GreenFacts
Facts on Health and the Environment

Scientific Facts on

Liquid Biofuels for Transport

Prospects, risks and opportunities

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Summary & Details:
GreenFacts

Level 2 - Details on Liquid Biofuels for Transport

This Digest is a faithful summary of the leading scientific consensus report produced in 2008 by the Food & Agriculture Organization (FAO):
"The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities"

The full Digest is available at: https://www.greenfacts.org/en/biofuels/

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- Each question is answered in Level 1 with a short summary.
- These answers are developed in more detail in Level 2.
- Level 3 consists of the Source document, the internationally recognised scientific consensus report which is faithfully summarised in Level 2 and further in Level 1.

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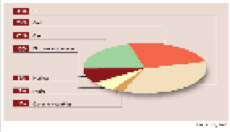
1. What are biofuels?

1.1 What is bioenergy?

Bioenergy is energy derived from biofuels. Biofuels are fuels produced directly or indirectly from organic material – biomass – including plant materials and animal waste.

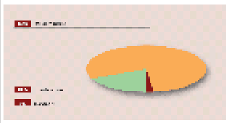
Traditional biomass is largely used in developing countries for cooking and heating
Credit: Roberto Faidutti

Overall, bioenergy covers approximately 10% of the total world energy demand. Traditional unprocessed biomass such as fuelwood, charcoal and animal dung accounts for most of this and represents the main source of energy for a large number of people in developing countries who use it mainly for cooking and heating.



World primary Energy Demand per Source OR Trends in Consumption of transport biofuels
[see Annex 6, p. 26]

More advanced and efficient conversion technologies now allow the extraction of **biofuels** from materials such as wood, crops and waste material. Biofuels can be solid, gaseous or liquid, even though the term is often used in the literature in a narrow sense to refer only to liquid biofuels for transport.



Use of biomass for energy
[see Annex 15, p. 33]

Biofuels may be derived from agricultural crops, including conventional food plants or from special energy crops. Biofuels may also be derived from forestry, agricultural or fishery products or municipal wastes, as well as from agro-industry, food industry and food service by-products and wastes.

A distinction is made between primary and secondary biofuels. In the case of **primary biofuels**, such as fuelwood, wood chips and pellets, organic materials are used in an unprocessed form, primarily for heating, cooking or electricity production. **Secondary biofuels** result from processing of biomass and include liquid biofuels such as ethanol and biodiesel that can be used in vehicles and industrial processes.

Bioenergy is mainly used in homes (80%), to a lesser extent in industry (18%), while **liquid biofuels for transport** still play a limited role (2%).

Even though the production of liquid biofuels for transport has grown rapidly in recent years it currently represents only 1% of total transport fuel consumption and only 0.2 to 0.3% of total energy consumption worldwide.

1.2 What are the different types of liquid biofuels for transport?

The most widely used liquid biofuels for transport are ethanol and biodiesel.

Ethanol is a type of alcohol that can be produced using any feedstock containing significant amounts of sugar, such as sugar cane or sugar beet, or starch, such as maize and wheat. Sugar can be directly fermented to alcohol, while starch first needs to be converted to sugar. The fermentation process is similar to that used to make wine or beer, and pure ethanol is obtained by distillation. The main producers are Brazil and the USA.

Ethanol can be blended with petrol or burned in nearly pure form in slightly modified spark-ignition engines. A litre of ethanol contains approximately two thirds of the energy provided by a litre of petrol. However, when mixed with petrol, it improves the combustion performance and lowers the emissions of carbon monoxide and sulphur oxide.

Biodiesel is produced, mainly in the European Union, by combining vegetable oil or animal fat with an alcohol. Biodiesel can be blended with traditional diesel fuel or burned in its pure form in compression ignition engines. Its energy content is somewhat less than that of diesel (88 to 95%). Biodiesel can be derived from a wide range of oils, including rapeseed, soybean, palm, coconut or jatropha oils and therefore the resulting fuels can display a greater variety of physical properties than ethanol.

Diesel engines can also run on **vegetable oils** and **animal fats**, for instance used cooking oils from restaurants and fat from meat processing industries.

The production processes for both bioethanol and biodiesel yield additional by-products such as animal feed.

1.3 What are second-generation biofuels?

Currently used liquid biofuels, which include ethanol produced from crops containing sugar and starch and biodiesel from oilseeds, are referred to as **first-generation biofuels**. These fuels only use a portion of the energy potentially available in the biomass.

Most plant matter is composed of cellulose, hemicellulose and lignin, and "**second-generation biofuel**" technologies refer to processes able to convert these components to liquid fuels. Once commercially viable, these could significantly expand the volume and variety of sources that could be used for biofuel production.

Potential cellulosic sources include municipal waste and waste products from agriculture, forestry, processing industry as well as new energy crops such as fast growing trees and grasses. As a result second generation biofuel production could present major advantages in terms of environmental sustainability and reduced competition for land with food and feed production. It could also offer advantages in terms of greenhouse gas emissions.

Various techniques are currently being developed to produce second generation biofuels. However, it is uncertain when such technologies will enter production on a significant commercial scale.

The **conversion of cellulose to ethanol** involves two steps. The cellulosic and hemicellulosic components of the plant material are first broken down into sugars, which are then fermented to obtain ethanol. The first step is technically difficult, although research continues on developing efficient and cost-effective ways of carrying out the process. Lignin cannot be converted to ethanol, but it can provide the necessary energy for the conversion process.

Gasification is a technique that converts solid biomass such as wood into a fuel gas. Gasifiers operate by heating biomass to high temperatures in a low-oxygen environment releasing an energy-rich gas. This gas can be burned in a boiler, used in a gas turbine to generate electricity.

1.4 How much liquid biofuel could be produced?

Current world oil demand amounts to about 4000 Million tonnes of oil equivalent (Mtoe) while the production of liquid biofuels amounts to 36 Mtoe representing less than 1% of this world demand.

Around 85% of the liquid biofuels are currently produced in the form of bioethanol with the main producers being Brazil and the USA. Biodiesel production is essentially concentrated in the European Union.

Table 1: Biofuel production by country, 2007 [see Annex 18, p. 35]

Large-scale production of biofuels from crops requires large land areas to grow them, which generates increasing competition for natural resources, notably land and water.Crop yields per hectare vary widely depending on the type of crop, the country and the production system. Currently, ethanol production from sugar cane and sugar beet produces the highest yields per hectare.

Table 2: Biofuel yields for different feedstocks and countries [see Annex 19, p. 36]

In its World Energy Outlook 2006, the IEA projected an increase in the share of the world's fertile land used to grow plants for liquid biofuel production from 1% in 2004 to around 4% in 2030, assuming favourable government policies and reasonable technical development.

Using conventional biofuel technologies, this land use would allow 5% of transport fuel demand to be met. If second-generation biofuel technologies were available, this could rise to 10%.

This illustrates that biofuels can only be expected to displace fossil fuels for transport to a very limited extent. Nevertheless, they have a significant effect on global agriculture and agricultural markets because of the large volumes of feedstocks and land areas needed for their production.

2. What are the economic and policy factors influencing biofuel development?

2.1 How are agricultural, energy and biofuels markets linked?

Agriculture both supplies and uses energy, so agriculture and energy markets are closely linked.The rapidly increasing demand for liquid biofuels is connecting agriculture and energy more closely than ever, both through market forces and government policies encouraging biofuel use.

Liquid biofuels such as bioethanol and biodiesel which are derived from agricultural crops compete with fossil fuels on **energy markets**. As biofuel volumes produced remain small compared to the global market of petroleum fuels, oil prices are an important driver of the prices of biofuels and of their agricultural feedstocks .

Agricultural crops grown for energy production also compete with food crops for resources. For example, a given plot of land can be used to grow maize for ethanol or for food. Farmers will sell their harvest to an ethanol or biodiesel processor if the price received is higher than what they could obtain from other sources such as food processing. As a consequence, when the value of biofuel feedstocks is high, prices for other agricultural crops tend to rise. For this reason, producing second generation biofuels from non-food crops, such as wood or grasses, will not necessarily eliminate the competition between food and fuel.

With the exception of bioethanol from sugar cane in Brazil, biofuels have not generally been competitive with fossil fuels without active **government support** to promote their development and subsidise their use, even at high crude oil prices. In general, granting subsidies to a sector that cannot ultimately achieve economic viability is not sustainable and may simply transfer wealth from one group to another while imposing costs on the economy as a whole Subsidies can also have complex impacts on producers and consumers in other countries.

2.2 What are the drivers of biofuel policies?

The main drivers behind government support for biofuels in OECD countries are concerns about climate change and energy security, and the political will to support the farm sector through increased demand for agricultural products.

Energy Security Secure access to energy is a longstanding concern in many countries. The recent increases in oil and other energy prices have increased the incentive to promote alternative sources of energy. Strong demand from rapidly developing countries, especially China and India, is adding to concerns over future energy prices and supplies. The transport sector depends mainly on oil. Liquid biofuels represent the main alternative source that can supply fuels suitable for use in current vehicles, without radical changes to transport technologies.

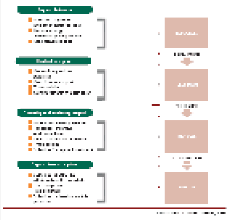
Climate change There is increasing concern about human-induced climate change, and the effects of greenhouse gas emissions on rising global temperatures. Bioenergy is often seen as a way to reduce greenhouse gas emissions.

However, the extent to which the production and use of a given biofuel reduces greenhouse gas emissions compared to the production and use of petroleum based fuels varies significantly depending on factors such as land-use change, type of feedstock, agricultural practices, conversion technology and end use.

Recent analyses suggest that large-scale expansion of biofuel production could even cause a net increase in greenhouse gas emissions.

Farm Support Supporting the farm sector has been a key objective of biofuel policies in several developed countries, and rural development is also being cited as a driver by developing countries. In countries with heavily subsidised farm sectors, bioenergy is seen as a way of revitalising agriculture. The possibility of boosting farm incomes while reducing income support and subsidies has considerable appeal for policy-makers, although the latter part of this strategy has been difficult to achieve.

2.3 What policy measures are influencing biofuel development?



Support provided at different points in the biofuel supply chain [see Annex 16, p. 34]

Policies on agriculture, energy, transport, environment and trade all have an influence on biofuel production. Schemes to promote and support biofuels have been introduced both in OECD and developing countries. Without these incentives, widespread biofuel production would in most cases not have been commercially viable.

The policies used by governments to promote and support biofuel development include various instruments. They can support the biofuel supply chain at different stages.

- **Agricultural policies** existed well before the introduction of biofuels. They include agricultural subsidies and price support mechanisms which directly affect production levels and prices of biofuel crops as well as production systems and methods. These policies also have implications at international level for agricultural trade and geographical pattern of agricultural production.
- **Blending mandates** defining the overall amount or proportion of biofuel that must be blended with petrol and diesel are increasingly being imposed.
- **Subsidies and support** for the distribution and use of biofuels are key policy components in most countries that promote the use of biofuels. Several countries are subsidising or mandating investments in infrastructure for biofuel storage, transportation and use, especially towards bioethanol which requires major investments in equipment.
- **Tariffs or import barriers** are duties usually imposed on imported goods. They are widely used on biofuels to protect the national agriculture and biofuel sectors, support domestic prices of biofuels and provide an incentive for domestic production.
- **Tax incentives** or penalties are among the most widely used instruments for stimulating demand for biofuels and can drastically affect the competitiveness of biofuels compared to other energy sources.
- **Research and development** is generally aimed at improving the efficiency and cost-effectiveness of biofuel production, and identifying sustainable feedstocks. In developed countries an increasing proportion of public research and development funding is directed towards second-generation biofuel technologies, in particular cellulosic ethanol and biomass-derived alternatives to petroleum-based diesel.

Support measures directly linked to levels of production and consumption are considered to have the greatest market-distorting effects, while support to research and development is likely to be the least distorting.

2.4 How costly are biofuel policies?

Estimates of total support for biofuels in the OECD countries show that biofuel subsidies are already relatively costly for taxpayers and consumers. In 2006, the USA spent an estimated 6.3 billion US$ to support biofuels, while the EU spent 4.7 billion US$. These figures include the cost of blending mandates, tax credits, import barriers, investment subsidies and general support such as public research investment, but exclude support to agricultural feedstock production.

Per litre of biofuel, support ranged from about US$0.20 to US$1.00 per litre in the OECD countries in 2006.

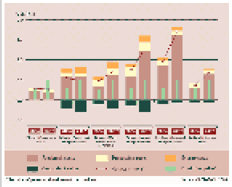
Table 6: Total support estimates for biofuels in selected OECD countries [see Annex 20, p. 36]

Table 7: Support per litre of biofuel in selected OECD countries [see Annex 21, p. 37]

Because the level of support is to a large extent linked to biofuel production, expenditures will increase as biofuel output grows.

In short, policies to promote and support biofuels have in most cases been costly. They have tended to introduce new distortions to national and international agricultural markets which are already severely distorted and protected. This has not encouraged an efficient international production pattern for biofuels.

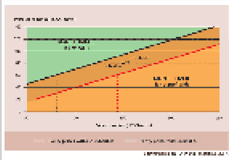
2.5 How viable are liquid biofuels?



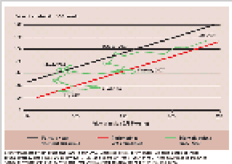
Biofuel production costs in selected countries, 2004 and 2007 [see Annex 17, p. 35]

In terms of litres of biofuel produced per hectare, sugar beet and sugar cane are currently the most productive crops. However, the costs of biofuel production vary widely depending on the type of feedstock, the country and various factors such as energy costs, processing costs and the value of co-products. Brazilian sugar-cane ethanol has a much lower total cost than other biofuels. Costs for other liquid biofuels exceed the market price of fossil fuels and require subsidies. The feedstock accounts for the largest share of total biofuel production costs. The energy costs of biofuel production can be offset by the value of by-products which may be burned for energy or sold.

Brazilian sugar-cane ethanol has a much lower total production cost than other biofuels due to the high efficiency of the production process. Sugar production costs have decreased over the last decades and bagasse, the major by-product of sugar-cane processing provides the energy necessary for the production process. In 2004 and 2007, costs for other liquid biofuels, such as sugar beet, wheat and maize ethanol in the EU or, rapeseed and soybean, all exceeded the market price of fossil fuels and required subsidies to remain competitive. Future profitability will depend on how these biofuels evolve in relation to fossil fuel prices.



Breakeven prices for maize and crude oil with and without subsidies [see Annex 1, p. 22]



Maize and crude oil breakeven prices and observed prices, 2003–08 [see Annex 2, p. 23]

The price that biofuel producers in the USA can pay for maize while remaining profitable varies both with and without government subsidies. It is estimated that for a crude oil price of US$60 per barrel, maize ethanol remains competitive on an energy basis as long as the market price for maize remains below US$79.52 per tonne, but the subsidies, which amount to about US$63 per tonne of maize, enable processors to pay up to US$142.51 per tonne and still remain profitable. When comparing observed monthly maize and crude oil prices with the maximum price that biofuel producers could pay for maize, it can be noted that maize ethanol in the USA has rarely been competitive with fossil fuels without subsidies.

Feedstock prices usually change with crude oil prices because energy is a significant cost factor in agricultural production and transport and rising crude oil prices contribute to a surge in demand for agricultural crops as feedstock for biofuels. For instance, between 2003 and 2008, prices for maize, rapeseed, palm oil and soybean have been highest when crude oil prices were high.

However, prices of agricultural products are also influenced by biofuel policies. For instance, the price of maize in the USA rose steadily during 2006, partly because of increasing ethanol production, while the price of crude oil remained stable

3. How are biofuel markets and production evolving?

3.1 How are prices for agricultural products evolving?

Food commodity price trends
[see Annex 3, p. 24]

During the 40 years up to 2002 food prices generally declined – taking into account inflation –but in recent years the prices of agricultural products have risen sharply. By early 2008 they were 64%above the levels of 2002, with vegetable oil and cereal prices showing the biggest increases, followed by dairy products and rice. However, those prices remained well below the levels reached in the 1970s and early 1980s once adjusted for inflation.

The following **factors are contributing to the increase in prices:**

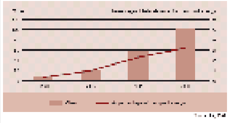
- Rapid economic and population growth in many emerging countries which have led to an increased demand for agricultural products.
- Increased use of food crops for the production of biofuels, with twice as much wheat and coarse grain used for ethanol in 2007 compared to 2005. Most of this growth in demand for grain occurred in the USA.
- Depreciation of the US dollar compared to many other currencies.
- Poor cereal harvests in major exporting countries in 2005 and 2006 and decline of the amount of grain held in storage since the mid-1990s.
- Higher petroleum prices increasing production costs of fertilisers and transportation costs, thus leading to higher overall costs for importing countries.
- Increasing fuel prices also contribute to the surge in demand for agricultural crops to produce biofuels.

In short, high prices were the result of a combination of factors including a rising demand coupled with a decline in agricultural production at a time when reserve stocks were at a relatively low level. The exact contribution of individual factors is nevertheless difficult to quantify.

As well as being higher, **prices have also fluctuated more than in the past**, especially for cereals and oilseeds. This volatility results from increased links between agricultural and energy markets, driven by policy support for biofuels and high energy costs.

Long-term projections suggest that prices for agricultural products will decline from their peak over the next few years. However, some pressures including biofuel demand will influence prices on the long term. Prices for grains and oilseeds are likely to remain above the levels seen during the previous decade. Future trends will also be highly dependent on crude oil prices.

3.2 How is biofuel production expected to evolve in the future?



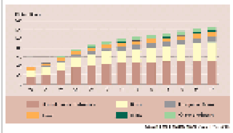
Trends in consumption of transport biofuels
[see Annex 14, p. 32]

3.2.1 **In the long term**, the International Energy Agency (IEA) foresees a significant expansion of the role of liquid biofuels for transport. From 19 million tonnes oil equivalent (Mtoe) in 2005, biofuel production could increase to 102 Mtoe or even 164 Mtoe in 2030 if all measures and policies currently under discussion are implemented. Nevertheless, even these large increases represent only a very small portion of the total transportation energy needs in 2030.

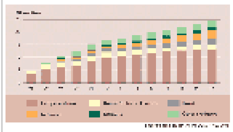
In contrast, current and projected production levels of crops to make biofuels are substantial compared to total agricultural production. Increased biofuel production could come from using more cropland for biofuel production and from improved yields. IEA projects an increase in the share of worldwide cropland devoted to biofuels from 1% in 2004 to 2.5% in 2030 with current policies and measures. With second generation biofuel technologies becoming available, this share of cropland could reach 4.2%. Most of the increased production would occur in the EU, the USA and Canada . However, if grasslands or forests are brought into agricultural production for this purpose, this would have environmental consequences.

Table 9: Land requirements for biofuel production [see Annex 22, p. 37]

3.2.2 **For the medium term**, various projections have been made in the OECD-FAO Agricultural Outlook 2008-2017 for future supply, demand, trade and prices for ethanol and biodiesel.



Major ethanol producers [see Annex 4, p. 25]

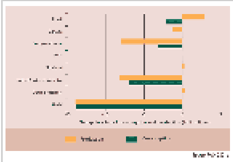


Major biodiesel producers [see Annex 5, p. 25]

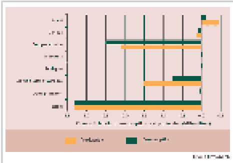
In the EU and in several other countries **ethanol** production is expected to grow rapidly. On the basis of current government policies, worldwide ethanol production is projected to double between 2007 and 2017. Brazil and the USA are expected to remain the largest producers, but strong production growth is forecast for China, India, Thailand and several African countries. In the EU, total production increase will likely not be sufficient to keep up with the growing demand, and increased imports are forecast.

Global **biodiesel** production is expected to grow at an even higher rate than ethanol, but the absolute volumes are lower – about 24 billion litres by 2017. Production is dominated by the EU, which accounts for about half of the total followed by the USA. Significant growth is also projected for biodiesel from soya in Brazil and from palm oil in Indonesia and Malaysia. In Africa and India there has been some investment in biodiesel production from jatropha.

3.2.3 Current trends in biofuel production, consumption and trade are strongly influenced by existing policies, especially those implemented in the EU and the USA, which promote biofuel production and consumption while protecting domestic producers with trade restrictions.



Impact of removing trade-distorting biofuel policies for ethanol [see Annex 7, p. 27]



Impact of removing trade-distorting biofuel policies for biodiesel [see Annex 8, p. 28]

If all trade barriers and subsidies were removed, it is estimated that global ethanol **production and consumption** would decline by about 10 to 15%. The largest reductions would occur in the EU, where ethanol support measured in per litre terms is very high, and in the USA, the largest ethanol producer. Imports would increase significantly in markets that are currently protected.

For biodiesel, the impact of removing trade barriers and subsidies would be larger in percentage terms than for ethanol, leading to reductions in production and consumption by around 15 to 20%.

Elimination of trade-distorting policies would increase global ethanol **prices** by about 10% because production in several heavily subsidised countries would decline more than consumption. In contrast, biodiesel prices would fall slightly because a reduction in EU consumption would reduce imports. Vegetable oil and maize prices would decline by about 5% and prices for sugar, the most cost-efficient biofuel feedstock, would rise.

Current biofuel support policies risk repeating past mistakes in the field of agricultural policies which led to misallocation of resources at international level. Biofuel policies of OECD countries have indeed **various negative consequences**. They impose large costs on their own taxpayers and consumers. They discriminate against producers in developing countries and impede the emergence of biofuel processing and exporting sectors in these countries. They also distort biofuel and agricultural markets. As a consequence, production of biofuels may not occur in the most economically or environmentally suitable locations.

The **future development of an economically efficient biofuel sector** at international level will therefore depend on the establishment of appropriate non-distorting national policies as well as trade rules that encourage an efficient geographical pattern of biofuel production.

3.3 What are the impacts of biofuel policies on international markets and trade?

To assess the net effect on greenhouse gas emissions of replacing fossil fuels by biofuels, we need to analyse emissions throughout the whole process of producing, transporting and using the fuel. Life-Cycle Analysis is the main tool used to do this. It compares a specific biofuel system with a reference system – in most cases petrol .

Greenhouse gas balances differ widely depending on the type of crop, on the location, and on how feedstock production and fuel processing are carried out. Biofuels from some sources can even generate more greenhouse gas emissions than fossil fuels.

A significant factor contributing to greenhouse gas emissions is the amount of fossil energy used for feedstock production and transport, including for fertilizer and pesticide manufacture, for cultivation and harvesting of the crops, and or in the biofuel production plant itself.

Emissions of nitrous oxide are another important factor. It is released when nitrogen fertilizers are used and its greenhouse gas effect is about 300 times stronger than that of carbon dioxide.

By-products from biofuel production such as proteins for animal feed make a positive contribution to climate change mitigation because they save energy and greenhouse gas emissions that would otherwise have been needed to produce the feed by other means.

Most studies have found that producing first generation biofuels usually yields reductions in greenhouse gas emissions of 20 to 60% when fossil fuels are replaced provided the most efficient systems are used and carbon dioxide emissions from changes in land-use are excluded.

Ethanol produced from sugar cane in Brazil and second-generation biofuels typically reduce emissions by 70 to 90%, again excluding carbon releases related to land-use change.

However, changes in land use can have dramatic effects on greenhouse gas emissions. When forest or grassland is converted to farmland to produce feedstocks, or to produce crops that have been displaced by feedstock production, carbon stored in the soil is released into the atmosphere. The effects can be so great that they negate the benefits of biofuels. Repaying this ‘carbon debt’ could take decades or even hundreds of years. In some cases it would be more cost-effective to strive for greater fuel efficiency and carbon sequestration through reforestation and forest conservation.

4. What are the environmental impacts of biofuel production?

4.1 Can biofuels help mitigate climate change?

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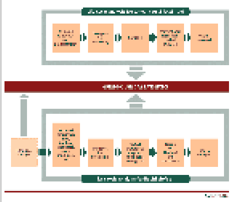

Life-cycle analysis for greenhouse gas balances [see Annex 9, p. 29]

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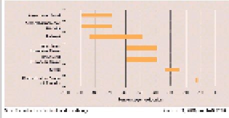

Reductions in greenhouse gas emissions of selected biofuels [see Annex 10, p. 30]

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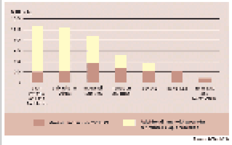
4.2 What changes to agricultural land would biofuel production require?

Since land-use changes have a significant impact on greenhouse gas emissions, it is important to know whether increased biofuels production will be met through improved land productivity or through expansion of cultivated area.



Potential for cropland expansion
[see Annex 11, p. 30]

Expansion of cultivated land

Of the world's 13.5 billion hectares of total land surface area, about 8.3 billion hectares are currently grassland or forest and 1.6 billion hectares cropland. After excluding forest land, protected areas and land needed for food, between 250 and 800 million hectares, are potentially available for the expansion of biofuel crop production.

In 2004, about 1% of global cropland was being used for biofuels, and the IEA expects this share to increase to 3 to 4 times this level by 2030. Some land that was not profitable in the past could be returned to production, for example in the Former Soviet Union. In practice, additional land is expected to come from non-cereal croplands and set-aside land in Australia, Canada, the USA and the EU, with some new, currently uncultivated land, especially in Latin America and Africa.

Intensive research has produced significant improvements in crop yields, but has focused on specific crops and regions. In many parts of the world actual yields are still below their potential. Africa, in particular, has not benefitted from modern high-yielding crop varieties and farming practices as much as other regions have.

Some potential biofuel crops such as jatropha, cassava, sweet sorghum, may be able grow on marginal land where food crops cannot strive. However, growing any crop, including those that are drought resistant, on land with low levels of water and nutrient inputs will result in lower yields. It is therefore likely that biofuels will intensify the pressure on the fertile lands where higher returns can be realised.

4.3 How will biofuel production affect water resources?

During biofuel production, water is used in large quantities for washing plants and seeds and for evaporative cooling. However, the biggest impact on local **water availability** stems from irrigation. Crops such as sugar cane, oil palm and maize have relatively high water requirements and are best suited to high-rainfall areas, unless they can be irrigated. Three quarters of the sugar-cane production in Brazil and slightly less of the maize production in the USA is rainfed.

The availability of water resources may constrain the production of biofuel crops in countries that would otherwise have a comparative advantage. The amount of irrigation water needed in lower rainfall areas can be significant. Many irrigated sugar-producing regions in southern and eastern Africa and north-eastern Brazil are already operating close to the limits of the available water. Even plants like jatropha that can be grown in semi-arid areas may require some irrigation during hot and dry summers.

Producing more biofuel crops will also affect **water quality**. For example, converting pastures or woodlands into maize fields may increase problems of soil erosion and runoff of excess nitrogen and phosphorous into surface and groundwaters. Pesticides and other chemicals can also wash into waterbodies. Of the principal feedstocks, maize is the one requiring the greatest amount of fertilizer and pesticides per hectare.

4.4 How will biofuel production affect soils?

Changes in land-use and intensification of agricultural production both have the potential to harm soil condition, but these impacts depend on the way the land is farmed.

Various farming techniques can reduce adverse impacts or even improve environmental quality while still increasing biofuel crop production. These include conservation tillage and appropriate crop rotations.

Removing plant residues that would otherwise nourish the soil and permanent soil cover that prevents erosion can reduce the quality of soil. Only 25 to 33% of available crop residues from grasses or maize can be harvested without detrimental effects on soil quality, especially on soil organic content.

The use of perennial plants that can be harvested over several years such as palm, short-rotation coppice, sugar cane or switchgrass can also improve soil quality by increasing soil cover and organic carbon levels compared with annual crops like rapeseed, maize or other cereals. In the case of sugar cane, soil quality can be maintained by applying nutrients from sugar-mill and distillery wastes.

Crops such as eucalyptus, poplar, willow or grasses can be grown on poor-quality land, and soil carbon and quality will tend to improve over time.

4.5 How will biofuel production affect biodiversity?

Biofuel production can affect wild and agricultural biodiversity in some positive ways, for instance through the restoration of degraded lands, but many of its impacts will be negative, for example when natural landscapes are converted into energy-crop plantations or peatlands are drained.

Conversion of forest or grassland for crop production has a significant effect on wild biodiversity, because of the loss of habitat. Many current biofuel crops are well suited for tropical areas, and this creates an economic incentive to convert natural ecosystems into plantations causing a loss of wild biodiversity in these areas.

For existing arable land, positive impacts on farmland biodiversity can be obtained by using crops which increase soil cover, avoiding tillage and reducing fertilizer and pesticide inputs.

The genetic diversity of crops (agrobiodiversity) can be compromised where large-scale production is practiced. Most biofuel feedstock plantations are based on a single species, using a narrow pool of genetic material, with traditional varieties being used less and less. Such low levels of genetic diversity increase the susceptibility of crops to new pests and diseases.

Second-generation feedstocks raise their own concerns, since some of the proposed plant species can be invasive. Similarly, care will be required when dealing with genetically modified bacteria that produce enzymes used for cellulose conversion.

Crops which do well on fertile soils may not be as effective in poorer conditions. For example, switchgrass performs less well on poor soils than a diverse mixture of native grassland perennial plants. In addition, such diverse mixtures can provide better wildlife habitat, water filtration and carbon sequestration than maize or soybean alone.

4.6 How could an environmentally sustainable biofuel production be ensured?

The adoption of “good practices” in soil, water and crop protection, energy and water management, nutrient and agrochemical management, biodiversity and landscape conservation, harvesting, processing and distribution can contribute significantly to making bioenergy sustainable.

For instance, good agricultural practices, such as conservation agriculture, and good forestry practices, can reduce the adverse environmental impacts of biofuel production.

The environmental concerns about biofuel feedstock production are the same as for agricultural production in general, and existing techniques to assess the environmental impact offer a good starting point for analysing the biofuel systems. New complementary methodologies are being developed to assess bioenergy specific issues, for instance FAO’s analytical framework for bioenergy and food security.

The development of sustainability criteria or standards as already under way in a number of fora, such as the Global Bioenergy Partnership and the Roundtable on Sustainable Biofuels, should be established with the active collaboration of developing country partners and go hand in hand with training and support for implementation.

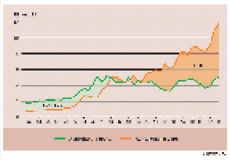
Payments for environmental services may also represent an instrument for encouraging compliance with sustainable production methods and standards.

Finally, for bioenergy to be developed sustainably, national policies will need to recognise the international consequences of biofuel development.

5. How will biofuel production affect food security and poverty?

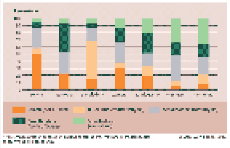
5.1 What will be the short-term impacts on food security?

Rapid growth in biofuel production will continue to influence food prices and this in turn will have an impact on food security. In 2006, FAO estimated that some 850 million people around the world were undernourished.



Agricultural trade balance of least-developed countries
[see Annex 12, p. 31]

5.1.1 At **national level**, some countries will benefit from higher prices, but for the least-developed countries the net food import bill is expected to increase. The global food import bill in 2007 was 29% higher than in 2006, and most of the increase was due to increased prices for cereals and vegetable oils, which are also feedstocks for biofuel production. More expensive animal feed has also led to higher prices for meat and dairy products. In addition, higher transport costs increased the costs of imported food affecting even further countries with a high dependence on imported petroleum products and cereals.



Short Distribution of poor net buyers and sellers of staple foods
[see Annex 13, p. 32]

5.1.2 At the **household level**, rural households which produce a surplus of food to sell may gain from increasing food prices as their income will increase. However, higher food prices will affect all those who have to buy food, especially poor people living in cities or in rural areas and who do not produce sufficient food for their own consumption. Food typically accounts for half or more of total expenditure for the poorest households.

When rice prices increased in Indonesia in the late 1990s, mothers in poor families responded by eating less to feed their children better, and the cost of rice meant that little money was left for more nutritious foods. As a result, the health of both mothers and children suffered. In addition, impacts are more severe for female-headed households, perhaps because they generally have less access to land and tend to spend a greater share of their income on food.

A potential benefit for poorer people is that higher prices could make agricultural production more attractive and generate an increased demand for unskilled agricultural labour.

The impact of higher world food prices on household food security depends on the extent to which international prices pass through to domestic markets. Governments may use storage, procurement and distribution as well as restrictions on international trade to stabilize prices. However, such policies are costly, and may impede or slow down a market-driven increase in food supply in responses to increased prices.

5.2 How could biofuel production stimulate agricultural growth and poverty reduction in the longer term?

In the longer term, the emergence of biofuels could increase the demand for agricultural products and help **revitalize agriculture in developing countries**. Higher food prices could indeed lead to increased agricultural production of non-food crops without compromising food crop production and could even lead to improved food security. The world's poorest countries could become major agricultural producers, while supplying feedstocks for liquid biofuel production.

Rural growth can reduce poverty. Agricultural growth, over the long term, helps to improve food security by generating rural income opportunities and reducing food prices for consumers. Growth in Gross Domestic Product (GDP) in the field of agriculture is at least twice as effective in reducing poverty as growth in other sectors.

However, the extent to which agricultural growth actually contributes to poverty alleviation depends on the degree of inequality in a country, in particular how land is distributed among the population.

Government support is essential. Barriers may prevent farmers from benefiting from increased income opportunities. For instance, higher energy prices mean higher costs for commercial fertilizer.

Government assistance to improve access to credit and infrastructure including local roads allows farmers to boost their incomes, and intensify food production. The introduction of non food crops, which yield cash flow, can also encourage private investment.

Increased farm productivity will be important to avoid long-term increases in food prices and excessive expansion of cultivated area. Under the right conditions, non-food crops can have a positive effect on agricultural production. For example in Mali, grains produced in rotation with cotton benefit from the residual effects of cotton fertilizers.

Technological change is the biggest driver of agricultural growth. However, the high research cost means that public funding remains essential.

Small scale contract farming – agricultural production carried out according to an agreement between a buyer and farmers – is an alternative to large scale plantations that could ensure small farmers' participation, provided active government policies and support are in place. Small scale does not mean low efficiency. In Thailand, small farmers compare favourably, in efficiency terms, with large- and medium-sized sugar farms in Australia, France and the USA. Support must focus particularly on enabling poor small producers to expand their production and gain access to markets.

5.3 How could biofuel production affect income distribution and women's status?

There is concern that cash crops that are grown solely to be sold on the market tend to lead to greater inequality. To what extent this is the case of crops grown for biofuel production depends on the type of crop and technology used. Private investors may favour large-scale projects, unless governments actively support small-scale farming.

Expansion of biofuel production will lead to greater competition for land. In the Philippines, for instance, many households lost their access to land following the introduction of sugar cane. A strong government policy and legal structure is needed to protect the livelihoods of households and communities.

Those most at risk are small farmers, women farmers and people raising livestock, who may have weak land-tenure rights. Policies need to assure equal opportunities and especially equitable access to markets. Although women are often responsible for carrying out much of the agricultural work, they typically own little of the land, especially in Sub-Saharan Africa. Exploiting marginal lands for growing biofuel crops may also work against female farmers. In India, these marginal lands, or so-called "wastelands", are frequently classified as common property resources and are often of crucial importance to the poor.

These issues are not specifically related to biofuels, however the development of biofuel production could and should take them into account.

6. How could biofuel policies be improved?

6.1 What are the challenges of biofuel policies?

Government incentives and support for biofuel production and use have been largely guided by national or regional interests rather than a more global perspective. The desire to support farmers and rural communities has been one of the strongest drivers.

There is a need for a more consistent set of policies and approaches, based on a clearer understanding of the economic, environmental and social implications, in order to balance the potential and risks.

These policies must be formulated in a situation of considerable uncertainty.

- The exact role of biofuels in future global energy supplies is unknown. Yet even if the contribution of biofuels to global energy supply remains small, it may still imply a considerable impact on agriculture and food security.
- The future economic viability of biofuels is uncertain, because it depends on fluctuating fossil fuel prices and on policy developments.
- Technological developments may also influence their profitability on the medium and long term. For instance, commercial competitiveness of second generation biofuel technologies may significantly improve the prospects for biofuel development.
- Replacing fossil fuels by biofuels is not guaranteed to lead to net greenhouse gas emission reductions. The impact depends on how biofuels are produced, transported and used, and the global impact on climate change is likely to be negative if large tracts of additional land are brought into cultivation.

Land requirements are too large to allow liquid biofuels to displace fossil fuels on a large scale; however they may still have a considerable impact on agriculture and food security. The unintended impacts of biofuels, especially on market prices and food-security have frequently been overlooked in policy discussions.

Increases in demand for farm output could boost rural incomes and stimulate rural development, but many poorer people will be disadvantaged by higher food prices and increased competition for land and water.

Biofuels are influenced by policies in agriculture, energy, transport, environment and trade, and these individual policies are not always coordinated. Biofuels can only contribute to policy objectives if their impact in each of these areas is considered.

6.2 What principles should guide biofuel policies?

Five guiding principles are proposed.

- (i) Biofuel policies must protect those who are poor and have insecure access to sufficient food. Priority should be given to the impact of higher food prices on vulnerable people in rural and urban areas who have to buy food, particularly in the least-developed countries.
- (ii) Policies should facilitate growth in developing countries by improving economic and technical efficiency and by creating conditions where poorer countries and small farmers can take advantage of future market opportunities.
- (iii) Biofuel policies should be environmentally sustainable. They should ensure that biofuels are produced in ways that are effective in reducing greenhouse gas emissions, while protecting land and water resources from depletion, environmental damage and pollution.
- (iv) Biofuel policies should seek to reduce existing distortions in biofuel and agricultural markets and avoid introducing new ones. They should also take into consideration unintended consequences that may go beyond national borders.
- (v) Policies should be developed with appropriate international coordination to ensure that the global system supports the goals of environmental sustainability, agricultural development and poverty and hunger reduction.

6.3 How could policies ensure environmental and social sustainability?

Higher agricultural and food prices driven, among other things, by an increased demand for biofuels, are having negative impact on food security in food-importing developing countries, and especially on the many of the poorest households. A sustained effort is needed to **protect the poor and food-insecure**.

In the immediate context, the most vulnerable people may require direct food distribution, targeted food subsidies, cash transfers, and nutritional programmes such as school feeding. In the short to medium term, social protection programmes must be developed. In the medium to long term, higher food prices could be mitigated by increasing food supply provided that policy interventions do not disrupt trade flows and that investments are made in infrastructure for storage and transportation.

Higher prices for agricultural products can present **opportunities for agricultural and rural development** in developing countries, but sustained improvements in research, infrastructure, and access to credit and risk management instruments are also needed to increase productivity.

Measures should specifically address the needs of poor smaller farmers by securing their access to natural resources and by ensuring that their land rights are respected.

Policies must ensure that further expansion of biofuel production is environmentally sustainable and will provide a positive contribution to climate-change mitigation. Therefore, an improved understanding of how biofuels affect land-use change is urgently needed, since this can have a significant negative effect on greenhouse gas emissions.

Promotion of good agricultural practices could help to reduce the negative effects of expanded biofuel production. Sustainability criteria are needed for biofuels that do not create trade barriers, particularly for developing countries. There is a need for an appropriate international forum to debate and agree on sustainability criteria.

In OECD countries, subsidies for the production and consumption of liquid biofuels and trade protection measures such as tariffs have restricted market access for biofuel producers in developing countries. These incentives were added to pre-existent high levels of subsidies to the agriculture sector, further exacerbating market distortions.

Biofuel policies need to be reviewed as they have had limited success in achieving energy security and climate-change mitigation. Rapid expansion of biofuel production may increase rather than reduce greenhouse gas emissions.

Subsidies and mandates have created an artificially rapid growth in biofuel production, exacerbating some of its negative effects and promoting biofuels compared to other sources of renewable energy. Expenditures on biofuels would be much better directed towards research and development to improve efficiency and sustainability. This would allow a more gradual development of the sector, reducing the stress on natural resources and the pressure on food prices.

The current combination of subsidies, mandatory blending and trade barriers does not lead to efficient and equitable international allocation of resources.

The international community must provide assistance to developing countries to develop their agricultural capacity while protecting the most vulnerable population groups from the effects of higher food prices.

7. Conclusions

7.1 Do biofuels threaten food security?

For many poor people in both urban and rural areas, higher food prices pose an immediate threat to their food security.

Although biofuels are only one cause of the recent high food prices, expanded biofuel production will tend to keep food prices high into the future.

The effects of high food prices on the poor can be mitigated through appropriately designed and targeted safety nets that support access to food such as direct food distribution, targeted food subsidies and cash transfers, or nutritional programmes including school feeding.

Price controls and export bans are often used to protect consumers from higher food prices but these measures may actually worsen the food security crisis Instead, it is important to allow rising prices to reach farmers to provide an incentive for increased production and as a consequence an increased supply.

7.2 Can biofuels help promote agricultural development?

In the longer run, higher food prices resulting from growing demand for biofuels present an opportunity for agricultural development

Providing market access to small farmers and marginalized groups such as women and minorities, will strongly improve the chances that agriculture can drive growth and poverty reduction.

Opportunities would also be expanded by the removal of subsidies and trade barriers that benefit producers in OECD countries at the expense of producers in developing countries.

7.3 Can biofuels help reduce greenhouse gas emissions?

Some biofuels may help reduce greenhouse gas emissions. However, this will depend on where and how the feedstocks are produced.

In many cases, greenhouse gas emissions from direct or indirect land-use change will partially offset and in some cases even exceed the greenhouse gas savings obtained by using biofuels for transport.

Good agricultural practices and increased yields can help mitigate some of the negative greenhouse gas effects. Second-generation biofuels, in particular, may improve the greenhouse gas balance significantly.

7.4 Do biofuels threaten land, water and biodiversity?

As for any form of agriculture, expanded biofuel production may threaten land and water resources as well as biodiversity, and appropriate policy measures are required to minimize possible negative effects.

The impacts depend on cultivation practices and whether new land is converted into cropland. The use of perennial plants that yield crops over several years on land of low potential represents an opportunity for sustainable biofuel production.

7.5 Can biofuels help achieve energy security?

First generation liquid biofuels made of starch or oil contained in agricultural crops can only make a limited contribution to global supply of transport fuels.

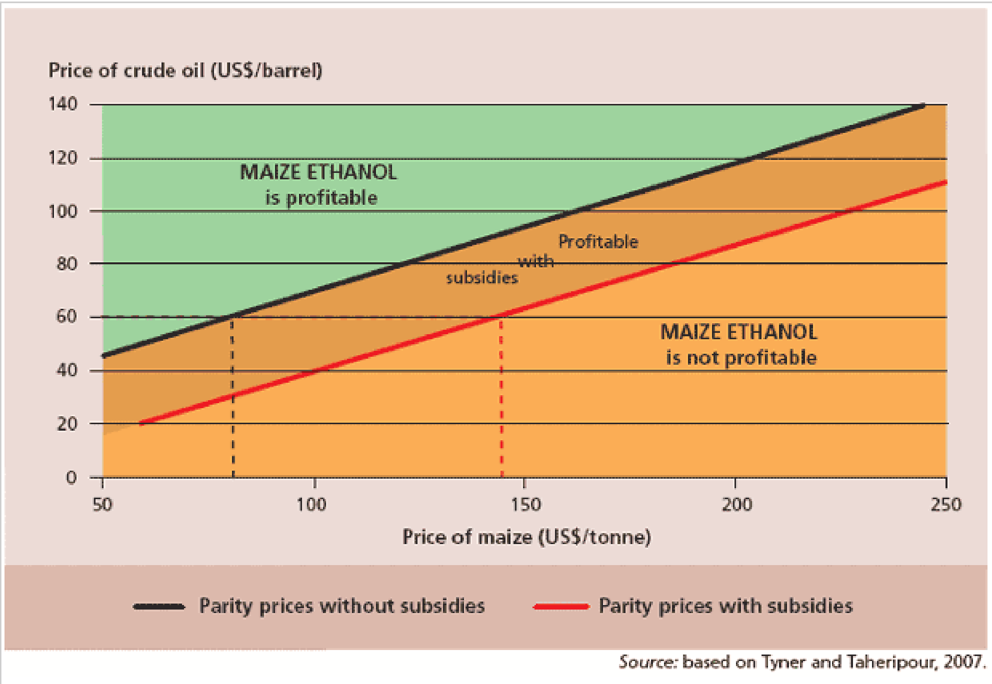
However, countries with abundant natural resources which can produce feedstocks competitively and process them efficiently may be able to develop an economically viable biofuel sector.

Second generation biofuels based on cellulosic feedstocks may expand the range of countries where biofuels could make a significant contribution to energy security. However, it is not clear when these technologies may become commercially viable.

Annex

Annex 1:

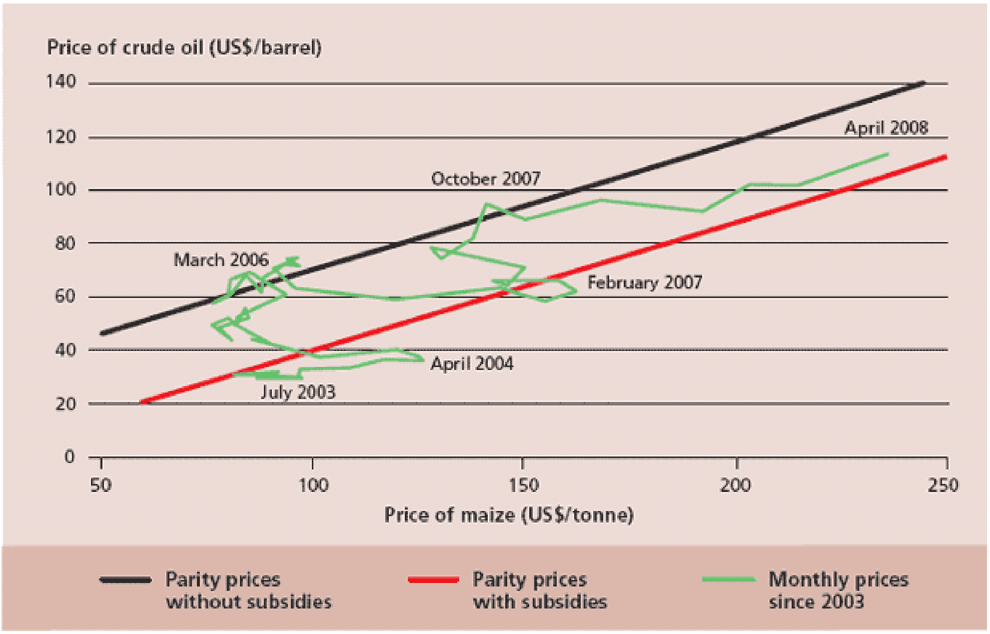
Figure 12: Breakeven prices for maize and crude oil with and without subsidies



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/ docrep/011/i0100e/i0100e00.htm], Chapter 3, Section Economic viability of biofuels, p.38

Annex 2:

Figure 13: Maize and crude oil breakeven prices and observed prices, 2003–08

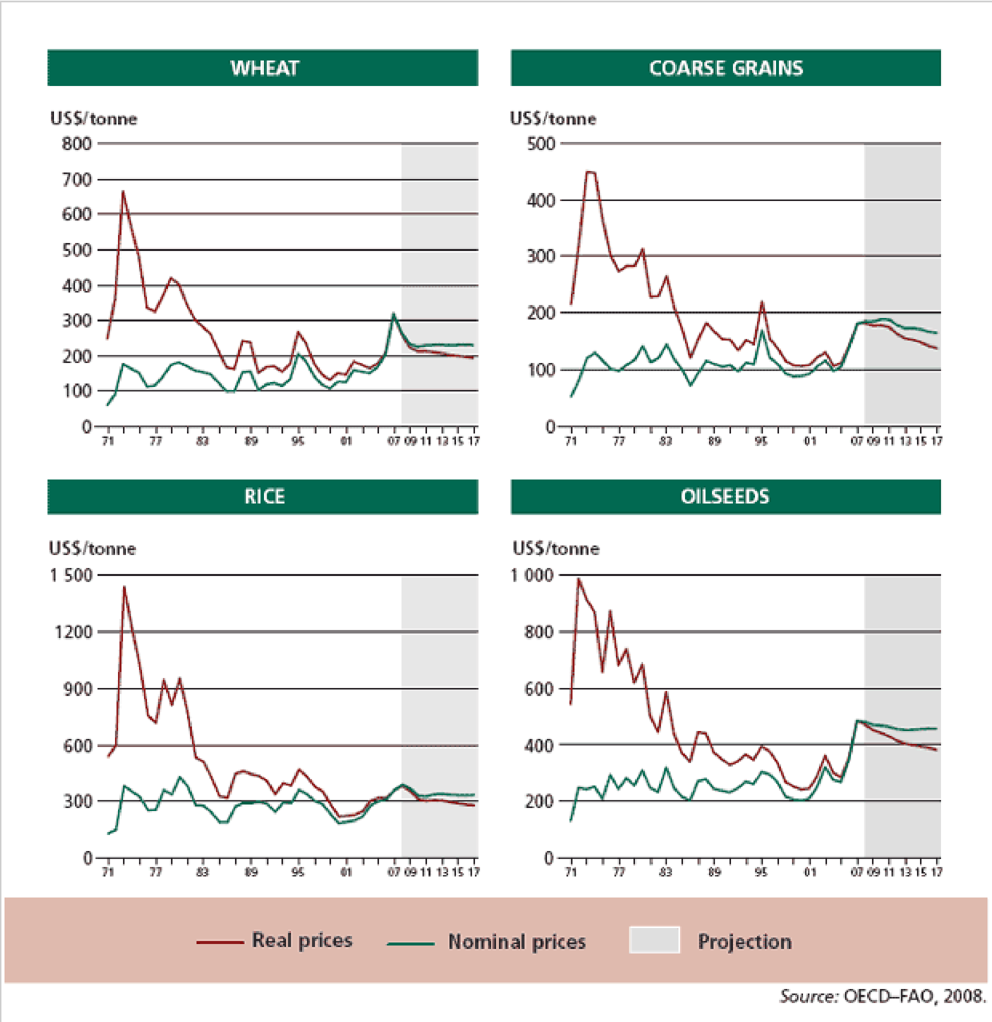


Sources: adapted from Tyner and Taheripour, 2007. Crude oil prices: Brent crude, Chicago Board of Trade (US$/barrel). Maize prices: US Yellow No. 2, Chicago Board of Trade (US$/tonne). Prices downloaded from the Commodity Research Bureau Web site (http://www.crbtrader.com/crbindex/) on 10 June 2008.

Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Section Economic viability of biofuels, p.38

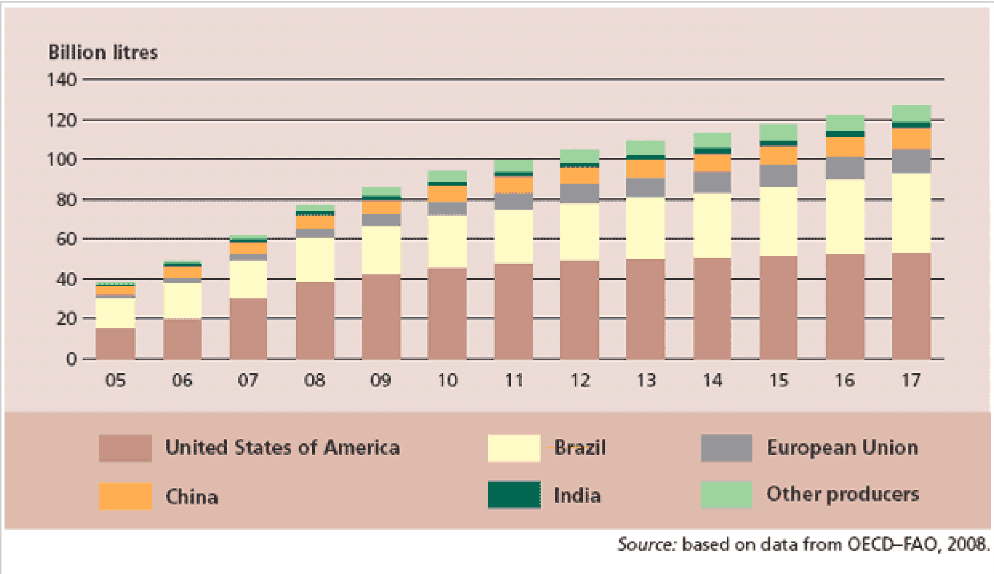
Annex 3:

Figure 15: Food commodity price trends 1971–2007, with projections to 2017



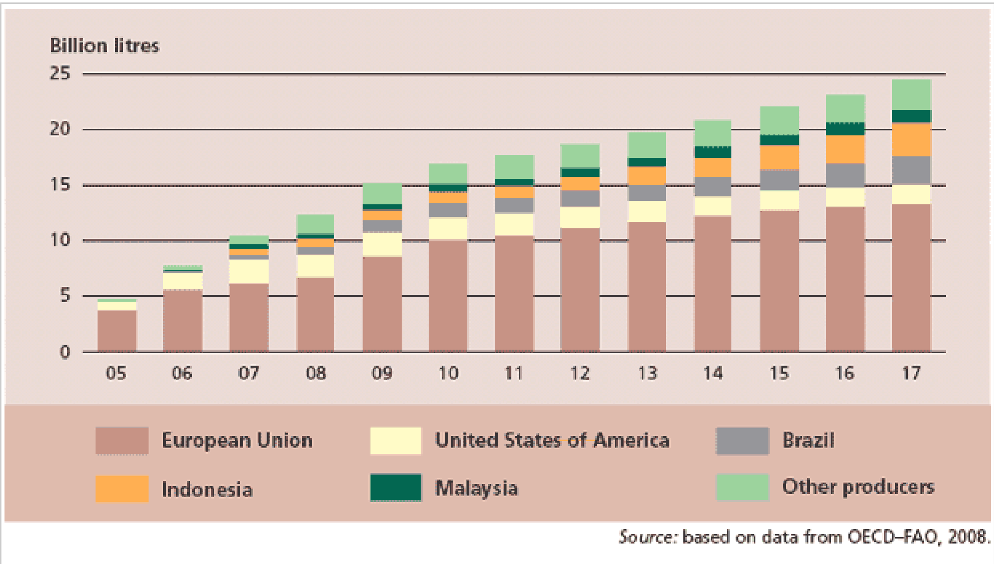
Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 4, Section Recent biofuel and commodity market developments, p.42

Annex 4:
Figure 17: Major ethanol producers, with projections to 2017



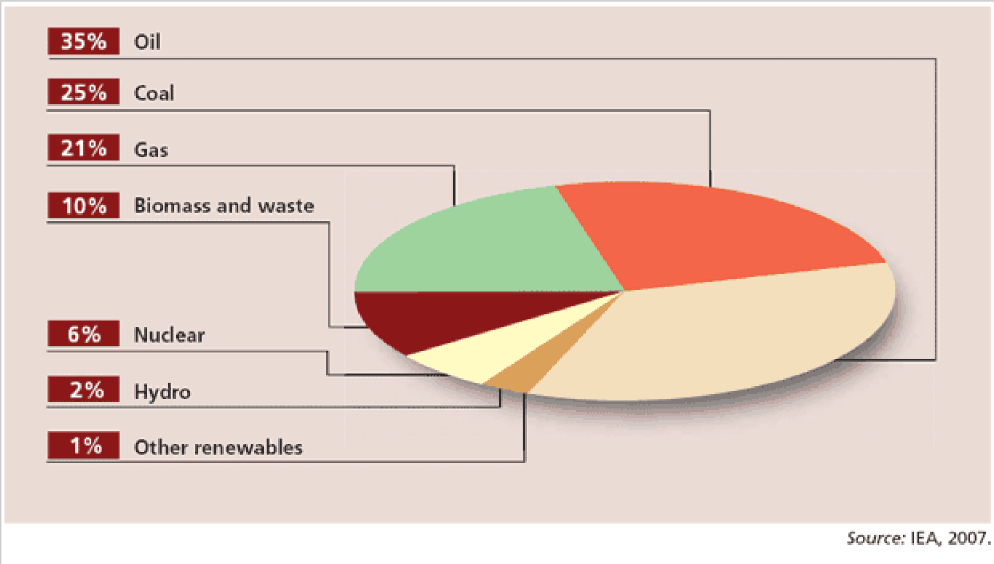
Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 4, p.47

Annex 5:
Figure 19: Major biodiesel producers, with projections to 2017



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 4, p.49

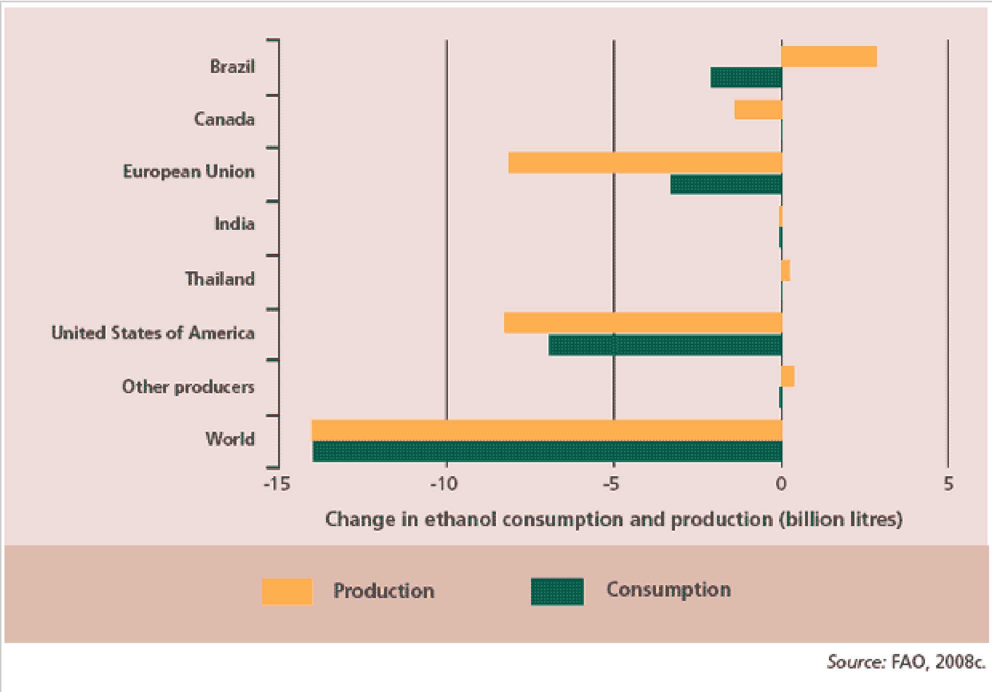
Annex 6:
Figure 1: World primary energy demand by source, 2005



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 1, Introduction and key messages, p.3

Annex 7:

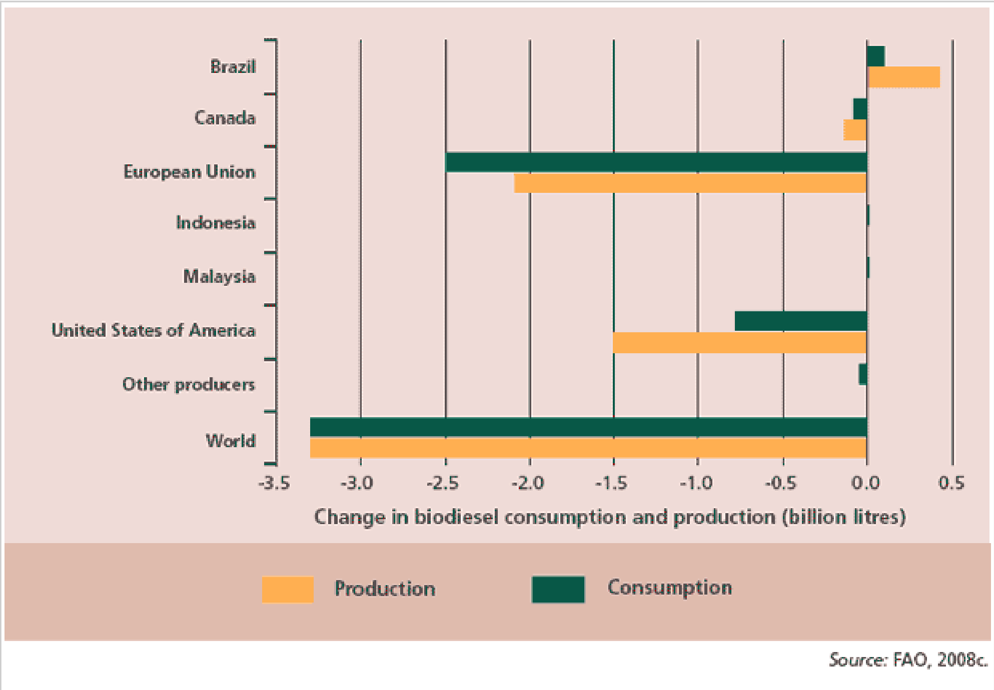
Figure 20: Total impact of removing trade-distorting biofuel policies for ethanol, 2013–17 average



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 4, p.50

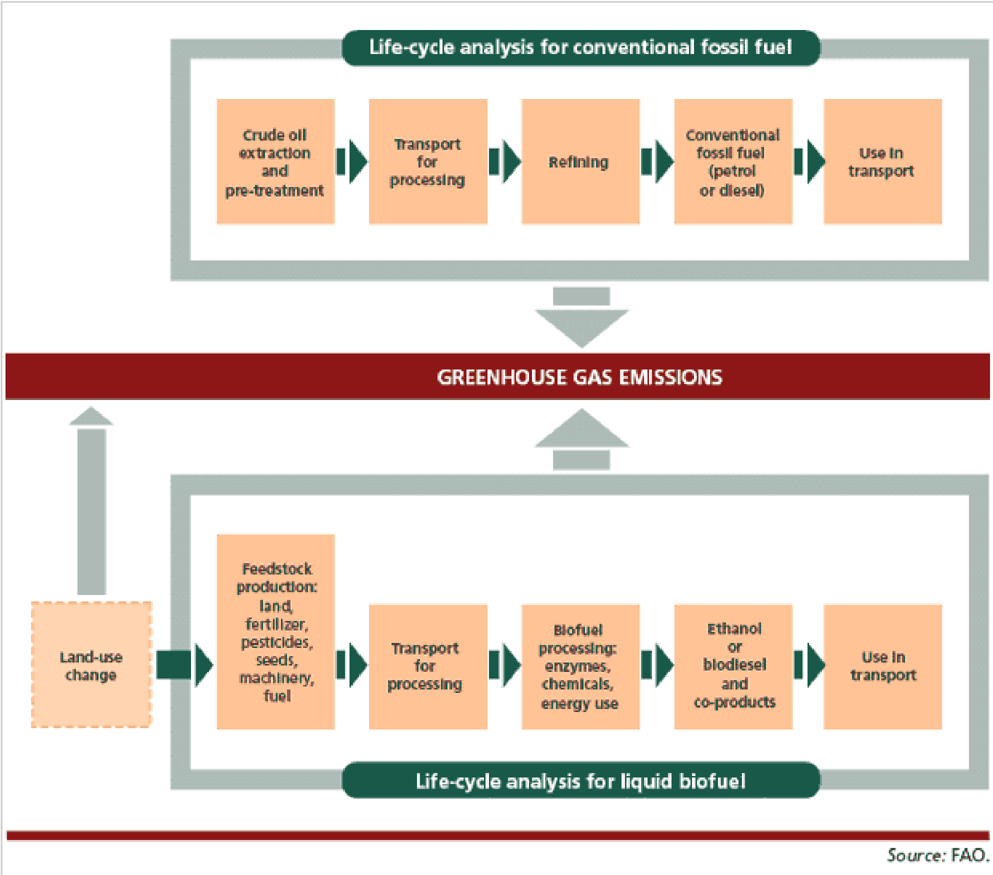
Annex 8:

Figure 21: Total impact of removing trade-distorting biofuel policies for biodiesel, 2013–17 average



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 4, p.51

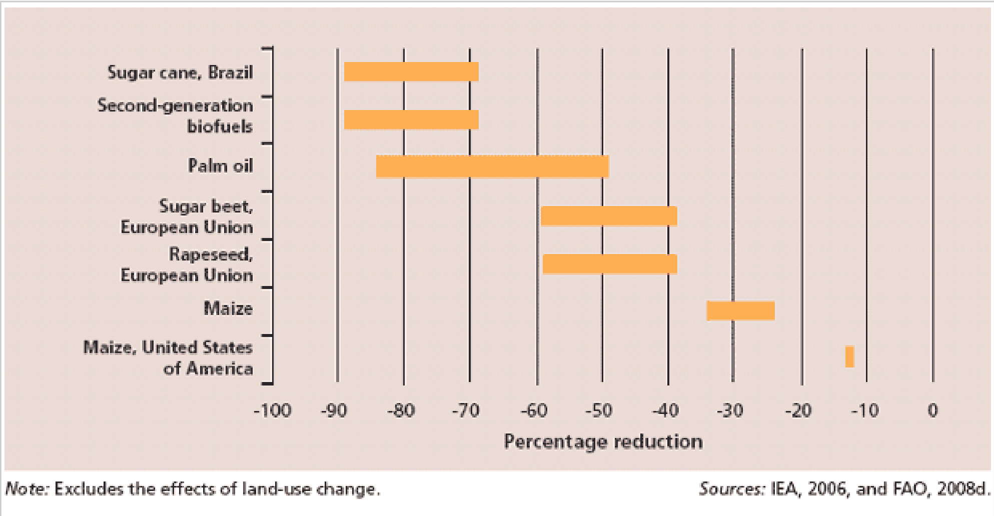
Annex 9:
Figure 22: Life-cycle analysis for greenhouse gas balances



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm],
Chapter 5, Section "Will biofuels help mitigate climate change?", p.56

Annex 10:

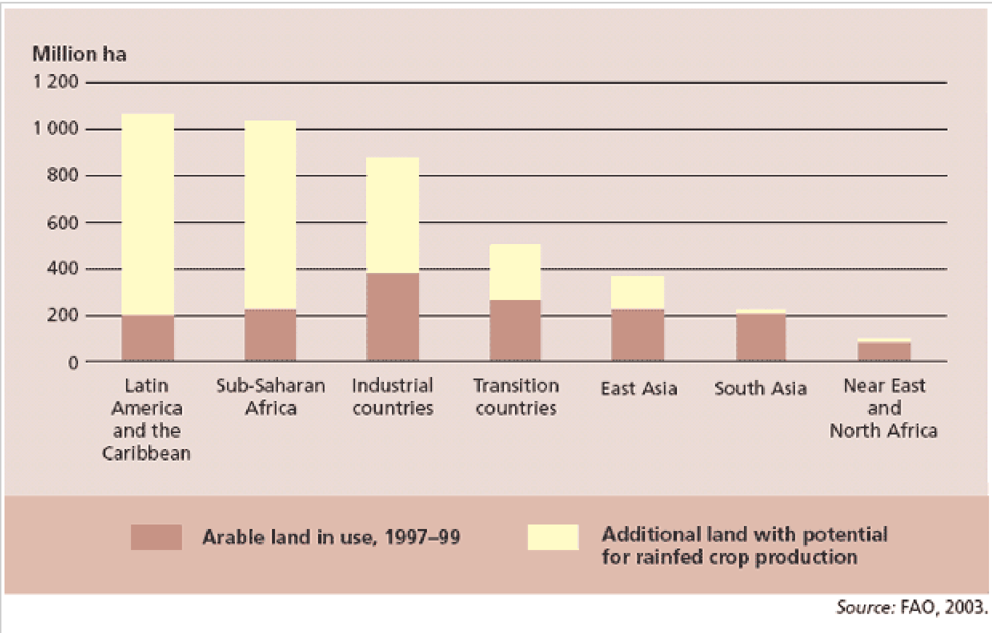
Figure 23: Reductions in greenhouse gas emissions of selected biofuels relative to fossil fuels



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 5, Section "Will biofuels help mitigate climate change?", p.57

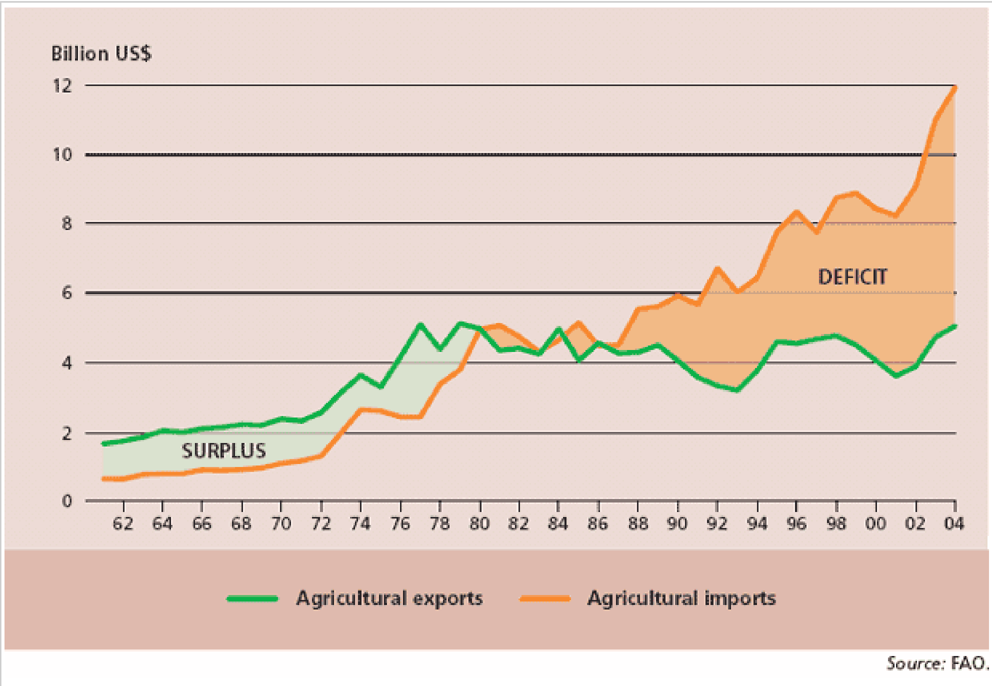
Annex 11:

Figure 24: Potential for cropland expansion



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 5, p.60

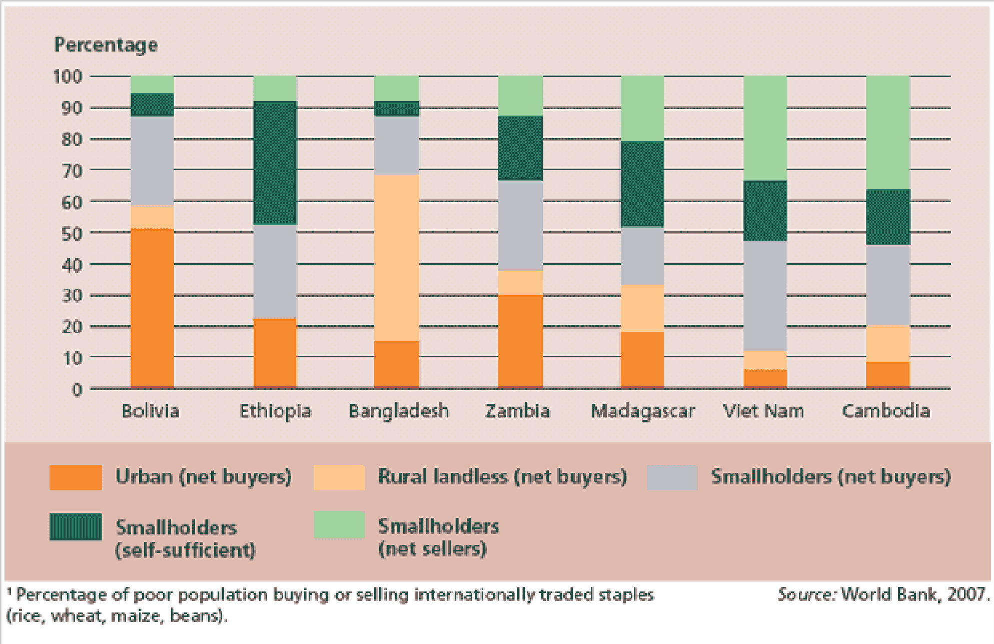
Annex 12:
Figure 27: Agricultural trade balance of least-developed countries



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 6, p.73

Annex 13:

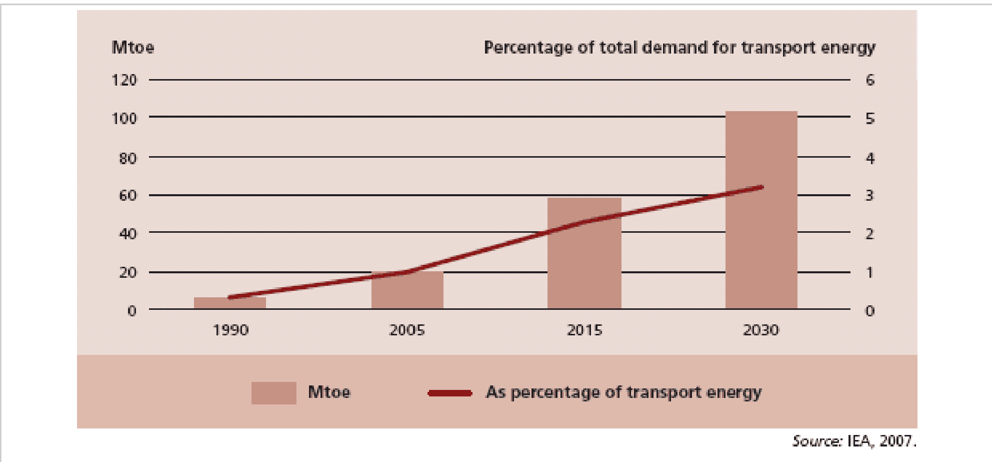
Figure 28: Distribution of poor net buyers and sellers of staple foods[1]



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 6, p.76

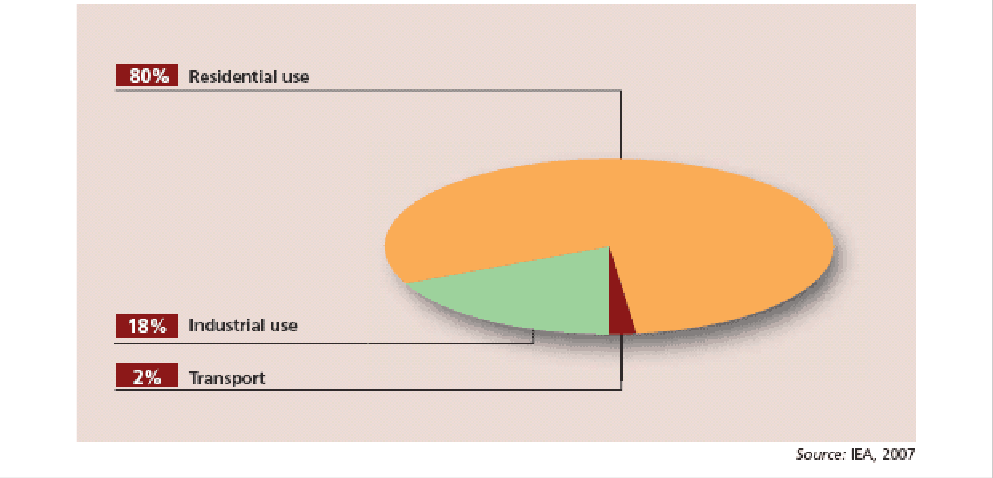
Annex 14:

Figure 3: Trends in consumption of transport biofuels



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 1, Introduction and key messages, p.6

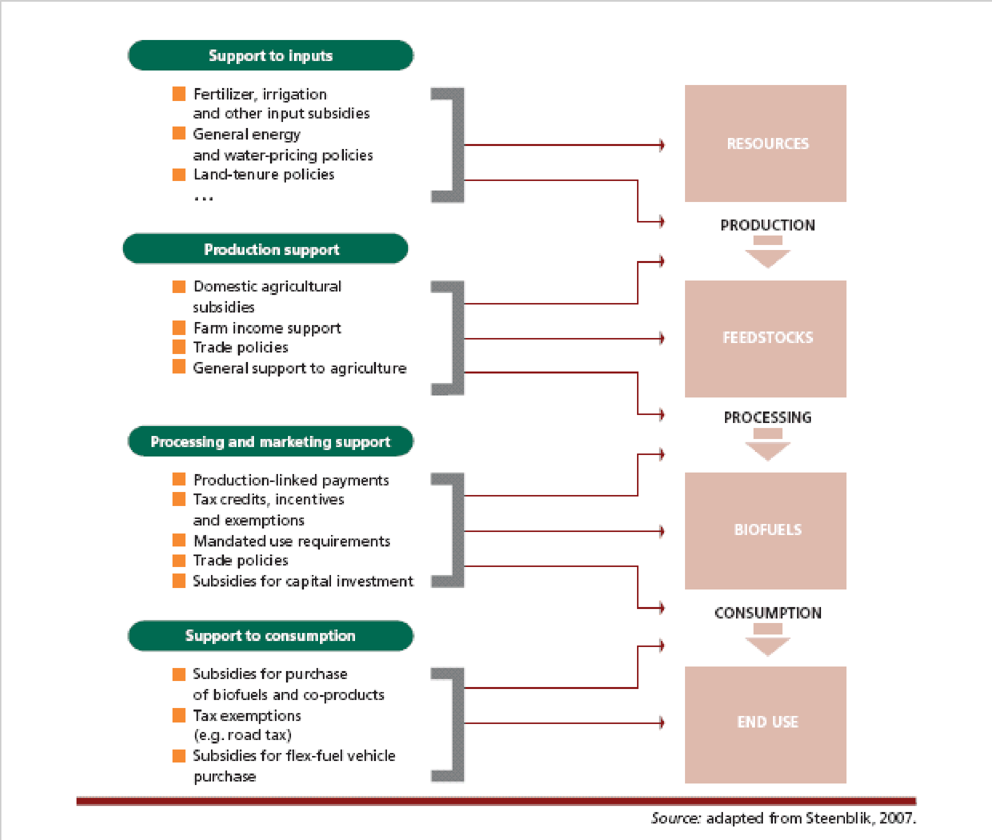
Annex 15:
Figure 5: Uses of biomass for energy



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 2, p.11

Annex 16:

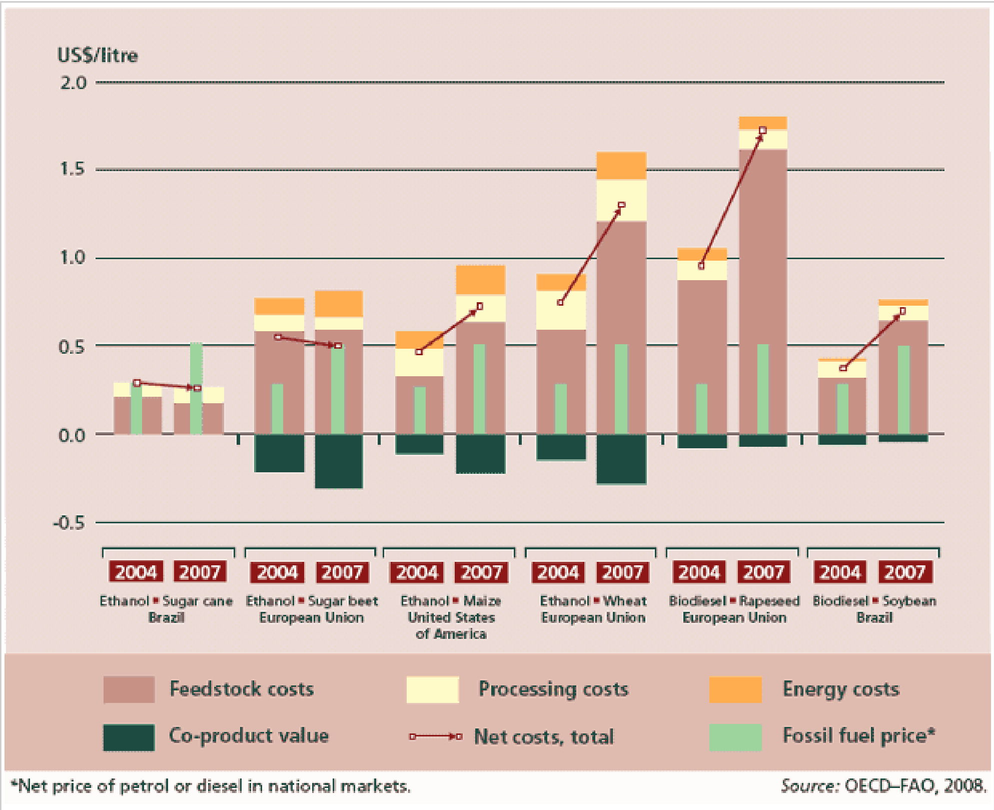
Figure 8: Support provided at different points in the biofuel supply chain



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 3, Section policy measures affecting biofuel development, p.28

Annex 17:

Figure 9: Biofuel production costs in selected countries, 2004 and 2007



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 3, Section Economic viability of biofuels, p.35

Annex 18:

TABLE 1: Biofuel production by country, 2007

COUNTRY/COUNTRY GROUPING	ETHANOL		BIODIESEL		TOTAL	
	(Million litres)	(Mtoe)	(Million litres)	(Mtoe)	(Million litres)	(Mtoe)
Brazil	19 000	10.44	227	0.17	19 227	10.60
Canada	1 000	0.55	97	0.07	1 097	0.62
China	1 840	1.01	114	0.08	1 954	1.09
India	400	0.22	45	0.03	445	0.25
Indonesia	0.00	0.00	409	0.30	409	0.30
Malaysia	0.00	0.00	330	0.24	330	0.24
United States of America	26 500	14.55	1 688	1.25	28 188	15.80
European Union	2 253	1.24	6 109	4.52	8 361	5.76
Others	1 017	0.56	1 186	0.88	2203	1.44
World	**52 009**	**28.57**	**10 204**	**7.56**	**62 213**	**36.12**
Note: Data presented are subject to rounding. Source: based on F.O. Licht, 2007, data from the OECD–FAO AgLink-Cosimo database.						

Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 2, Section Biofuels and agriculture, p. 15

Annex 19:

TABLE 2: Biofuel yields for different feedstocks and countries

CROP	GLOBAL/ NATIONAL ESTIMATES	BIOFUEL	CROP YIELD	CONVERSION EFFICIENCY	BIOFUEL YIELD
			(Tonnes/ha)	(Litres/tonne)	(Litres/ha)
Sugar beet	Global	Ethanol	46.0	110	5 060
Sugar cane	Global	Ethanol	65.0	70	4 550
Cassava	Global	Ethanol	12.0	180	2 070
Maize	Global	Ethanol	4.9	400	1 960
Rice	Global	Ethanol	4.2	430	1 806
Wheat	Global	Ethanol	2.8	340	952
Sorghum	Global	Ethanol	1.3	380	494
Sugar cane	Brazil	Ethanol	73.5	74.5	5 476
Sugar cane	India	Ethanol	60.7	74.5	4 522
Oil palm	Malaysia	Biodiesel	20.6	230	4 736
Oil palm	Indonesia	Biodiesel	17.8	230	4 092
Maize	United States of America	Ethanol	9.4	399	3 751
Maize	China	Ethanol	5.0	399	1 995
Cassava	Brazil	Ethanol	13.6	137	1 863
Cassava	Nigeria	Ethanol	10.8	137	1 480
Soybean	United States of America	Biodiesel	2.7	205	552
Soybean	Brazil	Biodiesel	2.4	205	491
Sources: Rajagopal et al., 2007, for global data; Naylor et al., 2007, for national data.					

Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 2, Section Biofuels and agriculture, p. 16

Annex 20:

TABLE 6: Total support estimates for biofuels in selected OECD economies in 2006

OECD economy	ETHANOL		BIODIESEL		TOTAL LIQUID BIOFUELS	
	TSE	Variable share [1]	TSE	Variable share [1]	TSE	Variable share [1]
	(Billion US$)	(Percentage)	(Billion US$)	(Percentage)	(Billion US$)	(Percentage)
United States of America [2]	5.8	93 %	0.53	89 %	6.33	93 %
European Union [3]	1.6	98 %	3.1	90 %	4.7	93 %
Canada [4]	0.15	70 %	0.013	55 %	0.163	69 %
Australia [5]	0.043	60 %	0.032	75 %	0.075	66 %
Switzerland	0.001	94 %	0.009	94 %	0.01	94 %
Total	**7.6**	**93 %**	**3.7**	**90 %**	**11.3**	**92 %**

1 The percentage of support that varies with increasing production or consumption, and includes market-price support, production payments or tax credits, fuel-excise tax credits and subsidies to variable inputs.
2 Lower bound of the reported range.
3 Total for the 25 Member States of the European Union in 2006.
4 Provisional estimates.
5 Data refer to the fiscal year beginning 1 July 2006.
Sources: Steenblik, 2007; Koplow, 2007; Quirke, Steenblik and Warner, 2008

Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 3, Section Economic costs of biofuel policies, p.32

Annex 21:

TABLE 7: Approximate average and variable rates of support per litre of biofuel in selected OECD economies

OECD economy	ETHANOL		BIODIESEL	
	Average	Variable	Average	Variable
	(US$/litre) [1]	(US$/litre) [1]	(US$/litre) [1]	(US$/litre) [1]
United States of America [2]	0.28	Federal: 0.15 States: 0.00–0.26	0.55	Federal: 0.26 States: 0.00–26
European Union [3]	1.00	0.00–0.90	0.7	0.00–0.50
Canada [4]	0.4	Federal: up to 0.10 Provinces: 0.00–0.20	0.2	Federal: up to 0.20 Provinces: 0.00–0.14
Australia [5]	0.36	0.32	0.35	0.32
Switzerland [6]	0.60	0.60	1.00	0.60–2.00

Notes:
1 Values (except in the case of the United States of America and Australia) are rounded to the nearest US$0.10.
2 Lower bound of reported range. Some payments are budget-limited.
3 Refers to support provided by Member States.
4 Provisional estimates; includes incentives introduced on 1 April 2008.
Federal and most provincial supports are budget-limited.
5 Data refer to the fiscal year beginning 1 July 2006. Payments are not budget-limited.
6 Range for biodiesel depends on source and type of feedstock. Some payments are limited to a fixed number of litres.
Source: Steenblik, 2007, p. 39.

Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 3, p.34

Annex 22:

TABLE 9: Land requirements for biofuel production

COUNTRY GROUPING	2004		2030					
			Reference scenario		Alternative policy		Second-generation	
	(Million ha)	(Percentage of arable land)	(Million ha)	(Percentage of arable land)	(Million ha)	(Percentage of arable land)	(Million ha)	(Percentage of arable land)
Africa and Near East	–	–	0.8	0.3 %	0.9	0.3 %	1.1	0.4 %
Developing Asia	–	–	5.0	1.2 %	10.2	2.5 %	11.8	2.8 %
European Union	2.6	1.2 %	12.6	11.6 %	15.7	14.5 %	17.1	15.7 %
Latin America	2.7	0.9 %	3.5	2.4 %	4.3	2.9 %	5.0	3.4 %
OECD Pacific	–	–	0.3	0.7 %	1.0	2.1 %	1.0	2.0 %
Transition economies	–	–	0.1	0.1 %	0.2	0.1 %	0.2	0.1 %
United States of America and Canada	8.4	1.9 %	12	5.4 %	20.4	9.2 %	22.6	10.2 %
World	13.8	1.0 %	34.5	2.5 %	52.8	3.8 %	58.5	4.2 %

Note: – = negligible.
Sources: FAO, 2008a; IEA, 2006.

Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities (2008) [see http://www.fao.org/docrep/011/i0100e/i0100e00.htm], Chapter 4, p.45