conversion can be expected, including in CDDCs that have not yet been the subject of environmental concern, such as in the rainforests and drylands of Africa. Large-scale estimates have been made for the future expansion of biofuel production without damage to existing agricultural systems or natural ecosystems, based on the use of "unused", "fallow", "marginal" and "waste" lands (e.g. 17.4 million hectares of wasteland for jatropha in India; Mishra and Awasthi 2006). They, however, do not take into account the current uses and functions of these areas for poor people's gathering of wild products for subsistence and cash, livestock grazing, wildlife corridors, maintenance of water quality, shifting agriculture and maintenance of soil fertility. Biofuels also displace other economic and land use activities, which then take place elsewhere. Such "displacement issues" are not often well understood, or ignored (Turner et al 2007).

Water use: Land availability is commonly cited as the key limitation to biofuel production but water may be the key limiting factor in many contexts. Currently 2% of global irrigation is used for biofuels. It takes 2700 litres of crop evapotranspiration and 1200 litres of irrigation water to produce one litre of biofuel, ranging from 1150 litres for sugarcane in Brazil to 3500 litres for sugarcane in India (de Fraiture et al 2007). Water consumption during processing is also high, for example, around four litres of water per litre bioethanol for maize biorefineries in the US (Turner et al 2007). As noted earlier (Chapter 4 on Choice of Feedstocks), projected gains in feedstock yields will depend on escalating use of water, at the immediate expense of competing water uses and reserves in aquifers and rivers.

Soil and water impacts: As for any other crop, the impacts of biofuels on the environment depend very much on farming techniques. Use of heavy machinery compacts the soil, thereby reducing oxygen and water availability and in turn biodiversity. Agrochemicals leave residues in run-off with on-site and downstream impacts. On the other hand, intercropping, rotations, use of nitrogen-fixing plants, windbreaks, wildlife corridors, set-asides, conservation tillage and use of organic fertilisers can all improve environmental impacts. For degraded areas, planting of perennial biofuel crops such as jatropha has the potential to regenerate agricultural potential, providing shade and nutrients for other crops (Becker and Francis 2003). Second-generation biofuels will be produced from waste, side-products of agriculture and forestry, and indigenous perennial plants, reducing environmental impacts relative to monoculture annuals used for first-generation biofuels and other cash crop purposes (UN-Energy 2007). Post-harvest pollution of water and soils is also an issue: liquids released from biorefineries are contaminated by organic matter (plus fertilisers and pesticides), though these break down faster than mineral oil (Worldwatch Institute 2006), and there is also a risk of spills during transport.

Greenhouse gases: Reduced greenhouse gas emissions are one of the main policy rationales for promoting biofuels (see Chapter 3 on Policy Goals). There are two ways in which biofuels can reduce carbon emissions (Kartha 2006). First, over their life cycle, biofuels absorb and release carbon from the atmospheric pool without adding to the overall pool (in contrast to fossil fuels). Second, they displace use of fossil fuels. However, production of biofuels does in most cases involve consumption of non-renewable fuels. While sugarcane-based ethanol and second-generation biodiesels may achieve 70-100% reduction in greenhouse gas emissions relative to gasoline, cereal-based ethanol shows lower reductions, or even gains in the case of the inefficient early experiences with bioethanol production from maize (Dufey 2006). Higher use of mechanisation and fertilisers during production is associated with higher emissions (Worldwatch Institute 2006), while transport of fuels is another contributing factor. Current evidence suggests that the value of biofuels in combating climate change through reduced greenhouse gas emissions will come from fuel switching from coal in the combined heat and power sector, rather than the current focus on the transportation sector (UN-Energy 2007), though the IEA predicts that biofuels in transport will contribute an important 6% reduction in global GHG emissions. Energy efficiency is another aspect of this debate (see Chapter 4 on Choice of Feedstocks), with important environmental implications (Kartha 2006). For example, clearance of natural forest to supply second-generation feedstock is not defensible from an energy balance nor from a greenhouse gas perspective, but may well be financially attractive in the short-term. Replanting of natural forest with an energy plantation, on the other hand, may be defensible (over several growing cycles) in terms of both energy and carbon balances, but will have negative impacts on biodiversity. Most analyses of GHG emissions related to biofuels do not consider changes in emissions related to land use changes.

Other air pollution: In life-cycle terms, the end-use of biofuels in transport is associated with lower overall emissions of noxious gases and particulates than transport using mineral fuels (Dufey 2006). Production of the fuels is associated with release of nitrogen dioxide, sulphur dioxide, particulates and other emissions from biorefineries – technologies exist to control emissions but require considerable investment (Worldwatch Institute 2006) – and with the extensive use of fire in growing areas, for example to clear arable land for palm oil production or to remove post-harvest pests and residues in sugarcane fields. Domestic consumption of biofuels for lighting and heating is associated with indoor air pollution, but at much lower levels than produced by traditional biomass energy sources such as firewood. Reduction of respiratory diseases and deaths due to indoor air pollution is a major reason for promoting biofuels (UN-Energy 2007).

Biosafety and biodiversity: One of the most cost-effective means to enhance yields of biofuel feedstocks is through genetic modification of planting material (ESMAP 2005b). A preference for genetically modified crops will create risks mainly associated with the increased use of herbicides, affecting for instance soil micro-organisms and birds. Second-generation biofuels generated through enzymatic breakdown are likely to be highly dependent on genetic engineering technology to produce the necessary enzymes. Contamination of genetically modified material from fuel to food is also a fear, as is the loss of agricultural biodiversity associated with biofuel monocultures (Biofuelwatch 2007). Invasion of native vegetation by biofuel crops is a major concern for some feedstocks, particularly castor oil, which has seeds that are highly toxic to humans, livestock and wild animals, and jatropha, which may threaten indigenous vegetation. Several of the short-cycle woody plants that hold promise for second-generation biofuels are also known as invasives (e.g. *Acacia and Pinus* species in South Africa and Uruguay; Kartha 2006). Even more important are the large-scale losses to biodiversity that accompany rapid large-scale land conversion (see above on land use).

6.2 Policy implications

Red lights for biofuels development:

- Movement of agricultural frontier into biodiversity-rich areas and protected areas
- High risks to water distribution and biosafety, including major diversion of water from production of food crops (or from other key agricultural, domestic and industrial uses) or threat of uncontrolled spread of introduced species and genotypes

Policy measures for environmental protection:

- Appropriate systems of tax-based and regulatory incentives to counter environ-mentally perverse incentives to convert natural forest (and other landscapes) into short-term biofuel stocks or plantations (Kartha 2006)
- Careful appraisal of the potential for agri-cultural expansion into unfarmed areas such as marginal lands and indigenous vegetation
- Development of "best practice" regulations or incentives for on-farm production: to minimise water depletion (i.e. use in excess of recharge rates), soil erosion, agrochemical runoff and greenhouse gas emissions, plus avoidance of land-use change from natural vegetation to crop monocultures (Turner et al 2007)
- Adaptive development of existing farming practices and crops as basis for biofuels expansion, rather than wholescale importation of foreign technologies and genetic materials
- Strategic use of opportunities in the carbon market at international level (see Chapter 8)

7. Social Issues

Aprimary motivation for the promotion of biofuels is their potential to promote rural development and employment, giving a boost to small farmers and improving their livelihoods. This may be an important goal in the context of CDDCs, as one of the features of these countries is a high proportion of small farmers. The expectation of a "win" for poverty reduction appears in many national strategies. Even if rural development is not the foremost policy goal for biofuels development, CDDCs may be looking for pro-poor and employment-generating pathways for biofuel production to maximise gains at the national level.

7.1 Key issues

Large-scale versus small-scale production: One of the key policy decisions for governments is the balance between large-scale and small-scale systems for production and processing of biofuels. In general, large-scale systems are more globally competitive and export-oriented, while small-scale systems offer greater opportunities for employment generation and poverty alleviation (Table 7.1). However, the two systems are not mutually exclusive and can interact successfully in a number of different ways, for example coordinated supply by smallholders into large-scale processing facilities, as is typical for palm oil in South-East Asia. Some of the models for partnership between large-scale and small-scale enterprises include outgrower schemes, cooperatives, marketing associations, service contracts, joint ventures and share-holding in processing facilities by small-scale producers (Mayers and Vermeulen 2001). India has cooperatives in which sugar farmers hold shares in the sugar mills (ICRISAT 2007); Indonesia is increasing small-scale independent mills for palm oil (Vermeulen and Goad 2006). Analysis by a UN consortium suggests that efficient clusters of small and medium-scale enterprises could participate effectively in different stages of the value chain (UN-Energy 2007). The main challenge, explored further in Chapter 10, is how to provide appropriate policy conditions to promote value-sharing and prevent monopolisation along the chain.

Land rights: The need to reduce production costs of biofuels offers considerable incentives for large-scale, mechanised agribusiness and concentrated land ownership. Displaced small-scale farmers can either be absorbed into the agribusiness wage economy or migrate elsewhere. The primary threat associated with biofuels is landlessness and resultant deprivation and social upheaval, as has been seen for example with the expansion of the sugarcane industry in Brazil (Worldwatch Institute 2006). The strength and nature of land rights will be a key determinant of patterns of land ownership under biofuel production – but difficult to predict given the range of experience to date for sugarcane and palm oil. In parts of Malaysia, for example, communities have been able to assert their land rights in response to high land values from palm oil, but in Indonesia there has been an erosion of land access and in Papua New Guinea legally recognised traditional land ownership has not resulted in marked improvements in incomes from or control over palm oil developments (Vermeulen and Goad 2006).

Employment generation: Biofuel production is expected to generate more employment per unit of energy than conventional fuels and more employment per unit investment than in the industrial, petrochemical or hydropower sector (UN-Energy 2007). Some of the estimates for job

Table 7.1 Large-scale (extensive) versus small-scale (smallholder) production

Large-scale, extensive production	Small-scale, smallholder production
Generally higher yields and higher efficiency (earnings:cost ratio) due to economies of scale	Generally lower yields and lower efficiency – but note that smallholders can achieve yields and cost savings equal to large-scale
Narrow social benefits	Wide social benefits
Lower and narrower returns on public investment	Higher returns on public investment due to reduced social spending
Lower exposure to risk and greater financial security	Higher exposure to risk and lower financial security
Faster uptake of technology	Slower uptake of technology
Safer private sector investment option	Riskier private sector investment option
Attractive to agribusiness	Attractive to entrepreneurs and small- and medium-scale enterprises
Can supply large-scale biorefineries and commodity export	Can supply local biodiesel and bioethanol refineries as well as larger-scale
More suitable for export-driven policies	More suitable for rural development policies

creation include: 370 person-days per hectare, with a total of 16 million person days per year in the jatropha industry in India (www.jatropha biodiesel.org quoted by ICRISAT 2007); up to 9.26 million jobs in the bioethanol sector in China (Chinese government figures quoted by Bhojvad 2006); 0.7 to 1.1 million jobs in sub-Saharan Africa through regional adoption of E10 for petrol and E5 for diesel (World Bank figures quoted by Worldwatch Institute 2007). However, a more efficient industry involves greater mechanisation, which in turn reduces labour demands. For example, total employment in the sugarcane industry in Brazil decreased from 670,000 in 1992 to 450,000 in 2003 (ESMAP 2005b). While biofuels will generate a range of employment opportunities, most jobs will be unskilled, often seasonal work in feedstock production, transport and processing (Peskett et al 2007). Oilseed crops such as castor oil and palm oil are, overall, more labour-intensive than bioethanol feedstocks and will thus provide more on-farm and off-farm employment, though sweet sorghum stands out as a bioethanol crop with high potential for local employment (ICRISAT 2007). Higher impact of biofuels on rural employment is likely to be oriented around local small-scale production and processing for local consumption.

Labour conditions: There is concern about the quality of employment in biofuel production, whether self-employment (small-scale farmers) or employment within large-scale operations (Worldwatch Institute 2006; UN-Energy 2007). Problems include the history of poor working conditions in agricultural plantations, notably in the sugarcane and palm oil industries, a lack of agreed or enforceable working standards in many countries, and lack of labour representation. The main cost component of biofuels is primary production and it is expected that the greatest savings over time will come through reducing production costs. While some gains can come through technology, there will be constant pressure on both large-scale operations and small-scale farmers to reduce labour costs, employing people at lower wages under less fair conditions (Peskett et al 2007).

Local-level economic multipliers: Biofuel production is likely to have the greatest boost to the local economy when produced for local consumption and involving small-scale farmers. Social and economic multiplier effects from biofuels are expected to be highest where producers, entrepreneurs and employees in the industry spend and reinvest funds locally, including through local taxation (UN-Energy 2007). By-products and co-products of biofuel processing, such as glycerin, high-protein livestock feeds and fertilisers, could also enhance local incomes, so long as price-crippling gluts are avoided (Worldwatch Institute 2006).

Access to energy through local manufacture and use of biofuels: Biofuels may increase access to affordable energy for isolated communities in CDDCs. Small-scale decentralised biofuel programmes in remote rural areas may offer an alternative to high-priced diesel and kerosene for local electricity grids serving homes and small enterprises (ESMAP 2005b). For example, a jatropha-based biodiesel project in rural Mali (where only 1% of people have access to electricity) has provided women with a clean, reliably available fuel that keeps money within the local community (Worldwatch Institute 2006). Existing diesel engines can easily be adapted to use biodiesel. Use of processed liquid biofuels for household cooking and heating could also help to reduce respiratory disease and death associated with burning solid biomass fuels indoors, to which women and children are especially vulnerable (UN-Energy 2007). This would of course require a cultural shift away from the traditional hearth, plus attention to safety in fuel storage, as liquid biofuels are highly flammable.

Public opinion: The success of biofuels in any country will also depend on the balance between positive and negative perceptions among rural and urban citizens. Relevant areas of public opinion include preferred pathways for rural development, foreign investment, climate change, use of genetically modified organisms, dependence on oil imports and perceived impacts of extensive agriculture. Experience to date is that the success or failure of pilot projects, such as trials with biofuel cars, has a major impact on public acceptance (Worldwatch Institute 2006).

7.2 Policy implications

Red light for biofuels production:

- Threat of serious disruption to rural areas: undermining of land rights, resulting landlessness, few alternative livelihood options and social upheaval
- Strong public resistance to biofuels

Policy measures to maximise social benefits:

- Protection of communal and individual land rights to ensure continued access to land for rural communities and flows of biofuels benefits to those communities
- Deliberate inclusion of smallholders, for example through improve support to small-scale farmer organisations and cooperatives, and preferential market conditions, such as tax incentives to those companies that source their feedstock form small-scale farmers (the "Social Seal" in Brazil).
- Provision of incentives for revenue sharing at all stages of the value chain (see Chapter 10)
- Enforcement of labour standards for workers in the biofuels industry, and recognition of farmers' unions and trade unions
- Support to decentralised production of biofuels and local use of the energy produced, through technical extension, tax breaks on small-scale capital investments, and decentralisation of energy management
- Public education on all aspects of biofuels

8. Economic Issues

Probably the most important challenge to a widespread development of the biofuel industry is their economic costs. Some estimates show biofuels to be twice as costly as conventional fuels (Dufey 2006). However, the current level of oil prices makes the production from the most efficient producing countries competitive (Table 8.1)[8].

Table 8.1 Oil price threshold when biofuels become competitive

Country/feedstock	Thresholds (US$/barrel)
Brazil (sugarcane)	30 - 35
Thailand (cassava)	38
Malaysia (palm-oil)	45
Southern Africa (sugarcane)	45 - 55
US (Maize)	50 - 60
EU (wheat/beet)	70- 80
Pacific Islands (sugarcane)	100

Source: elaborated from Schmidhuber 2007; Kojima and Johnson 2005; Cloin et al 2007

The economics of biofuels critically depend on the price of fossil fuels, price of feedstocks, the cost of conversion (including investment needs) and the revenues generated by the co-products. Storage, transport and logistic costs also need to be included. Available experience suggests that the biofuels sector is not commercially viable on its own, at least in the initial phases of sector development. Therefore policy interventions are required in some form, bringing the costs and benefits of public policies also need to come into the equation. These benefits and costs need to be weighed against equivalent costs of the energy being replaced. The following chapter discusses some of the key issues involved, based on learning from experience to date.

8.1 Key learning on the economics of biofuels

Costs vary depending on the type of biofuels, feed-stock and country

Biofuels economic costs tend to differ widely depending on the type of biofuel, feedstock, the country of provenance and the technology used (Table 8.2). Brazil, is by far the most efficient producer country, with production costs starting from US$ 23, while in temperate countries such as US and EU these are not lower than US$ 40 and US$ 50, respectively. Low cost sugar producing countries such as Thailand and Australia also show relatively lower costs.

For biodiesel, in general, costs tend to be higher than those for bioethanol. While information on biodiesel production costs is widely available for the EU and the US, information for new producing countries or with “less traditional” feedstocks is scarcer and rather anecdotal Overall, the lowest cost of production seems to come from palm oil based biodiesel. For coconut oil, the estimated cost of conversion in the Pacific Island countries is US$ 0.30 to US$ 0.60 per litre, which is currently perceived to be too high to make it viable as a feedstock (Cloin et al 2006). For jatropha, one of the few studies available estimates jatropha-based biodiesel in India to cost between US$ 0.40 and US$ 0.53 per litre, but with strong dependence on the price of by-products (Johnson et al 2005). For the second generation of biofuels, costs are much higher and are not yet commercially competitive compared to the first generation. EC (2007a) estimates that current costs of the second generation of feedstocks are 30% (for bioethanol) to 70% (biomass to liquid (BTL)) more expensive than those of first generation biofuels

Table 8.2 Biofuels production costs

Bioethanol		Biodiesel	
Country/feedstock	Cost/litre	Country/feedstock	Cost/litre
EU (wheat/beet)	US$ 0.51 – 0.80	EU (rapeseed, 2002)	US$ 0.40 – 0.80
Brazil (sugarcane, 2005)	US$ 0.25	US (soy, 2002)	US$ 0.40 – 0.67
US (maize)	US$ 0.40 – 0.50	India (jatropha, 2005)	US$ 0.40 – 0.53
Australia (sugarcane 2005)	US$ 0.38		
Thailand (sugarcane 2005)	US$ 0.27		
China (sugarcane 2005)	US$ 0.53		

Source: Authors’ elaboration based on Henniges and Zeddies 2006, Licht 2005, ESMAP 2005b, IEA 2004

8 Production costs may have changed substantially over the last two years due to fluctuations in currency exchange rates and the rise in feedstock prices, so these figures should be read as indicative.

under current conditions and prices (although yields can be substantially higher). The US, however, is devoting immense efforts in R&D to halve the prices of second-generation cellulosic bioethanol by 2012.

Authors concur that today the most economically viable option for biofuel is sugarcane-based bioethanol. In the long term, it is argued that prospects for bioethanol are better than those for biodiesel as the costs for the former are expected to fall faster, especially once cellulosic bioethanol becomes commercially competitive (IEA 2006).

Feedstock account for a majority portion of total costs

Feedstock account for the majority of total costs of production and vary between some 50-75% (OECD 2006). The highest share of the costs is for those energy crops used for biodiesel production. This implies that any changes in feedstock production costs or in their international prices can have a huge impact on overall biofuel cost of production. At present there is an importat rise in agricultural commodity prices[9] driven by several short-term factors including increased biofuel demand. In the long term, a higher international demand for biofuels together with further liberalisation of agriculture in developed countries is widely expected to raise commodity prices. This in turn, would make biofuels more expensive and less competitive with other forms of energy, creating an automatic check on further biofuel expansion (Murphy 2007).

Capital costs also need to be considered

In addition to labour, other inputs and environmental compliance costs involved in the production process, capital expenditure costs also need to be considered. Average capital costs for plants of a given size at a particular location are highly variable due to costs associated with unique circumstances, such as utility access and environmental compliance. For instance, USDA (2006) reports that new construction costs for US maize bioethanol plants averaged US $1.50/gallon of annual capacity, with variation from US$ $1.05 to $3.00/gallon. In Louisiana (US) a 32 million gallon per year (MGY) bioethanol plant (utilising molasses as a feedstock) would cost US$41 million or $1.28/gallon of annual capacity. For Brazil, a 45 MGY plant utilising sugarcane as a feedstock would cost US$ 60 million, or $1.32 per gallon of capacity. In India, a 40 MGY plant using sugarcane molasses would cost US$ 1.03-1.05 per gallon. For southern African countries, Johnson et al (2006) argue that the capital costs for a bioethanol distillery to be in the range of US$ 50-80 million.

Costs are sensitive to by-products

The economics of biofuels are strongly affected the revenues generated by the associated by-products. For bioethanol, the main by-products include "solubles" from maize and wheat (a high protein animal feed), maize oil, bagasse from sugarcane (used for electricity generation), and lignin from cellulosic bioethanol (used for wood products). For biodiesel, the key by-products are glycerine (used as a degreaser, hand soap or for general use in the cosmetic industry and others) and oil seed meal (animal feed). Sale of by-products is critical to offset the high cost of biofuels production. In the US, for instance, by-product sales amounted an estimated 24% of the total revenue from maize-based bioethanol in 2004 (ESMAP 2005b). On the other hand, increases in biofuel production can decrease the price of by-products price (e.g. as it is happening with glycerine), negatively affecting biofuels economics.

Costs are affected by the scale of production

Costs of biofuel production are scale-dependent, with higher cost for small-scale operations. The impact of economies of scale on the total cost of biofuels production is expected to be especially important in more advanced second-generation biofuel technologies, due to their requirements for more capital intensive, complex production facilities, giving a further advantage to large companies and large facilities (ESMAP 2005b).

The challenge of the costs gives an incentive for large-scale systems. This may favour improved efficiency but act in detriment of social goals such as inclusion of small-scale farmers. The right scale of production would depend therefore on the desired policy goal for biofuels: whether the final policy goal for biofuels is to promote rural development and small farmer inclusion, or export markets, where production efficiency and international competitiveness become the key issues (see Chapters 7 and 9). This trade-off is important as many CDDCs are characterised by a high proportion of small producers.

9 In exception of sugar, whose price surged between late 2005-early 2006 and then fell back again

But the relationship between small farmers and low productivity/efficiency does not always hold true. In terms of efficiency, smallholder farms in Malaysia are able to compare favourably with large-scale plantations (Vermeulen and Goad 2006), while small-scale sugar farmers in Thailand compare favourably with large and medium-size sugar farms in Australia, France, and the US (ESMAP 2005b). Moreover, small-scale and large-scale systems can coexist and cooperate (see Chapter 7).

Biofuel economics can be improved

The economics of biofuels are dynamic and can be improved. The apparently easiest option for cost reduction consists in increasing yield per acre (Chapter 4), though it is not clear whether such yield gains can be spread easily among small-scale farmers. In the long term, technological advancement will also lead to costs reductions. This is especially relevant for bioethanol production, where the greatest promise for the future lies in lowering the processing cost of cellulosic biomass resources. Regarding biodiesel, the transesterification of oil with alcohol is a relatively simple process, so it offers little scope for efficiency improvement. As a result, cost reduction strongly relies on reducing feedstock production costs (ESMAP 2005b).

Biofuel economics are sensitive to fossil fuel prices

Perhaps the most important single determinant of the economics of biofuels is the price of oil. If world oil prices remain high for a prolonged period of time, biofuel programs have a better chance of becoming financially viable without sustained government support in a larger number of countries. As suggested by the Table 8.1, with oil prices above US$ 45-50 a barrel (and other variables such as feedstock prices remaining constant), biofuels produced in the most efficient countries become commercially competitive, viable without public subsidies. IEA (2006) does not expect oil prices to fall below USD 48 through 2030.

In fuel-importing land-locked or remote countries with poor infrastructure and high transportation costs, prices of gasoline and diesel may be markedly higher than the international prices. In these cases, if biofuel production and processing are located near to consumption centres or can be transported to them at relatively low costs, they can be competitive against imported fossil fuels.

It should be noted, however, that biofuels are “price-takers” in the energy market, representing a tiny fraction of the total value of the market. Biofuels expansion will make agricultural commodity prices more responsive to changes in oil prices, but any major rise in commodity prices will price biofuels out of the market altogether and so depress demand again (ESMAP 2007). This will not stop volatility and speculative investment, especially in the short-term. It will, however, put a brake on the long-term expansion of the sector – not so much biomass for energy at large, where there are more efficient and cost-effective technologies available, but definitely for liquid biofuels, which are used for the most part in conjunction with fossil fuels (Murphy 2007).

Transportation, distribution costs and logistics

Biofuels costs are also affected by the available infrastructure for transport and distribution of both the feedstocks and the biofuel. For instance, the sale price of Brazilian bioethanol in the EU varies in the range of € 200-300/tonne of oil equivalent (toe) and transport and distribution costs can add an extra €150-200/tonne (GAIN 2007).

Infrastructure not only involves suitable roads, waterways and pipelines to transport products to the markets (Box 8.1), but also communication infrastructure, which is essential for notifying producers, processors and traders on weather and market conditions. Inadequate or lack of infrastructure is a major constraint in many CDDCs, especially in Africa, and therefore it can constitute an important factor undermining the commercial viability of biofuel production.

At low blending levels with traditional fuels, biofuels can generally be accommodated and distributed via the existing fossil fuels distribution infrastructure. In higher blends on in their pure forms, some special measures to upgrade the existing infrastructure must be taken (Box 8.1). But the experience in Sweden and Switzerland suggest that these costs are relatively low (UN-Energy 2007).

There are also differences in infrastructure needs depending on whether production is destined for local use or for national and international consumption. For the former, distribution and logistics are relatively straightforward, but for the latter they could be a major challenge for market development.

Box 8.1 Technical considerations on biofuels transportation and distribution

Bioethanol: Pipelines are the safest and most cost-efficient method of transporting liquid fuels. Bioethanol absorbs water and impurities that normally reside in fuel pipelines, which can cause phase separation of the bioethanol-gasoline blend reducing engine performance. An additional problem is Stress Corrosion Cracking (SCC) – the formation of brittle cracks caused by corrosion processes and stress – associated with the transport of high bioethanol blends. The need to avoid contamination with water and SCC explains why bioethanol is not distributed through existing fuel pipelines and instead is blended into gasoline at terminals by splash-blending just before loading trucks, rails, barge or ships going to filling stations. However, shipment of fuel grade bioethanol via pipelines is feasible through especially dedicated pipelines. Brazil's COPEL, owned by the Parana state government, has concluded feasibility studies for a US$ 336-million dedicated bioethanol pipeline (528 km). The pipeline would be ready to operate by 2010, with a 3 billion litres capacity, linking bioethanol mills in Parana state to Paranagua port.

Biodiesels made from tropical oils typically require thinning agents if they are, for example, to be exported to temperate climates (which involves additional costs). This is because biodiesel based on tropical oils (e.g. palm or coconut oil) typically has higher viscosity than biodiesel based on temperate oils (rapeseed or soy).

Biofuels public policies, their costs and benefits

Available experience suggests that the biofuels sector requires some form of policy support, at least in the initial phases of sector development. Policies need to respond to specific policy goals associated with biofuel production (Chapter 3). A detailed review of the types of existing policy tools to support the sector goes beyond the scope of this document and many of them are interrelated, but the most commonly used include:

- Setting of national targets for biofuels (voluntary or mandatory)
- Use of financial incentives to support biofuels production and consumption (e.g. subsidies to feedstock and biofuel production, fuel tax exemptions)
- Price and production controls
- Trade policy measures (e.g. tariffs and quotas)
- Investment incentives such as soft loans, grant, tax reduction, accelerated depreciation
- Policy incentives targeting the inclusion of small-scale producers
- Support to demonstration projects and pilot projects
- Support to R&D for technology development
- Support to the introduction of flexi-fuel cars (FFV)

Such policies differ in terms of their trade impact (e.g. producer subsidies and trade tariffs versus support to R&D), social returns (e.g. policies to promote small-scale producer inclusion versus policies based on large-scale production), GHG reductions (e.g. environmental taxes on biofuels versus other forms of carbon reduction) and economic cost involved (e.g. the foregone fuel duty revenue).

In many countries, the main rationale behind biofuels production is to decrease the costs associated with imported fossil fuels. One of the costs of such a policy is the foregone duty on fuel imports, which results in a decline in government revenues. For instance, in Brazil, the forgone tax revenue in the state of São Paulo, which accounts for more than one-half of the total hydrous ethanol consumption in the country, was about US$ 0.6 billion in 2005 (ESMAP 2005b). In the UK, the government estimates that, under present arrangements, annual foregone fuel duty revenue will total £90 million if biofuels achieve a 1% market share (Dufey 2006). This poses a significant challenge for developing countries, where there are a multitude of urgent needs competing for scarce fiscal resources. Moreover, in some cases the diversion of feedstock exports for biofuel production into domestic and local markets means that countries may suffer reductions in their export earnings.

Another issue is that once granted and the biofuel industry has been launched, subsidies are difficult to withdraw. Every country with a biofuel program has provided subsidies to the industry, and none of them has yet removed the subsidies entirely. In Brazil, globally the most competitive country, success has come through 20 years of government support.

Even today the government continues to maintain a significant tax differential between gasoline and hydrous ethanol (ESMAP 2005b). In Germany, where positive incentives were the initial policy mechanism to promote biofuels, pressure on the public budget has led to the government to commence taxing biofuels from June 2006, with regulation replacing tax incentives as the primary mechanism to support existence of the industry. A major challenge to reduce policy support is the vested interests created in the domestic industry (Henniges and Zeddies 2006).

Biofuels policies need to be designed so as to reach the desired target group. Indeed, resources that flow to agriculture all too often benefit politically powerful, large producers and modern enterprises disproportionately at the expense not only of the society as a whole, but of those that are supposed to be the main beneficiary group: smallholder farmers and landless workers. Examples include untargeted producer subsidies and distortionary subsidies for privately used inputs such as water and electricity (ESMAP 2005b).

According to ESMAP (2005b), promoting biofuels for energy diversification can make sense if large government subsidies are not required. The benefits of diversification can also be greatly enhanced if trade of biofuels is liberalised. On the other hand, UN-Energy (2007) argues that, even though small-scale producers may require larger subsidies than large producers (due to economies of scale), this may be money well spent. Governments tend to get higher returns on their public spending by fostering small-scale production due to the lowered demand for social welfare spending and greater economic multiplier effects (see Chapter 7). Governments, however, also need to assess the pros and cons of promoting biofuels to support poor rural communities versus those of other alternatives. Similarly, biofuels have also been criticised as a cost-ineffective form of promoting GHG reductions when assessed against the costs of other policy instruments to achieve the same goal.

Leveraging investment

Production of biofuels requires channelling investment for feedstock production, processing and distribution. This represents a major challenge in the context of CDDCs that have poorly developed financial systems and a high risk associated with investment. For instance, Johnson et al (2005) in the context of southern African countries argue that "significant investment will be needed to upgrade facilities in order to harness the cane resource and stimulate industrial development. The establishment of a new estate and sugar factory processing two million tonnes of cane per year would cost US$ 200-300 million; the capital costs for an ethanol distillery are in the range of US$ 50-80 million; the costs of a cogeneration plant are about US$ 1,000-1,200 per installed kilowatt. Further costs for transport infrastructure and storage would also be incurred. It will be difficult to attract such investment to the region, where poor infrastructure and high investment rates often pose formidable barriers."

Governments play an important role in creating the enabling environment for investment. The fundamentals for attracting investment include a sound macro economic environment, the establishment of a clear, stable, and transparent legal and fiscal framework, and an efficient administration. Government can also provide basic rural and road infrastructure.

The less favourable risk rating compared to more well established energy technologies implies that small-scale biofuels projects can face challenges obtaining finance from traditional financing institutions (UN-Energy 2007). In those cases, governments can help providing market infrastructure including micro-credit or other alternative credit delivery system and/or acting as a guarantor to assist them in all the stages of the process. Policy and technical support can also reduce the perceived risk. Foreign investment can also constitute an important source of capital. Governments need to make sure, however, the investment involves important domestic benefits, for example in terms of technology transfer.

Developing countries can also make use of the carbon finance markets for attracting investment into biofuels projects using the market value of expected GHG emission reductions. The Clean Development Mechanism (CDM) under the Kyoto Protocol is the most important example of the carbon market for developing countries. The CDM allows developed countries (or their nationals) to implement project activities that reduce emissions in developing countries in return for certified emission reductions (CERs). Developed countries can use the CERs generated by such project activities to help meet their emissions targets under the Kyoto Protocol. Although the CDM is a potential source of financing for biofuels projects, taking advantage of it can present a number of challenges for the developing country host. Firstly, so far there is no liquid-biofuels baseline and monitoring methodology approved. Calculation of GHG emissions is not straightforward and for many countries biofuels are still a relatively expensive means of reducing GHG emissions relative to other mitigation measures.

An additional challenge in the context of CDDCs is that the existing experience with CDM projects shows that approved projects are strongly concentrated in a handful of large developing countries, with over 60% of all CDM projects distributed across China, India and Brazil alone. While there are simplified procedures for small-scale projects, the current structure of the CDM tends to select for large-scale projects. The transaction costs associated with registering a CDM project are often prohibitively expensive for smaller developing countries, which implies that economies of scale are relevant (Bakker 2006). For bioenergy projects specifically, the exclusion of all land use activities from the CDM except for afforestation and reforestation is another significant limiting factor, since in the poorest developing countries, land-use related emissions make up the bulk of GHG emissions from biomass energy systems (Schlamadinger and Jürgens 2004).

International financial institutions (IFIs) have a key role in reducing political risk in developing countries. For instance the Inter-American Development Bank (IDB) has recently approved a US$ 120 million biofuels project in Brazil. The IDB is also analysing the possibilities to facilitate technology transfer and technical assistance from Brazil, so that other countries in the region can benefit from Brazilian know-how. It is important that IFIs not only focus on large-scale projects but also on small-scale ones in which social benefits are highest.

In the long term, UN-Energy (2007) argues that investment today is likely to attract investment in the second generation of biofuels: "those countries that have already begun to develop bioenergy industries may be the most likely to attract investment and benefits from the resulting technology transfer".

8.2 Policy implications

Red light for biofuels development:

- Indications that in the long term the economic costs of biofuels development will outweigh the net benefits to national welfare (social, environmental, economic)
- If any other fuel or development option is a more cost-effective means than biofuels of achieving a specific policy goal (energy security, rural development, exports development, climate change mitigation)

Policy measures to increase welfare benefits:

- Tracking and analysis of how developments in international oil, feedstocks and by-products markets are affecting the economics of biofuels domestically
- Identification of policy support in terms of explicit policy goals associated with biofuels rather than catch-all pro-biofuel policies
- Careful assessment of the pros and cons of the different policy tools to promote biofuels development
- Provision of enabling environment for investment, including a stable macroeconomic and policy environment, basic infrastructure and micro-credit
- Identification of opportunities to take advantage of FDI, carbon markets and other potential sources of foreign investments
- Coordination of private and public sectors
- Tracking of developments in second generation of biofuels, paying attention to how their commercial availability will affect the market and how the country can benefit from them

9. Trade Issues

Tropical and sub-tropical crops, such as palm oil and sugarcane, produce more energy than grain or cereal-based biofuels. This, coupled to the geographical mismatch between international supply and demand for biofuels, represents an opportunity for those commodity-producing countries to develop new export markets and to increase their export revenues. However, the development of a successful biofuel export-oriented sector is not automatic. Beyond the natural advantages for production of biofuels, any assessment of whether a biofuel export-oriented strategy makes sense, has to look at trade barriers, preferential market access conditions and domestic capacities to become an international player. This chapter addresses key issues to consider, based on international experience to date.

9.1 Key learning on trade in biofuels

Trade barriers are critical to export strategies

The different policy goals associated with biofuels highlight the strategic nature of the product and therefore the existence of some degree of protectionism in almost any producing country. Protectionism can be especially acute where energy security is associated with self-sufficiency or where biofuels are being promoted to help domestic farmers in high-cost producer countries. Key trade barriers include:

Tariffs: The use of tariffs to protect domestic biofuel industries is a common practice both in industrialised and developing countries. Table 9.1 shows import tariffs on bioethanol in key countries, which can be very high. These tariffs, however, are only indicative. The actual level of tariffs applied vary widely as, for instance, both the EU and the US have preferential trade agreements providing preferential access market to different countries. Import tariffs on biodiesel are considerably lower: 6.5% and 4.6% in the EU and the US, respectively.

Tariff escalation: Another key barrier to trade is the existence of tariff escalation. For instance, while the EU impose a 0% and 3.2% tariff on imports of soyabean and crude soya oil for industrial use, respectively, it applies a 6.5% tariff duty on biodiesel imports. Crude palm oil imports for industrial use in the EU also enter duty free. The use of tariff escalation favours the production and export of the energy crops while the processing and the value-added phases are usually carried out in the importing country.

Subsidies: Probably every producer country, especially in the industrialised world, has some form of domestic support for biofuel production, including support to energy crops production, biofuel processing and commercialisation. The US, for instance, provides a US$ 0.51/gallon tax credit for bioethanol and US$ 1 per gallon of biodiesel from virgin oils or fats (Dufey 2006), and US subsidies to the biofuels industry are estimated to be between US$ 5.5 billion and US$ 7.3 billion a year (Koplow 2006). In the EU, total support to bioethanol and biodiesel in 2006 amounted €0.52/litre and 0.50/litre, respectively (Kutas et al 2007). The impacts of these policies on the competitiveness of CDDCs need to be explored, as domestic support in these countries is likely to be very limited.

Quality standards: Diverging technical regulations in different countries may constitute one of the most serious restrictions to biofuels trade. At the very least, a producer wishing to export to other markets will have to incur extra costs to have their biofuels tested according to the importer country's conditions (Oestling 2001). For producers wishing to enter multiple markets, each with different standards, these costs become very high. Restrictive technical regulations may also be problematic. Both th e EU Directive 2003/17/EC on fuels quality that limits the use of bioethanol to 5% and the European Standard EN590 that limits the use of soya and palm oil on biodiesel production are considered to be restricting biofuel market development in the EU (Oestling 2001; EC 2005). The EC is currently analysing the

Table 9.1 Import tariffs on bioethanol

Country	Import Tariff
US	2.5% on undenaturated alcohol 1.9% on denaturated alcohol Extra US$ 14 cents/litre for fuel use (makes a 46% ad valorem)
EU	€ 19.2/hl on undenaturated alcohol (63% ad valorem) € 10.2/hl on denaturated alcohol
Canada	4.92 US$ cent/litre
Brazil	20% *
Argentina	20%
Thailand	30%
India	186%on undenatureated alcohol 30% on denaurated alcohol

Source: adapted from Dufey 2006 and RFA 2007;
* Temporarily lifted in February 2006

introduction of a separate petrol blend with higher permitted oxygenate content (up to 10% ethanol) and amendments to the biodiesel standard to include a wider range of vegetable oils. Overall, the importance of harmonised technical standards to foster integration and trade is suggested by Philippines and Thailand, which in 2004 forged an agreement to jointly formulate regional fuel standards for the use of bioethanol as a gasoline blend (Globalmanufacture 2004). Likewise, the major bioethanol producing countries, Brazil and the US, in March 2007 announced their decision to join forces to develop a standardised definition of bioethanol so that it can be traded on global commodity markets.

Sustainability standards: Today there are several initiatives towards the development of sustainability certification for biofuels. They have been led by governments (e.g. the UK and the Netherlands), NGOs (e.g. WWF) and the Roundtable on Sustainable Biofuels (RSB) led by Lausanne University, and focus on environmental and social aspects of biofuels. The European Commission has also proposed two principal environmental standards: reducing GHG emissions greenhouse gas emissions and ensuring the protection of so-called "mega biodiverse" zones (such as rainforests). Although the existence of sustainability assurance schemes for biofuels production is paramount, the proliferation of different standards, with insufficient consideration of producing countries' relevant environmental and social conditions, and without mutual recognition among them, is bound to establish significant trade barriers. The complex procedures and high costs usually associated with these assurance schemes also raise concerns about the regressive effect these may have on small-scale producers in developing countries. Overall, sustainability standards are likely to become more and more important in the future. Exporting countries will need to invest in the development of robust and credible certification systems that satisfy importing countries requirements.

The WTO and other trade agreements provide opportunities and restrictions

The World Trade Organisation (WTO) needs discussion of many issues before progressing on biofuels trade liberalisation – for example, a basic decision on whether biofuels will be treated as industrial, agricultural or environmental goods[10]. In each case, different WTO rules apply. Moreover, the current Doha Round is at an impasse, and agreement on the Doha Agenda now looks unlikely. Even if an agreement eventually comes, the proposals under consideration will not change the underlying structures of domestic support for agriculture in developed countries. Nor are tariffs in the main crops used for biofuels likely to change, especially with the creation of a category of "special products" (Murphy 2007).[11]

On the other hand, bilateral or regional trade agreements involving the US or the EU, provide preferential market access for biofuels imported (especially bioethanol) from many developing countries. The US, for instance, provides an exemption from the additional duty (see Table 9.1) to trade partners including NAFTA, Israel or Andean countries, and provides duty free access (but subject to quotas) to CBI and CAFTA countries (Box 9.1). Likewise, the EU provides duty free access to bioethanol imports from more than 101 developing countries (but not Brazil). These trade agreements open important export opportunities for many CDDCs.

Development of a successful export-oriented biofuels sector involves more than land availability, good climate, cheap labour and preferential market access

The development of a successfully export-oriented biofuels sector crucially depends on countries' *domestic capacity* to expand biofuels production efficiently. This implies having access to the technology to produce efficiently and in compliance with the relevant technical standards in importing markets; development of the suitable transport infrastructure (roads, water ways and ports) to reach exports markets; and sufficient capacity in policy implementation and project management to run biofuels production and processing effectively.

10 While bioethanol and feedstocks are classified as agricultural products and their trade is governed by the Agreement on Agriculture of the WTO, biodiesel is categorised as an industrial good and subject to the general rules of the GATT. Biofuels could also be included in a list of "environmental goods" for accelerated trade liberalisation under the current Doha Round.

11 For instance, sugar (the most protected of the crops considered here) will likely continue to be protected by high tariffs in both the USA and the EUbutyl-ester (ETBE)

Box 9.1 Selected trade agreements granting preferential market access to biofuels

US-Caribbean Basin Initiative (CBI): CBI countries are allowed to export bioethanol produced by foreign feedstock (i.e. sugar from another country) into the US duty free to up to 7% of total US bioethanol production. After that 7%, an additional 35 million gallons can be imported duty free, provided that at least 30% of the bioethanol is from local feedstocks. Anything above that is duty-free if at least 50% of the bioethanol is from local feedstocks. The CBI cap on duty free bioethanol imports was 240.4 million gallons for fiscal year 2005.

Central American Free Trade Agreement (CAFTA): CAFTA makes the CBI allowances permanent. It also establishes specific shares for Costa Rica and El Salvador within the overall CBI quota. El Salvador is guaranteed 5.2 million/gal in the first year, with annual increases of 1.3 million/year, not exceeding 10% of the quota. Costa Rica is allocated 31 million gallons per year.

Cotonou Agreement: Under the agreement the EU provides to African, Caribbean and Pacific countries duty-free and quota-free access for denatured and undenatured alcohol under code 2207 with the exception of South Africa, which until December 2005 enjoyed the 15% tariff reduction under the GSP scheme, but now has to pay full duty.

EU Generalised Systems of Preferences (GSP): The new GSP Regulation no longer provides for any tariff reduction under code 2207 (still classified as a sensitive product) but puts in place a special incentive arrangement for sustainable development and good governance (the new GSP+ incentive scheme). The GSP+ applies on a permanent basis from 1 January 2006 to 31 December 2008 and grants unlimited and duty-free access to denatured or undenatured alcohol under code 2207 to Bolivia, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Nicaragua, Panama, Peru, El Salvador and Venezuela.

The EU's "Everything but Arms" (EBA): The EBA grants least developed countries (LDCs) duty-free access to the EU for all products, except arms and ammunition.

Source: adapted from Dufey 2006

South-South cooperation can help in overcoming some of these challenges. CDDCs can benefit from more experienced countries in biofuel production, which can help with technological transfer and developing global markets. Brazil, for instance, is at the forefront of sugarcane based bioethanol production and trade. India has important experience with jatropha. Both Brazil and India are supporting a programme in Senegal to produce biofuels. In this tripartite programme, Senegal supplies the land and labour, Brazil provides scientific and technical knowledge and Indian entrepreneurs contribute the necessary capital (Biopact 2006). China has also closed a bilateral agreement on bioethanol production with Nigeria and made a first investment. Technical cooperation can also be South-North-South as illustrated by the Brazil-UK-Africa Partnership for bioethanol development.

International trade involves North-South and South-South regional trade

Countries with large land endowments and with significant cost advantages in agricultural commodity production, such as Brazil, Malaysia, Indonesia and Argentina, are already expanding their production capacity to take advantage of biofuel international markets. Exporting countries are targeting both main northern markets such as US, EU and Japan, but also, in some cases, regional southern markets taking advantage of their proximity to, for example, Asian markets. Malaysia, for instance, envisages playing a major role not only in the biofuels trade but also as a feedstocks supplier to neighbouring countries such as Singapore (Chaturvedi 2006). The Philippines is also developing a regional market involving Japan. These countries together with Indonesia and Thailand are also well positioned to serve China, India and South Korea. Countries with long experience in sugar production in southern Africa and the Caribbean, are also analysing the potential benefits of diversifying their export-oriented sugar industries towards biofuel. For instance, countries from the Caribbean Basin Initiative (CBI) are developing export-oriented biofuel industries taking advantage of preferential market access conditions provided by the trade agreement with the US. In Africa, the Association of Non Oil Producing African Countries (PANPP) which includes countries such as Senegal, Niger, Benin, Guinea, the Comoros, Zambia, Mali, Togo, and Burkina Faso, is analysing the potential that regional biofuels trade can offer to increase energy cooperation and security in the region.

9.2 Key policy implications to increase export benefits

- Policy makers need to identify their export potential for biofuels. This should go beyond an analysis of natural competitive advantages to include market access conditions and distortions in the different importing countries, potential to develop South-South regional trade, and a comprehensive analysis of the country's domestic capacities to expand production and trade.
- Policy makers need to pay special attention to technical standards, which are set to become more and more important for the biofuels trade. A key policy implication is that they require the development of strong institutional capacities for the implementation of robust and credible certification systems that satisfy importing countries' requirements.
- Policy interventions can be targeted to increase the trade returns to primary producers, for example, the use of tax breaks for those companies that assure a fair returns to primary suppliers (as in Canada, Thailand and Brazil). This is valid for chains targeting export or national markets alike.
- Countries need to explore the potential that South–South cooperation offers in overcoming many of the technological challenges imposed by the development of a successful biofuel industry and global markets. Again, this is valid for those chains targeting export or national markets alike.

10. Value Share Along the Chain: Implications for Rural Development

To make rational choices built on the realities of where and how value is created and captured, it is essential that policymakers, as well as business and farmer leaders, understand how biofuel value chains operate. It is equally important to understand which business models and government policies and programmes work well for retaining value in rural areas and therefore for rural development (Tyrchniewicz et al 2006).

10.1 Biofuel value chains

Value chains describe a range of value added activities between the consumption and the production components of a certain product. A recent CFC report on the development role of commodities (CFC, 2006) reported how rapid shifts in the structure of agro-commodity value chains can occur, when new categories of buyer emerge, seeking to secure a supplier base through alliances and contracts between producers and buyers.

Value chain analysis has interpreted the growth alliances and direct contracting as a shift in chain governance, with lead firms shape the functional division of tasks along the chain. Buyer-driven chains (Gereffi, 1994) are more regulated, and characterised by high levels of governance and long-term vertical coordination between producers, supplier-integrators, processors and retailers, for the purpose of building efficiency, traceability, consistency of product, and assurance across their entire operations. The resulting chains have barriers to entry, including "voluntary" standards, codes and benchmarks. Many agri-food commodity markets are moving in this direction, including identity-preserved grains.

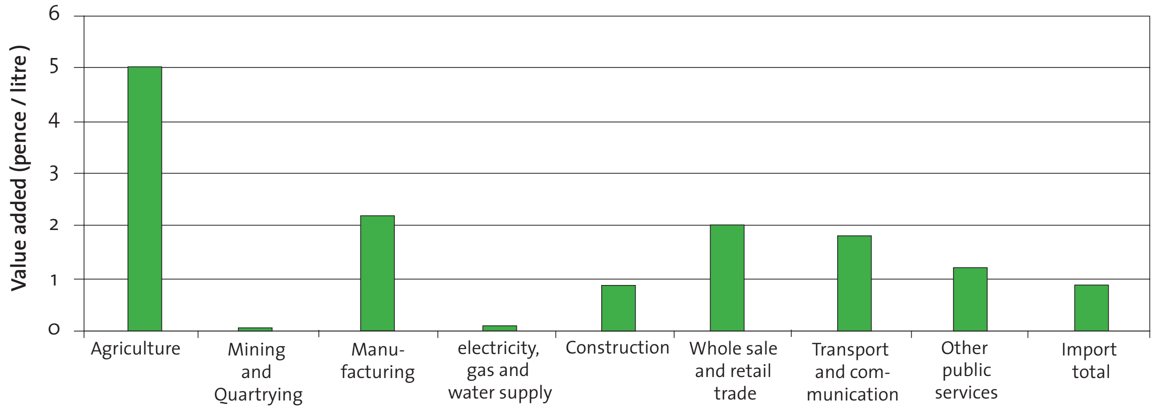
Do we see these shifts in chain governance in biofuels chains, from feedstock to distribution? What are the trends, and what are the implications for the promise of rural development?

In Europe, the biodiesel chain has been described as highly producer-driven with farmers and the agro-industry in lead firm position through a vertically integrated network structure. The position of producer-drivenness has been reinforced by regulations that have protected domestic biofuel value chain actors, against foreign competition and created entry barriers to newcomers (Aantjes 2007). The strong influence of external factors, especially the regulatory environment, is a common feature in the governance of biofuel value chains.

The fact that the agro-industry retains a lead role in chain governance is reflected in the distribution of value added across the principle economic sectors. In the UK wheat-to-bioethanol chain, the agricultural sector, manufacturing, wholesale, retail and distribution sectors are the main beneficiaries (Figure 10.1). The authors expect a similar breakdown for biodiesel.

A detailed study of the palm oil value chain in Honduras (Fromm 2007) makes a similar observation. There, 11 extractors (eight of which are privately owned) are the central figures in the chain, and most producer associations or cooperatives produce under contract to the extractors – see Table 1. The leading firms Hondupalma and Coapalma define who and what is being produced, but contracts they have with producers allows producers to continue in the expectation of a secure an income in the next years.

Figure 10.1 Distribution of value added for bioethanol from UK wheat



Source: Turley et al 2003

Table 10.1 Honduras Palm Oil Chain and Characteristics

Link	Number	Characteristics
Producers	4710	Small-scale producers: 1 to 10 ha Medium-scale producers: 11 to 100 ha. Large-scale producers: over 100 ha.
Intermediaries	10	Extractors have given them credits for their operation. Sometimes offer credit to small producers.
Extractors	11	3 are cooperatives and have a low extraction capacity. 8 belong to the private sector and have optimal extraction capacity, as well as technical and managerial know-how. 9 export crude and refined palm oil.
Refineries	4	2 are private sector companies. High technological investments. Highly qualified management teams.
Fractionation Plants	4	Active in national market.
Exporters	6	Access to national and international credit. Own trucks and equipment for transportation. Main markets include Mexico and Central America.
Distributors	3	Own warehouses and infrastructure. Transportation, highly qualified personnel. Access to credits.
Local Wholesalers	3000	Own transportation and storage facilities. Have access to credit
Local Retailers	25.000	
Local Consumers	5 million	

Source: Fromm 2007

Both lead firms have plantations but they also source from associated and independent producers.

10.2 Value share along the chain

The potential for value to be created and retained in rural areas depends strongly on whether biofuels are being developed for local and sub-regional markets with small-scale production, or for large-scale commercial production for national or global markets, and also on the pattern of ownership (Woods 2006).

In common with other bulk commodities, controlling value-added parts of the production chain "is critical for realising the rural development benefits and full economic multiplier effects associated with bioenergy" (UN-Energy 2007). For example, in the US, the benefit to farmers of a 40 million gallon bioethanol plant is calculated to be about US$1.5 million a year if the facility is absentee owned, but rises to US$ 6-12 million a year if the farmers own it (Morris 2006). Networks of new generation cooperatives, and other forms of economic organisation whose members can develop and manage the links in a value chain, may benefit from this emerging development of value chains. Box 10.1 provides insights on the importance of farmer ownership in the biofuels value chain.

Box 10.1 Farmer ownership in the biofuels value chain

There are real economies of scale in biofuels processing, which tend to drive absentee ownership and significantly reduce the benefits to rural communities. This is visible in the US, where there has been a strong shift back to absentee ownership in biofuel processing after a spell in the 1990s and early 2000s when farmer-owned initiatives dominated the building of new capacity. As with food commodities, large groupings of farm businesses are required to achieve the scale of output that is commercially viable for dealing with processors and retailers. Smaller farmer-owned co-operatives can survive for a while by selling ethanol through larger marketing alliances, but the long-term picture for farmers is unclear.

Policy makers must therefore weigh the loss of rural development benefits against small decreases in production costs. The Institute for Local Self-reliance believes that the link between increased demand for biofuels and increased rural prosperity has been overstated, and the link between local ownership and rural prosperity has been overlooked. They cite studies in Minnesota and Iowa that indicate that locally owned bioethanol plants return US$ 0.75 for every US$ 1 in local economic activity, compared to US$ 0.25 for absentee owned energy production.

Continued: Box 10.1 Farmer ownership in the biofuels value chain

In the US there is much debate on whether federal and state laws should promote local ownership and smaller scale production, and if so, how to redesign renewable energy tax and regulatory incentives. Some argue that the most effective way to support local biofuel production would be to target the subsidies to actual producers as opposed to blenders and to provide greater incentives to those plants that are majority-owned by farmers. Around fourteen states already have some type of producer incentive programme, and many states have limited the number of gallons the subsidy will support. Capping production incentives is also seen to address the challenge of generating transportation fuels from biomass appropriate to their climates, soils, and water constraints.

This principle of producer ownership also applies in other sectors and in levels of economic development. In South Africa, farmers of wattle trees can join SAWGU, the South African Wattle Growers Union, where membership confers a shareholding in the tannin extracting factories. Small-scale growers are assisted in membership via the Phezukomkhono scheme, which provides soft loans for agricultural inputs and fire insurance and guarantees small producers a minimum 15% representation on the SAWGU executive body. Exemptions from parts of competition legislation may be required to make farmer ownership successful, and to avoid repeat mistakes that have prevented farmer-owned business from gaining critical mass. This was seen in the UK dairy sector, where deregulation increased competition on the supply side amidst consolidation in milk processing, and placed dairy farmers in a weak and vulnerable position. By comparison, farmer controlled businesses in other European countries – such as Arla – have grown into Europe's largest processors.

Sources: Morris, 2007; Farrell, 2007; O'Brien, 2005; Mayers and Vermeulen 2002.

Community-level production, perhaps sold in the informal sector for agricultural uses such as operating irrigation pumps (reported from India), may be particularly appropriate for fuel-importing landlocked regions where poor infrastructure and high transportation costs can make biofuels competitive with imported petroleum fuels (ESMAP 2005b; ICRISAT 2007).

But for farmers to retain a stake in emerging commercial biofuels markets requires deep pockets and advanced organisation. To produce high-quality biofuel, commercial value chains are designed around consistency and reliability of supply—both significant barriers to market entry for small producers and their organisations. Consistency drives a need to standardise and transfer farming technology to remove sources of variation (Cereal Industry Forum 2007), as well as the need to introduce forms of traceability and preservation of identity. For the export sector, social and environmental standards and the need for rigorous carbon reporting along the chain will also present challenges for small producers and suppliers (see Chapter 9).

Economies of scale can tend to favour larger producers and land concentration (See Chapter 8). The size and scale of ethanol and biodiesel plants is rapidly increasing, and cellulosic ethanol plants are expected to require even greater capital investments of at least US$100 million. Individual plants must also be part of a marketing alliance in order to get their products to the best markets. Capitalisation and concentration of market power within the agro-fuels industry is indeed gathering speed. The US biofuels sector has seen a shift away from farmer ownership. Based on announced plant developments, farmer-owned projects represented only 26% of new capacity in 2006 (Kenkel and Holcomb 2006).

This experience of smallholder exclusion from commercial biofuel chains is repeated in the Honduran palm oil case. It is estimated that 80% of the producers in Honduras have no access to transportation and are obliged to sell to intermediaries who collect the fruit directly at the plantation. They consequently find themselves outside of the preferred supplier arrangements that have direct contracts with extractor companies, and their profit margin is lower, and they risk exclusion from participating in the chain (Fromm 2007).

The US market is being driven by large-scale agribusiness and energy firms. If an enterprise is owned by external investors such as ADM or Cargill, Chevron or BP, then benefits of biofuel to crop producers will be reflected in grain crop demand as opposed to value-added returns. It has even been suggested that "in grain deficit areas where an increase in grain prices is perceived as a negative externality, the development of investor-owned biofuel plants could actually have a negative impact on the agricultural community" (Kenkel and Holcomb 2006).

The core of governance is therefore likely to shift away from farmers and oil producers and processors towards the downstream chain, which is "effectively an oil & gas chain and very mature from a logistical perspective" (Cereal Industry Forum 2007). Even in Europe, where government involvement has fostered "buyer-drivenness" of biofuels markets, these shifts in governance will accompany an increasing reliance on imports (Aantjes 2007).

Overall, the record of value-added agricultural enterprises as a significant generator of rural jobs, income, and community development over the long term has not been particularly bright.

10.3 Policy implications

Community-level production may be resilient in the face of changes in national and global markets. But large-scale production for national or global markets, which have been *producer-driven* and have had significant producer ownership, will likely short towards *buyer-driven* chains. For this reason, it must be noted that, just because the biofuels industry is agri-based and job intensive does not necessarily mean that it an effective means to link smallholders and the informal economy with the formal economy.

This shows the importance of public policies and mechanisms that encourage competition, reward local ownership, and promote revenue sharing. ICRISAT (2007) points to examples from agriculture (dairy and soy in India, cotton in Burkina Faso) where models of pro-poor business development can be found for the biofuels sector. Some models are already at work in biofuels, such as smallholder cane farmers in Mauritius who share the revenues from large-scale bagasse-based cogeneration plants. The "Social Fuel Seal" in Brazil is a promising example of a tool to improve the equity of the "biofuels revolution" by providing the downstream biodiesel industry with incentives to source their feedstock from smallholders and family farmers.

11. Key Options for Strategic Policy

Chapter 3 introduced the four main policy goals associated with the development of a biofuels sector – energy security, rural development, export development and climate change mitigation – and a decision tree to guide countries their decision-making regarding the biofuel sector. Chapters 4 to 10 addressed the key issues – feedstock choices and food security, environmental, social, economic, trade and value chain aspects – that policy-makers need to consider to guide their decision-making about biofuels development.

Once these steps of decision making have been completed, and policy makers have weighed food security, environment and development implications, then this last chapter may provide useful strategic policy options for policy-makers willing to maximise the overall net benefits of biofuels development.

11.1 Overarching policy considerations in biofuel production

Biofuels imply long-term policy support: Country experience shows that the development of a robust biofuels industry is a long-term task. It requires a sustained commitment from governments in terms of budget allocation, inter-sectoral coordination and adaptive policy to provide an appropriate set of incentives for producers, processors and consumers. This will have a sizable impact on government's revenues. Governments need to conduct a comprehensive assessment of how long this process may take and how much it would cost, and decide whether they are prepared to deal with the impacts that this may have on their revenues (see Chapter 8). The long-term costs will need to be weighed against the net benefits of biofuels promotion to national welfare and also compared against of the costs of other policy options to achieve a specific policy goal. Moreover, given that once granted and the biofuel industry has been launched, subsidies are difficult to withdraw, governments wishing to reduce subsidies will need to confront the vested interests created within the industry.

Policy mechanisms need to be designed in response to specific policy goals associated with the development of the biofuel industry. Policy design will differ depending on each country's context and needs. Timeframe matters: policy requirements for the development of an infant industry are different from those to support a more mature one. Policy space is also important: countries wanting to promote biofuels to reduce energy imports need to be aware of what type of polices they can actually apply to protect domestic production in terms of the international commitments (e.g. trade agreements) to which they are committed. Overall, governments will need to commit to a long-term, regular process of iterative policy review and adaptation.

Policy coherence*:* Any strategy towards promoting the development of a biofuels industry should be aligned with existing national policies, including sectoral policies or national policies, and plans such as Sustainable Development Strategies and Poverty Reduction Strategies. This requires coordination and coherence among the different bodies involved, such as Ministries of Agriculture, Energy, Environment, Industry and Trade. In those countries committed to decentralisation, policy coherence at the sub-national level will also be a key issue.

Policy coherence is also required at the international level. Countries need to make sure that while promoting the development of the biofuel industry they comply with the different international frameworks to which they are committed, including the Convention on Biological Diversity, Kyoto Protocol and international trade rules.

Enabling environment for biofuels sector development: Beyond providing a suitable policy environment to promote the biofuels sector (incentives, regulations and support), governments also need to provide the "fundamentals" that incentivise private sector investment. These include a sound macro-economic environment, the establishment of a clear, stable, and transparent legal and fiscal framework, and an efficient administration. In addition to the fundamentals, an enabling environment that maximises the rural benefits of biofuels includes the promotion of producer ownership, which may be achieved through simple realigning of regulatory incentives, as set out in Chapter 10.

Realising synergies from different policy goals for biofuels: In some cases there is potential for reaching synergies and win-win-win opportunities among the different policy goals. For instance, there are synergies between rural development and energy security goals. A decentralised energy policy – built on local production of biofuels – may improve economic resilience, especially in remote areas. Bringing in a further policy goal of environmental improvement, the production of some biofuel feedstocks such as jatropha may help to restore degraded dryland areas. Policy goals can also be linked stepwise over time. Strategically, the development of a biofuels sector orientated to supply the national market efficiently, can increase the opportunities for the country to become an international seller in the longer term, particularly if the initial industry pays attention to international standards and market links.

Need to keep track of developments in international oil and agricultural markets, and the second generation of biofuels: Biofuels markets and policies are strongly affected by developments in international fossil fuel and agricultural markets. Likewise, technology developments such as the commercial availability of the second generation of biofuels will also have important impacts on market structure. Governments will need to track and respond to these dynamics of markets and technology.

11.2 Specific policy considerations

The decision tree (Chapter 3) ends with policy decisions related to three possible market channels: biofuels for local-remote-landlocked areas, for the national market and for the international market. This section identifies key policy options to maximise overall benefits of each of these alternatives. Although these policy options tend to focus on those that are critical for the development of the supply side in each of these alternatives, policy-makers need to be aware that demand-side development is also crucial (e.g. by setting of national targets for biofuels or tax exemptions to biofuel consumption). In fact, as Woods 2006 asserts "much of the history of modern bioenergy development has been described as a "chicken and egg" conundrum in that the supply sector cannot be established before a demand for their products is in place, and the demand cannot be established before the supply structure is in place."

Biofuels production for local-remote-landlocked areas

Key policies should:

- Promote access and transfer of biofuels technologies. This may include provision of subsidised technology and capacity building and training in how to access and use the technology.
- Promote access to micro-credit, for instance, providing soft loans or loan guarantees.
- Promote producer collaboration to achieve economies of scale, so that smaller scale producers can "cooperate to compete".
- Remove constraints to sector development (e.g. restrictions on small-scale sugarcane cultivation in Madagascar and on small-scale distilleries in Zimbabwe).

Biofuels production for the national market

Key policies should:

- Identify the desired type of business model: small producer; large scale or combination of the two, making the most of synergies between energy sector development and equitable rural development as far as possible.
- Promote better participation and ownership in the value chain. Reaping the largest benefits of biofuels need to focus on the biofuels processing end of the chain rather than feedstock production end.
- Promote access and transfer of biofuels technology. This can be done through, for example, lowering of tariffs to imports of biofuels capital; training in the use and adaptation of biofuels technologies. South-South cooperation can play and important role.
- Promote access to finance/credit. This may include provision of soft loans, loan guarantees, and cooperation with IFIs, with a particular emphasis on finance for small-scale producers and processors, to reduce the perceived risk of the biofuels sector and also to prevent that investment will only focus on large projects. Additional sources of finance can come through the promotion of South-South cooperation, carbon trading schemes and promoting FDI with strong domestic benefits such as forward or backward linkages.
- Create market infrastructure, testing of the technology and demonstrate production potential though, for example, supporting demonstration/ pilot projects.

Facilitate development of biofuels distribution infrastructure (e.g. roads).

Biofuels production for the international market

Key policies should:

- Decide which international market to supply. This decision will be an outcome of the country's international competitiveness, existing trade preferences, market distortions in key importing markets, proximity to main regional markets and capacity to comply with international standards.

- Negotiate favourable trade terms for biofuels and the elimination of existing domestic distortions e.g. taxes on biofuels exports.
- Decide on the types of business model (e.g. large-scale or cooperation between large-scale and small producers) for which to provide incentives, and mechanisms to ensure equitable access to ownership and value along the chain.
- Build domestic capabilities to become an international player. This can involve devoting resources for the development of R&D programmes; promoting partnerships with countries with more advanced biofuel industries; promoting FDI with strong domestic benefits such as forward or backward linkages.
- Promote access to biofuel technologies including cutting-edge technologies. This could involve, for example, import tariff reductions to biofuel technological goods and training in the use, transfer and adaptation of biofuels technologies. South-South cooperation can play and important role.
- Promote access to finance/credit. This may include provision of soft-loans, guarantees, cooperation with IFIs to reduce the perceived risk of the sector, and South-South cooperation.
- Build capacity on biofuel standards: both to develop domestic capacities to *comply* with international technical and sustainability standards but also to participate in international standard development processes – to pass from being a standard "taker" to standard "setter".

12. References

Aantjes, J.C. 2007. ***Driving biofuels in Europe. A research on the interaction between external regulation and value chain governance.*** MSc Thesis, Department Global Business and Stakeholder Management, Erasmus University Rotterdam. May 2007

Abramovay, R. and Magalhaes, R. 2007. ***The access of family farmers to biodiesel markets: partnerships between big companies and social movements.*** Regoverning Markets Programme. www.regoverningmarkets.org

Bakker S.J.A. 2006. ***CDM and biofuels - Can the CDM assist biofuels production and deployment?***, Energy Research Centre of the Netherlands, October, available at: http://www.senternovem.nl/mmfiles/CDMandBiofuels_tcm24-222843.pdf

Bauen, A., Chase, A., Franzosi, M., de Groot, P. and Woods, J. 2006. ***Feasibility study on the production of bioethanol from sugar cane in the Caribbean Region.*** Report prepared for the UK Department for International Development. E4Tech (UK) Ltd, London, UK.

Becker K. and Francis G. 2003 ***Bio-diesel from Jatropha plantations on degraded land.*** Department of Aquaculture Systems and Animal Nutrition, University of Hohenheim. Available at: http://www.uni-hohenheim.de/~www480/docs/publish/jatropha_on_degraded_land.pdf

Biofuelwatch, Corporate Europe Observatory, Ecologistas en Acción, Econexus, Ecoropa, Grupo de Reflexión Rural, Munlochy Vigil, NOAH (Friends of the Earth Denmark), Rettet Den Regenwald, Carbon Trade Watch and Watch Indonesia 2007. ***Agrofuels – towards a reality check in nine key areas.*** Report prepared for the twelfth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) of the Convention on Biological Diversity, Paris, 2-6 July 2007.

Biopact 2006 '***The Year in Review: Africa***' Biopact, December 27, available at:

Cereal Industries Forum 2007. ***Cutting Costs – Adding Value in Cereals***. Cereal Industry Forum Case study, April 2007.

CFC 2006. ***Current Trends and the New Development Role of Commodities***. Common Fund for Commodities, Amsterdam, The Netherlands. November 2006

Chaturvedi S. 2006. '***Opportunities for Biofuel in Select Asian Economies: Emerging Policy Challenges***' in Linking Trade, Climate Change and Energy, ICTSD Trade and Sustainable Energy Series, International Centre for Trade and Sustainable Development, Geneva, Switzerland, November.

Cloin, J. 2007. ***Liquid biofuels in Pacific island countries***. SOPAC Miscellaneous Report 628. Pacific Islands Applied Geoscience Commission, Suva, Fiji.

De Fraiture, C., Giordano, M. and Yongsong, L. 2007. ***Biofuels: implications for agricultural water use***. International Water Management Institute, Colombo, Sri Lanka.

Dufey, A. 2006. ***Biofuels production, trade and sustainable development***: emerging issues. Sustainable Markets Discussion Paper 2. International Institute for Environment and Development, London, UK. Available at: http://www.iied.org/pubs/pdf/full/15504IIED.pdf

Dufey, A. 2007 ***International trade in biofuels: Good for development? and Good for the Environment?***, IIED Policy Briefing. International Institute for Environment and Development, London, UK. Available at: http://www.iied.org/pubs/pdf/full/11068IIED.pdf

EC 2005 ***'Biomass Action Plan, Communication from the Commission COM(2005) 628final'***, European Communities. Available at: http://ec.europa.eu/energy/res/biomass_action_plan/doc/2005_12_07_comm_biomass_action_plan_en.pdf.

EC 2007a '***Note to the File: The impact of a minimum 10% obligation for biofuel use in the EU-27 in 2020 on agricultural markets, Impact assessment Renewable Energy Roadmap***' European Communities, March. Available at: http://ec.europa.eu/agriculture/analysis/markets/biofuel/impact042007/text_en.pdf

EC 2007b. '***Proposal for a Directive of the European Parliament and of the Council***' amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and the introduction of a mechanism to monitor and reduce greenhouse gas emissions from the use of road transport fuels and amending Council Directive 1999/32/EC, as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC (presented by the Commission)' COM(2007)18 Brussels, 31 January, available at: http://ec.europa.eu/environment/air/pdf/fuel/com_2007_18_en.pdf

ESMAP 2007 '***Considering Trade Policies for Liquid Biofuels***' Energy Sector Management Assistance Programme, The International Bank for Reconstruction and Development, Washington DC, June

ESMAP 2006. ***Annual Report 2005***', Energy Sector Management Assistance Programme, The International Bank for Reconstruction and Development, Washington DC, June. Available at: http://www.esmap.org/filez/pubs/ESMAP05.pdf

ESMAP 2005a. '***The Vulnerability of African Countries to Oil Price Shocks: Major Factors and Policy Options - The Case of Oil Importing Countries***' Energy Sector Management Assistance Programme, Report 308/05, The International Bank for Reconstruction and Development, Washington DC, August. Available at: http://wbln0018.worldbank.org/esmap/site.nsf/files/308-05+Final_to_Printshop.pdf/$FILE/308-05+Final_to_Printshop.pdf

ESMAP 2005b. '***Potential for biofuels for transport in developing countries***'. Energy Sector Management Assistance Programme, World Bank, Washington DC, USA. Available at http://esmap.org/filez/pubs/31205BiofuelsforWeb.pdf

FAPRI 2007 '***FAPRI 2007 World Agricultural Outlook***' Staff Report. , International Food Policy Research Institute, Iowa State University and University of Missouri-Columbia, Ames, Iowa.

FAPRI 2006 '***Global Scenarios for Biofuels: Impacts and Implications'***, International Food Policy Research Institute

FAO 2007. ***Proceedings of the First FAO technical consultation on bioenergy and food security***. 16-18 April 2007. Food and Agriculture Organisation of the United Nations, Rome, Italy.

Farrell, J. 2007. ***Wind and Ethanol: Economies and Diseconomies of Scale***. Institute for Local Self-Reliance, July 2007. www.newrules.org

Fromm, I. 2007. ***Integrating Small-scale Producers in Agrifood Chains: The Case of the Palm Oil Industry in Honduras***. Paper presented at 17th Annual Food and Agribusiness Forum and Symposium, Parma, Italy, June 23-26, 2007

GAIN 2006. ***EU-25 Biofuels Annual***GAIN Report Number: E36102, USDA Foreign Agricultural Service, November 7th, available at: http://www.fas.usda.gov/gainfiles/200702/146280256.pdf

Globalmanufacture 2004. '***The Philippines and Thailand preparing standards for ethanol use***' Globalmanufacture.net. Available at: http://www.globalmanufacture.net/home/communities/qualityassurance/ethanol.cfm

GMF 2007. ***EU and US Policies on Biofuels: Potential Impacts on Developing Countries***' German Marshal Fund of the United States, Washington DC, USA.

Henniges, O. and Zeddies, J. 2006 ***Bioenergy in Europe: Experiences and Prospects*** in Bioenergy and Agriculture: Promises and Challenges, IFPRI, FOCUS 14, Brief 9 of 12, December, available at: http://ifpri.org/2020/focus/focus14/focus14_09.pdf

ICRISAT 2007. ***Pro-poor biofuels outlook for Asia and Africa:*** ICRISAT's perspective. International Crops Research Institute for the Semi-Arid Tropics, Nairobi, Kenya.

IDB 2007. ***IDB approves US$120 million for biofuel project in Brazil*** International Development Bank Press Release, July 25, 2007, available at: http://www.iadb.org/NEWS/articledetail.cfm?artid=3954&language=En

IEA 2006 '***World Energy Outlook 2006***' International Energy Agency, Paris,

IEA 2004 '***Biofuels for Transport An International Perspective'*** International Energy Agency, Paris, April.

Johnson F., Seebaluck V. Watson H and Woods J. 2006. ***Bioethanol from sugarcane and sweet sorghum in Southern Africa***: Agro-Industrial Development, Import Substitution and Export Diversification" in Linking Trade, Climate Change and Energy, ICTSD Trade and Sustainable Energy Series, International Centre for Trade and Sustainable Development, Geneva, Switzerland, November.

Johnson, F.X. and Rosillo-Calle, F. 2007. ***Biofuels, livelihoods and trade: challenges and opportunities for the EU and Southern Africa.*** Stockholm Environment Institute, Stockholm, Sweden.

Johnston, M. and Holloway, T. 2006. ***A Comparative International Analysis of the Potential Gains from Biodiesel Production and Export***, Center for Sustainability and the Global Environment, University of Wisconsin

Kartha, S. 2006. ***Environmental effects of bioenergy***. In Hazell, P. and Pachauri, R.K. (eds) Bioenergy and agriculture: promises and challenges. 2020 Vision Focus 14. International Food Policy Research Institute, Washington DC, USA, and The Energy and Resources Institute, New Delhi, India.

Kenkel, P. and Holcomb, R.B. 2006. ***Challenges to Producer Ownership of Ethanol and Biodiesel Production Facilities***. Journal of Agricultural and Applied Economics, August

Kokonut Pacific 2006 '*Coconut Oil - a Significant Bio-fuel*' available at: http://www.kokonutpacific.com.au/index.html?Biofuel.htm

Koplow, D. 2006 '***Biofuels: At What Cost? Government Support for Ethanol and Biodiesel in the United States***' report prepared by Earth Track, Inc for The Global Subsidies Initiative (GSI) of the International Institute for Sustainable Development (IISD), Geneva, Switzerland.

Kutas, G and Lindberg, C. forthcoming, '***Biofuels – At what Cost? Government Support for Ethanol and Biodiesel in the European Union***' for the Global Subsidies Initiative (GSI), IISD, Geneva

Mayers, J. and Vermeulen, S. 2002. ***From raw deals to mutual gains: company-community partnerships in forestry***. Instruments for Sustainable Private Sector Forestry series. International Institute for Environment and Development, UK.

Ministerio da Agricultura, Pecuaria e Abastecimiento and Assessoria de Gestao Estrategica, 2006 '***Agribusiness Projections: World and Brazil, Executive Summary***' available at: http://www.agricultura.gov.br/pls/portal/docs/page/mapa/menu_lateral/agricultura_pecuaria/projecoes_agronegocio/copy_of_projecoes_agronegocio/executive%20summary%20agribusiness%20projections_0.pdf,

Mishra, S. and Awasthi, K. 2006. ***Jatropha jam***. Down to Earth September 15, 2006.

Morris, D. 2006. ***Biofuels: What's in it for Farmers and Rural America***? Presentation to Oklahoma Governor's Conference on Biofuels, University of Oklahoma, October 3-4, 2006. Available at http://conferencepros.org/growPresentations/Morris.pdf

Morris, D, 2007. ***Energizing Rural America:*** Local ownership of renewable energy production is the key. Center for American Progress. www.americanprogress.org/issues/2007/01/pdf/rural_energy.pdf

Murphy, S. 2007 (forthcoming). '***A Multilateral Framework For Eco-Fair Energy From Agriculture: What To Consider***?', International Institute for Environment and Development and Institute for Agriculture and Trade Policy.

O'Brien, D. 2006. ***Biofuels: Policy and Business Organization Issues***. National Agricultural Law Centre, www.NationalAgLawCenter.org

OECD - FAO 2007. ***OECD & FAO Agricultural Outlook 2007-2016***. Organisation for Economic Cooperation and Development, Paris, France, and Food and Agriculture Organisation of the United Nations, Rome, Italy.

OECD 2006 '***Agricultural Market Impacts of Future Growth in the Production of Biofuels***' AGR/CA/APM(2005)24/FINAL Directorate for Food, Agriculture and Fisheries, Committee for Agriculture. Organisation for Economic Co-operation and Development, Paris. Available at: www.oecd.org/dataoecd/58/62/36074135.pdf.

Oestling A 2001 ***Bioethanol Added to Fuel, European Parliament Briefing Note No07/2001***, February, available at: http://www.europarl.eu.int/stoa/publi/pdf/briefings/07_en.pdf;

OGJ 2007 '***Brazilian state studies ethanol pipeline***' Oil and Gas Journal, July 11th

Peskett, L., Slater, R., Stevens, C. and Dufey, A. 2007. ***Biofuels, agriculture and poverty reduction***. Report prepared for the UK Department for International Development. Overseas Development Institute, London, UK.

Pioneer Press 2005 ***Biofuel imports anger farmers; Tax break irks ag-state lawmakers***, November 30th, available at http://www.agobservatory.org/headlines.cfm?refID=77672.

Republic of South Africa 2006. ***Draft Biofuels Industrial Strategy of the Republic of South Africa***. Department of Minerals and Energy, November 2006. Available at www.dme.gov.za/pdfs/energy/renewable/Biofuels_Strategy_SA.pdf

RFA 2007. '***Ethanol Industry Outlook 2007: Building New Horizons***', Renewable Fuels Association, February,. Available at: http://www.ethanolrfa.org/objects/pdf/outlook/RFA_Outlook_2007.pdf

Rohter, L. 2007. ***In the Amazon: Conservation or Colonialism***? New York Times July 27, 2007.

Rosegrant, M.W. 2007. ***Water futures – sustainability and growth: some reflections***. Presentation at the Panel Discussion for the World Bank Water Week, 27 February – 1 March 2007, Washington DC, USA.

Rosegrant, M.W., Msangi, S., Sulser, T. and Valmonte-Santos, R. 2006. ***Biofuels and the global food balance.*** In Hazell, P. and Pachauri, R.K. (eds) Bioenergy and agriculture: promises and challenges. International Food Policy Research Institute, Washington DC, USA, and The Energy and Resources Institute, New Delhi, India.

Schlamadinger, B. and Jürgens, I. 2004. ***Bioenergy and the Clean Development Mechanism***, joint International Energy Association (IEA Bioenergy Task 38) and FAO policy paper. Available at http://www.ieabioenergy-task38.org/publications/.

Schmidhuber, J. 2007. ***Biofuels: an emerging threat to Europe's food security***? Notre Europe Policy Paper 27. Notre Europe, Paris, France.

Turley, D., Graziano, C., Bullard, M. and Martin, D. (2003). ***Liquid biofuels – industry support, cost of carbon savings and agricultural implications.*** Report prepared for Defra Organic Farming and Industrial Crops Division, August 2003. Available at www.defra.gov.uk/farm/crops/industrial/research/reports/biofuels_industry.pdf

Turner, B.T., Plevin, R.J., O'Hare, M. and Farrell, A.E. 2007. ***Creating markets for green biofuels: measuring and improving environmental performance***. Research report UCB-ITS-TSRC-RR-2007-1. Transportation Sustainability Research Centre, University of Berkeley, USA.

Tyrchniewicz, A., Hickson, A., McLachlin, R., Morris, M and Tyrchniewicz, E. 2006. ***Development of Bioproduct Value Chains in the Canadian Economy: A Study of Value Creation, Value Capture and Business Models***. Report prepared under contract for Industry Canada and Bioproducts Canada. Tyrchniewicz Consulting Ltd. and University of Manitoba, July 2006. Available at www.tyrchniewicz-consulting.com/PDFs/Bioproducts_Final_Report_July2006.pdf

UNCTAD 2006. ***The emerging biofuels market: regulatory, trade and development implications.*** United Nations Conference on Trade and Development. UNCTAD/DICT/TED/2006/4

UN-Energy 2007. ***Sustainable bioenergy: a framework for decision makers.*** United Nations. Available at http://esa.un.org/un-energy/pdf/susdev.Biofuels.FAO.pdf

USDA 2007 '***USDA Agricultural Projections to 2016***' Office of the Chief Economist, World Agricultural Outlook Board. February. Available at: www.ers.usda.gov/publications/oce071/oce20071.pdf.

Vorley B 2003 '***Food Inc. Corporate concentration from farm to consumer***' UK Food Group – International Institute for Environment and Development.

Woods, J. 2006. ***Science and technology options for harnessing bioenergy's potential*** In Hazell, P. and Pachauri, R.K. (eds) Bioenergy and agriculture: promises and challenges. 2020 Vision Focus 14. International Food Policy Research Institute, Washington DC, USA, and The Energy and Resources Institute, New Delhi, India. Available at www.ifpri.org/2020/focus/focus14/focus14_06.pdf

Worldwatch Institute 2006. ***Biofuels for transportation: global potential and implications for sustainable agriculture and energy in the 21st century.*** Report prepared for the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV). Worldwatch Institute, Washington DC, USA.

Annex 1: List of Commodity-Dependent Developing Countries (CDDCs)

Armenia
Belize
Benin
Botswana
Burkina Faso
Burundi
Central African Republic
Cook Islands
Cote d'Ivoire
Cuba
Eritrea
Ethiopia
French Polynesia
Ghana
Guinea
Guyana
Honduras
Kenya
Kyrgyzstan
Madagascar
Malawi
Maldives
Mali
Mongolia
Mozambique
Namibia
New Caledonia
Nicaragua
Niger
Panama
Papua New Guinea
Paraguay
Peru
Rwanda
Sao Tome & Principe
St Vincent & the Grenadines
Seychelles
Sierra Leone
Togo
Uruguay
Tanzania
Uganda
Zimbabwe

Annex 2: Checklist of issues or critical questions for Decision Tree

Issue Feedstock choice	Yes	No	Not sure
1. Are feedstocks suited to biophysical conditions?			
2. Does a quick assessment suggest that returns will returns outweigh costs for production of that feedstock in a chosen biophysical zone and type of farming system?			
Food security analysis: Is it possible to assure food security alongside biofuel production?			
1. Is it clear that energy savings and earnings from biofuels at the national level will outweigh any increases to the national food bill?			
2. Is it possible to assure access to food for all sectors of society, including poor urban and rural consumers?			
Environmental analysis: Is it possible to assure environmental protection in biofuel production and use?			
1. Can biofuel production be undertaken without movement of the agricultural frontier into biodiversity-rich and protected areas?			
2. Can fair and ecologically sustainable allocation and use of water be maintained under biofuels production?			
3. Is it assured that biofuels production will not compromise national environmental policies nor international agreements?			
4. Is it assured that the chosen feedstocks will not bring high risks to biosafety and biodiversity?			
Social analysis: Is it possible to assure positive social outcomes through biofuel production and use?			
1. Can biofuel production be undertaken without threat of serious disruption to rural residents' land rights and livelihood options?			
2. Does public opinion broadly favour biofuels development?			
Economic analysis: Will biofuels' returns to national welfare outweigh the economic costs in the long term?; Are biofuels the most cost-efficient means of achieving these policy goals?			
1. Are all the economic, environmental and social costs and benefits of biofuels development included in the equation?			
2. Has the impact that biofuel policies will have on government revenues in the long term been considered?			
3. Are the biofuels policies targeting the right group of stakeholders?			
4. Have other policy instruments to achieve the same policy goal been considered?			
5. Are the costs of biofuel development lower than those of alternative policies?			