Chapter 2

How did we get here? The story of biofuels

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Box 2.1: Overview

Biofuels make up only a small fraction of overall fuel consumption in most countries, with the exception of Brazil. However, owing to the powerful drivers discussed in the previous chapter and existing policy incentives such as biofuel targets, the percentage of biofuels in the fuel mix has recently increased and is expected to rise significantly over the next two decades. It is therefore necessary to ensure that future large-scale biofuels production does not lead to unforeseen detrimental consequences.

After a brief description of the production of biofuels that are already established, this chapter outlines three case studies which illustrate the experiences gained in the development of biofuels from different sources in different countries: bioethanol from corn in the US; bioethanol from sugar cane in Brazil; and biodiesel from palm oil in Malaysia.

These three case studies show vividly that there were powerful incentives for governments to support the introduction of the particular biofuel in their country. The potential promises of biofuels were seen to justify policy instruments, standards and subsidies that supported commercial biofuels production, and there is little doubt that in all three cases, biofuels can be seen as a successful example of policy-driven economic development.

However, experience to date has shown that the promise is more uncertain than was once thought and biofuels involve significant problems. These include: concerns over food security and food prices; the rights of farmers, farm workers and land holders, particularly for vulnerable populations; and a wide range of problems related to environmental protection. These problematic effects have had major political and social repercussions, with protests against biofuels as extreme as violence in the streets. In response to some of these challenges governments have begun to develop new policies, although it is too early to have evidence of their impact.

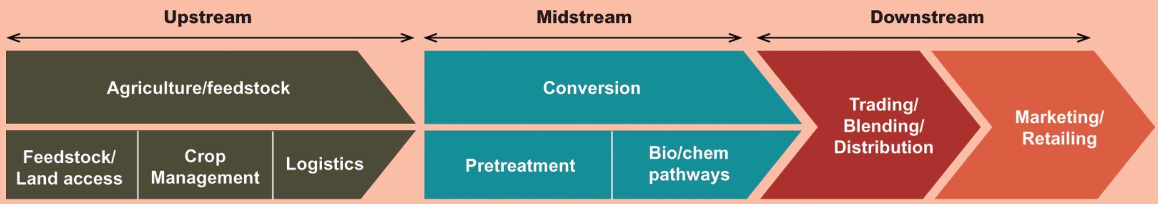
Introduction

2.1 Given the established policies to support biofuels, and the formidable forces behind those policies (described in Chapter 1), there is likely to be a reliance on current biofuels for the foreseeable future. Providers and suppliers striving to fulfil mandatory targets for renewable fuels will use the technological pathways that are best established and that can be scaled up quickly without requiring a great deal of additional research and investment. With very few exceptions, such scaling up of production is currently possible only with biofuels made from food crops. A transition to new biofuels will depend on future discoveries from scientific research and the effectiveness of policies to promote their development (discussed in Chapters 3 and 5). To respond to the challenges involved in evaluating *all* biofuels, it is important to understand the experience gained in the development of biofuels to date. Chapter 1 described the reasons why biofuels were seen as an attractive alternative to fossil fuels, and how worries over energy security, climate change and economic development continue to promote their development. This chapter provides information on the current production and use of biofuels and employs three examples to demonstrate the problems which became apparent once they were produced on a commercial scale – leading thus to the quest for better approaches to biofuels production.

Characteristics and production of biofuels

2.2 The diagram in Box 2.2 summarises the main practical steps that are involved in the three stages of the biofuels production chain. Upstream, a sufficient amount of biomass feedstock, i.e. the source material used for biofuels, is necessary and in most cases this involves issues of access to sufficient land. Crop management and logistics, such as transporting bulky biomass to the processing facility are also important stages in the upstream process and can present barriers to production. All stages of the midstream conversion process can involve significant practical obstacles, and there is potential for improvement (discussed in Chapter 3). Finally, blending, distributing and retailing the fuel, which are all important stages in the downstream part of production, depend on available infrastructure and the type of fuel.

Box 2.2: Biofuels production chain



2.3 Biodiesel is a convenient fuel with several advantages. It has been shown that biodiesel blends of 20 per cent[131] produce lower emissions (around 15 per cent less on average) of particulate matter, carbon monoxide, total hydrocarbons and other toxic compounds,[132] with potential advantages for air quality and public health.[133] Moreover, there are pragmatic advantages to biodiesel at several stages of the production chain. For example, the biodiesel production process of transesterification (see Box 2.3) is chemically rather simple. Biodiesel can also be delivered through existing distribution systems and – if produced to sufficiently high quality standards – can be used in cars without the need to alter vehicle fuel technology, an important feature to help achieve the goal of improved energy security (see Chapter 1). Some vehicles can even run on pure vegetable oil, avoiding the need for the transesterification process.

Box 2.3: Producing biofuels[134]

The production of biofuels involves three main stages.

Feedstock production (upstream)
In the case of established methods for biofuels production, this means growing and harvesting crops such as corn, soybean, wheat, sugar cane, sorghum, oilseed rape, oil palm, etc., using established agricultural practices. The resulting feedstocks then need to be stored (biomass is much bulkier per unit of energy than crude oil) and transported to the conversion facility.

Conversion of the feedstock (midstream)
Turning the feedstocks into biofuels involves pretreatment and processing. Biodiesel is made from plant oils or fats using the process of transesterification. The chemical name of biodiesel is fatty acid methyl (or ethyl) ester (FAME). The plant oils are mixed with sodium hydroxide and methanol (or ethanol) and the resulting chemical reaction produces FAME and glycerol (which can be used for other purposes). Bioethanol is made using microorganisms such as yeasts, and enzymes. Enzyme digestion releases sugars from starches derived from crops. Bioethanol is then produced by fermenting the sugars using yeast and removing water through distillation and dehydration. Biobutanol – a biofuel with higher energy content than bioethanol – can be produced in a similar fashion from similar feedstocks: rather than using yeast, the fermentation step is typically carried out by the bacterium *Clostridium acetobutylicum*.

Blending, distributing and selling the fuel end product (downstream)
Finally, biofuels need to be blended with petrol (with the exception of high-quality biodiesel) and transported so they can be sold at biofuel pumps. The distribution of biofuels often requires new infrastructure.

2.4 In contrast to biodiesel, bioethanol can only be used as a supplement in a fuel blend, with a typical ‘blend wall’ at 10 per cent bioethanol. This is in part due to the fact that ethanol absorbs water from the atmosphere and so cannot be used unmixed in current infrastructure. Replacing a higher percentage of petrol with ethanol, for example blending 15 per cent of petrol with 85 per cent of ethanol (E85 blend) requires cars with altered vehicle technology. In 2008, more

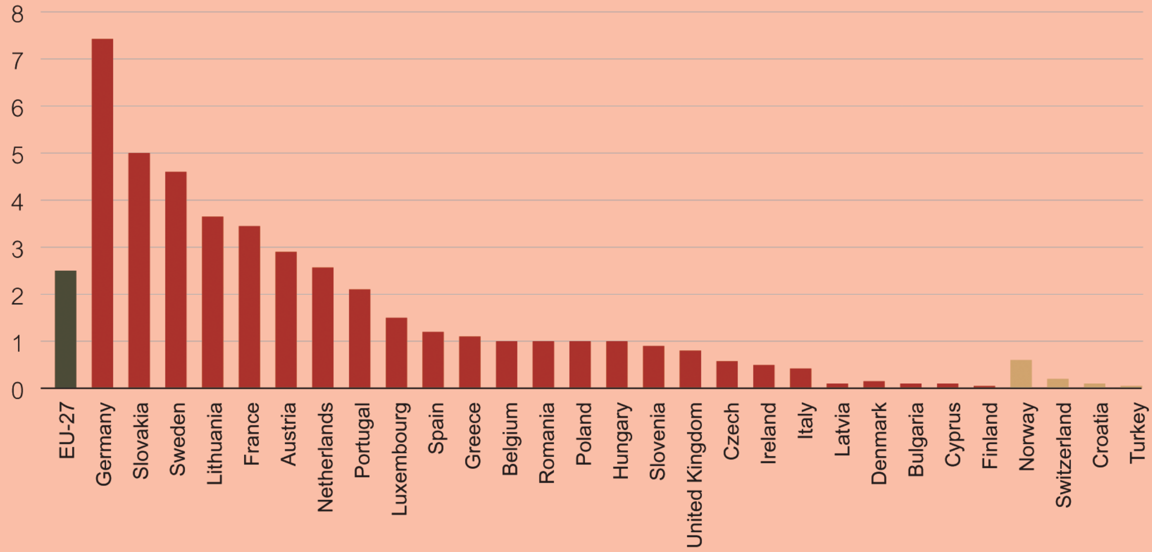
131 That is, blends of 80 per cent petroleum diesel and 20 per cent biodiesel.
132 McCormick RL (2007) The impact of biodiesel on pollutant emissions and public health *Inhalation Toxicology* **19**: 1033–9.
133 This is an area of ongoing investigation. For example, it has been shown that in an animal exposure study, biodiesel exhaust has effects similar to that of conventional diesel. Meanwhile, some studies have found no difference between the fuels in terms of particulate matter causing mutations, whereas one study has shown that biodiesel causes fewer mutations owing to its lower emissions of these; see: McCormick (2007) The impact of biodiesel on pollutant emissions and public health *Inhalation Toxicology* **19**: 1033–9.
134 Here, we describe the principles of biofuels production mainly with regard to the so-called ‘first generation’ biofuels made from food crops. Newer developments are detailed in the following chapter.

than 82 per cent of cars registered in Brazil in that year were flexible fuel vehicles[135] (2,33 million in 2008),[136] there were 8 million flexible fuel vehicles on the road in the US,[137] and over 215,000 on the road as of 2011 in Sweden.[138] At the end of 2009, there were only 604 petrol/alcohol vehicles on the road in the UK.[139] Both bioethanol and biodiesel have lower energy densities than their fossil fuel equivalents, so motorists will be able to drive fewer kilometres on a litre of these biofuels compared with a litre of conventional fuel. This affects retailing and is one reason why there is interest in developing biobutanol which has an energy density closer to that of petrol.

Current use of biofuels

2.5 Biofuels make up only a small fraction of overall fuel consumption in most countries, with the exception of Brazil. In 2007, the European average was approximately 2.5 per cent of overall transport fuel consumption, but with a large disparity between countries (see Box 2.4). Germany was in a very clearly leading position at over 7 per cent while the UK was below 1 per cent.

Box 2.4: Percentage of biofuels in total transport fuel consumption in Europe, 2007[140]



Data for Estonia and Malta not available.

Chart adapted from Eurostat.

2.6 Following the implementation of policy incentives as described in Chapter 1, the percentage of biofuels in the fuel mix has been growing, and is expected to continue to do so. In 2007, the International Energy Agency projected that by 2030 biofuels will account globally for seven percent of road transport fuel use.[141] And indeed, current developments support this prediction: for example, between 1998 and 2009, the production of biodiesel in the European Union

135 A flexible fuel vehicle (FFV) is one that can operate on petrol, ethanol blends (such as E85) or a mixture of the two.
136 ANFAVEA - Associação Nacional dos Fabricantes de Veículos Automotores (Brasil) (2009) *Brazilian Automotive Industry Yearbook, Vehicles – production, domestic sales, and exports*, available at: http://www.anfavea.com.br/anuario2009/capitulo2a.pdf, p70 and p73.
137 National Renewable Energy Laboratory US Department of Energy (2011) *Alternative and advanced vehicles*, available at: http://www.eere.energy.gov/afdc/vehicles/flexible_fuel.html.
138 BioAlcohol Fuel Foundation BAFF (Sweden) (2010) *Bought flexifuel vehicles – total per year*, available at: http://www.baff.info/english/.
139 Personal communications, Robert Kennedy, The Society of Motor Manufacturers and Traders Limited.
140 Eurostat (2010) *Share of biofuels in total fuel consumption of transport, 2007*, available at: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php?title=File:Share_of_biofuels_in_total_fuel_consumption_of_transport,_2007_%281%29_%28%25%29.PNG&filetimestamp=20100504144213.
141 International Energy Agency (2007) *Renewables in global energy supply: an IEA fact sheet*, available at: http://www.iea.org/papers/2006/renewable_factsheet.pdf, p15.

increased more than ten-fold (see Box 2.5) – and this despite the fact that production is currently well below capacity.[142]

Box 2.5: EU Member States' biodiesel production ('000 tonnes)[143]

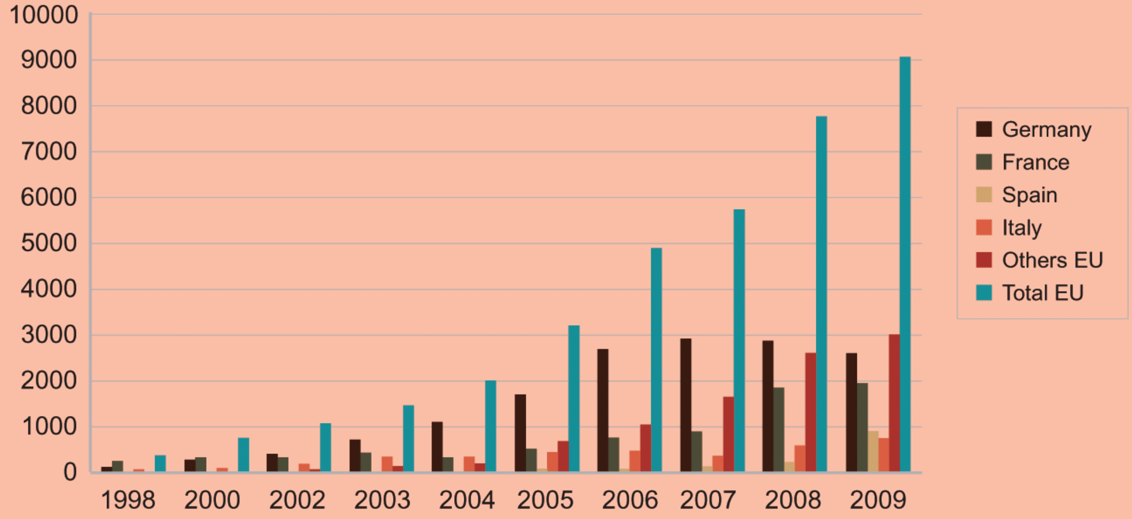


Chart adapted from European Biodiesel Board.

2.7 During 2008–2009, 2.7 per cent of UK road transport fuel was biofuel; 1,284 million litres of biofuel were supplied[144] – an increase on previous years. The upward trend continues: during 2009–2010, 1,568 million litres of biofuel were supplied, comprising 3.33 per cent of the UK's road transport fuel. This exceeded the Government's target of 3.25 per cent.[145] Biodiesel accounted for 71 per cent of biofuel supplied, with the most widely reported source of biodiesel being soybean from Argentina.[146] Bioethanol comprised 29 per cent of biofuel, mostly from Brazilian sugar cane.[147] Almost 200,000 kilograms of biogas were produced from municipal solid waste and then used as biofuel.[148] In Brazil in 2008–2009, almost 28 billion litres of bioethanol were produced from sugar cane.[149] Biodiesel production in Brazil, while developing, is relatively marginal. In the US, the minimum volume for renewable fuel was set at about 8 per cent in 2011 (where the percentage represents the ratio of renewable fuel volume to petrol and diesel volume).[150]

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142 For example, in 2009 the European biodiesel production capacity was almost 21 million tonnes; however, only an estimated 9 million tonnes was produced; see: European Biodiesel Board (22 July 2010) *2009–2010: EU biodiesel industry restrained growth in challenging times*, available at: http://www.ebb-eu.org/EBBpressreleases/EBB%20press%20release%202009%20prod%202010_capacity%20FINAL.pdf, pp1 and 4.

143 European Biodiesel Board (2010) *The EU biodiesel industry*, available at: http://www.ebb-eu.org/stats.php.

144 Renewable Fuels Agency (2010) *Year one of the RTFO: Renewable Fuels Agency report on the Renewable Transport Fuel Obligation 2008/09*, available at: http://www.renewablefuelsagency.gov.uk/sites/renewablefuelsagency.gov.uk/files/_documents/year_one_of_the_rtfo_a4.pdf, p16. An Olympic-size swimming pool is a minimum of 2.5 million litres.

145 Renewable Fuels Agency (2011) *Year two of the RTFO*, available at: http://www.renewablefuelsagency.gov.uk/sites/rfa/files/Year_Two_RTFO_v2.pdf, p16.

146 Renewable Fuels Agency (2011) *Verified RFA quarterly report 8: 15 April 2009 – 14 April 2010*, available at: http://www.renewablefuelsagency.gov.uk/sites/rfa/files/24_RFA_verified_report_RTFO_year_two_v1.0.0_0.pdf, p2.

147 Ibid., p2.

148 Ibid., p21.

149 UNICA Sugar Cane Industry Association (2011) *Quotes and stats: ethanol production – Brazil*, available at: http://www.unica.com.br/downloads/estatisticas/eng/BRAZILIAN%20ETHANOL%20PRODUCTION.xls.

150 US Environmental Protection Agency (2010) *EPA finalizes 2011 Renewable Fuel Standards*, available at: http://www.epa.gov/otaq/fuels/renewablefuels/420f10056.pdf, p3.

Case studies

2.8 The following three case studies illustrate the experiences gained in the development of now commercially established biofuels from different feedstocks in different countries: bioethanol from corn in the US, bioethanol from sugar cane in Brazil, and biodiesel from palm oil in Malaysia. These particular case studies have been included for illustrative purposes and they are neither intended to represent all biofuels production nor all the issues associated with current biofuels. Indeed, we do not attempt to comment on or decide some of the contentious elements in each case study – a significant literature already exists on these topics and we could add little new insight. However, these case studies, which include the two biggest producers of biofuels in the world (the US and Brazil), vividly demonstrate some of the important issues that have emerged from large-scale production of biofuels. They thus provide us with important material for the ethical analysis of biofuels, which we undertake in the later chapters of this report. Moreover, information on the policy background helps to understand which of the drivers described in Chapter 1 were most relevant in each case study, and whether expectations were fulfilled. This lays some groundwork for our policy recommendations in Chapter 5.

Case study I: Bioethanol from corn in the US

Policy background

2.9 The US is the world's largest bioethanol producer: in 2009, an estimated almost 40 billion litres of ethanol were produced.[151] In the US, bioethanol is mainly derived from corn. A very small fraction of bioethanol is produced from sorghum.

2.10 The worry over energy security contributed significantly to the expansion of biofuels development in the US, in particular following the oil embargo by the Organisation of Petroleum Exporting Countries in 1973–1974. To reduce dependence on foreign sources of oil, a subsidy was introduced for the use of 'gasohol', a mixture of petrol and ethanol.[152] The subsidy did not at the time lead to a significant expansion of the ethanol industry as the price of oil dropped in the 1980s, making it difficult for the ethanol industry to compete even with the subsidy. However, in the 1990s, the subsidy once again became an incentive for US bioethanol production when the price of oil and oil imports rose. The incentive for bioethanol production has become more compelling as the price of oil has continued to rise. However, an even more important economic incentive for rapid expansion was the phasing out of methyl *tert*-butyl ether (MTBE) in the mid-1990s. MTBE was used as an oxygenate additive to petrol in order to raise the octane number, but it was found to be toxic and a powerful environmental pollutant. Declining use of MTBE created a demand for an oxygenate at an attractive price and led to a stampede among farmers groups who were interested in moving up the value chain. Finally, as mentioned before, agricultural overproduction rendered the conversion of food crops into biofuels an attractive prospect to farmers. Most of the corn bioethanol plants today are owned by groups of farmers who made the decision to finance and operate corn bioethanol plants entirely based on economic calculus.

2.11 Domestic legislation and policy have moreover in recent years created a favourable environment for the US corn-based bioethanol industry. A framework including legislation, mandates and other policies that support production, distribution and consumption of biofuels, including bioethanol specifically, exists at both federal and state levels (see Box 2.6).

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151 Renewable Fuels Association (2010) *Climate of opportunity: 2010 ethanol industry outlook*, available at: http://ethanolrfa.org/page/-/objects/pdf/outlook/RFAoutlook2010_fin.pdf?nocdn=1, p6.
152 Tyner WE (2008) The US ethanol and biofuels boom: its origins, current status, and future prospects *BioScience* **58**: 646–53.

Box 2.6: Biofuels policy framework in the US

Under the Clean Air Act Amendments of 1990, the US Government requires the use of oxygenated gasoline (petrol) in areas with unhealthy levels of air pollution,[153] given that oxygenated gasoline burns with fewer harmful exhaust fumes than conventional gasoline. In one of the two associated programmes, bioethanol is the primary ingredient for oxygenation.[154]

The Energy Policy Act (EPAct) of 2005 established the Renewable Fuel Program.[155] This set the first renewable fuel volume mandate for fuel sold in the US, requiring that 7.5 billion US gallons (approximately 28 billion litres) of renewable fuel be blended with gasoline by 2012. The Energy Independence and Security Act (EISA) of 2007 later established the Renewable Fuel Standard (RFS) program, mandating that renewable fuels must account for 36 billion gallons (approximately 136 billion litres) of US transport fuel by 2022;[156] these numbers represent almost a nine-fold increase from the amount of bioethanol produced in the US in 2005.[157] Whereas other legislation – both domestic and European – has set minimum *proportions* for biofuels use in terms of total transport fuel used, US legislation has established standards for *absolute* biofuels use. EISA, while focusing on US energy security, also had environmental goals in that it required the US Environmental Protection Agency (EPA) to ensure that any renewable fuel, produced from facilities built after the enactment of EISA, produced fewer greenhouse gas (GHG) emissions than the petroleum fuel it replaced.[158] In February 2010, the EPA finalised its revision of the regulations for the RFS program. This established new specific annual volumes for renewable fuel to be used for transport.[159] It also included new definitions and criteria for both renewable fuels and the feedstocks used to produce them, including new GHG emissions savings thresholds as determined by life cycle assessment. The regulations for the RFS program apply to domestic and foreign producers and importers of renewable fuel used in the US. In addition, a whole suite of further policies are in place to promote bioethanol production.[160]

The US domestic bioethanol market has also been protected by policy. There is a 54 cents per gallon tariff on imported bioethanol, criticised by some as "[serving] largely to keep low-cost Brazilian ethanol from sugar cane out of the [US]".[161] Indeed, imports of bioethanol into the US have been recorded as being low (below 0.6 billion litres annually).[162]

Finally, individual states have implemented legislation that impacts on bioethanol production. For example, in California the Low Carbon Fuel Standard program has been enacted, which calls for a 10 per cent reduction in the carbon intensity of California's transportation fuels by 2020.[163]

To meet this policy-driven demand, by January 2010 there were an estimated 189 biorefineries in the US with a collective operating production capacity of approximately 45 billion litres of bioethanol a year.[164] As of November 2010, there were 204 operating bioethanol biorefineries with a total production capacity of approximately 52 billion litres.[165]

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153 sec 218 Clean Air Act Amendments of 1990.
154 US Environmental Protection Agency (2008) *Methyl tertiary butyl ether (MTBE)*, available at: http://www.epa.gov/mtbe/gas.htm.
155 sec 1501 Energy Policy Act of 2005.
156 s202 Energy Independence and Security Act of 2007.
157 US Energy Information Administration (2007) *Biofuels in the U.S. transportation sector*, available at: http://www.eia.doe.gov/oiaf/analysispaper/biomass.html.
158 s202 Energy Independence and Security Act of 2007.
159 US Environmental Protection Agency (2010) *EPA finalizes regulations for the national Renewable Fuel Standard program for 2010 and beyond*, available at: http://www.epa.gov/oms/renewablefuels/420f10007.pdf.
160 For example, the Volumetric Ethanol Excise Tax Credit (VEETC) was created under the American Jobs Creation Act 2004. The VEETC effectively subsidises the production of bioethanol in the US by crediting blenders who mix ethanol into gasoline with 51 cents per pure gallon of ethanol blended. Small ethanol producers with production capacity up to 60 million gallons are also supported: following the EPAct of 2005, they are credited with 10 cents per gallon as a production income tax credit. These credits were extended by the US Congress in December 2010 for a further year. In addition, there are policies to promote the use of bioethanol in transport, including the requirement under the EPAct of 2005 that the federal government fleet of dual-fuelled vehicles operate on alternative fuels.
161 Runge CF (2007) Biofuel: corn isn't the king of this growing domain *Nature* **450**: 478. In December 2010, the US Congress extended this tariff for a further year.
162 Oosterveer P and Mol APJ (2010) Biofuels, trade and sustainability: a review of perspectives for developing countries *Biofuels, Bioproducts and Biorefining* **4**: 66–76.
163 California Environmental Protection Agency Air Resources Board (2010) *Low Carbon Fuel Standard program*, available at: http://www.arb.ca.gov/fuels/lcfs/lcfs-background.htm.
164 Renewable Fuels Association (2010) *Climate of opportunity: 2010 ethanol industry outlook*, available at: http://ethanolrfa.org/page/-/objects/pdf/outlook/RFAoutlook2010_fin.pdf?nocdn=1, p3.
165 US Department of Energy (2011) *Biorefineries*, available at: http://cta.ornl.gov/bedb/biorefineries/Biorefineries_Overview.shtml. For the most up to date figures, see: Renewable Fuels Association (2011) *Biorefinery locations*, available at: http://www.ethanolrfa.org/bio-refinery-locations/.

Controversies over food security

2.12 Production of corn bioethanol in the US was blamed for causing increases in the price of corn and other grains and foods by increasing competition for finite vital resources. The 'tortilla riots' in Mexico during late 2006 and early 2007, widely publicised in the media, are one example. It has been reported that these were triggered when yellow corn – which had typically been imported from the US for use as animal feed – increased in price. Mexicans began to use white corn, a grain that is traditionally used to make tortilla, as animal feed instead, and thus the price of white corn and tortilla soared.[166] Tortilla is a staple food for the poor. When prices rose, street demonstrations occurred with thousands marching down the street and the Mexican Government eventually had to intervene to subsidise the sale of corn for tortillas.

2.13 These consequences of (not only) US biofuels production for food security are the subject of fierce debate (see Box 2.7). Several recent reports by advocacy organisations have accused large-scale biofuels production of driving up food prices or threatening food security by other means, using the strongest language of human tragedy and misery.[167] In addition, the *Gallagher Review*, an independent review prepared for the UK Government of the indirect effects of current biofuels production, found that increasing demand for biofuels contributed to rising food prices that harm the poor.[168] However, the review noted that the scale of effects on the prices of commodities was both complex and uncertain to model. Indeed, while there is general agreement that biofuels production did contribute to high food prices, there is little consensus as to the extent of its impact.

Box 2.7: Biofuels and food security: controversies

On the Mexican tortilla riots

"There is another problem with relying on a food-based biofuel, such as corn ethanol, as the poor of Mexico can attest. In recent months, soaring corn prices, sparked by demand from ethanol plants, have doubled the price of tortillas, a staple food. Tens of thousands of Mexico City's poor recently protested this 'ethanol tax' in the streets."[169]

"…the allegation that the increase in corn prices in the US led to food price increases overall and specific corn shortages in Mexico was exaggerated. It seems that [an] increase in oil/gasoline prices and related increases in natural gas/fertilizer prices contributed to the increase in prices and the supply/demand/price consequences we observed."[170]

On biofuels and food security

President Luiz Inácio Lula da Silva, Brazilian President: "Biofuels aren't the villain that threatens food security."[171]

Jean Ziegler, United Nations Special Rapporteur on the Right to Food: "[Biofuels are] a crime against humanity".[172]

2.14 For example, a research paper in 2008 found that from June 2002 until June 2008 "biofuels and the related consequences of low grain stocks, large land use shifts, speculative activity and export bans" accounted for approximately 70–75 per cent of the increase in food prices during

[166] For more details, see: Westhoff P (2010) *The economics of food: how feeding and fueling the planet affects food prices* (New Jersey: FT Press), pp17–9. Westhoff also notes that the increase in yellow corn prices may have provided an incentive for at least some Mexican farmers to grow yellow corn rather than white corn. This too would have affected the availability of white corn for tortilla.

[167] For example, see: ActionAid (2010) *Meals per gallon: the impact of industrial biofuels on people and hunger*, available at: http://www.actionaid.org.uk/doc_lib/meals_per_gallon_final.pdf; Friends of the Earth Europe (2010) *Africa: up for grabs: the scale and impact of land grabbing for agrofuels*, available at: http://www.foeeurope.org/agrofuels/FoEE_Africa_up_for_grabs_2010.pdf, p27; Christian Aid (2008) *Fighting food shortages: hungry for change*, available at: http://www.christianaid.org.uk/Images/food_report_2008.pdf, pp3–4.

[168] Renewable Fuels Agency (2008) *The Gallagher Review of the indirect effects of biofuels production*, available at: http://www.renewablefuelsagency.gov.uk/sites/renewablefuelsagency.gov.uk/files/_documents/Report_of_the_Gallagher_review.pdf, p9.

[169] David Tilman, ecologist at the University of Minnesota, and Jason Hill, research associate in the Department of Applied Economics at the University of Minnesota, writing in: The Washington Post (25 Mar 2007) *Corn can't solve our problem*, available at: http://www.washingtonpost.com/wp-dyn/content/article/2007/03/23/AR2007032301625.html.

[170] Advanced Biofuels USA, responding to the Working Party's consultation.

[171] President Lula speaking at a conference of the Food and Agriculture Organization of the United Nations in Brazil, 2008: BBC News (17 Apr 2008): *Brazil president defends biofuels*, available at: http://news.bbc.co.uk/1/hi/sci/tech/7351766.stm.

[172] Mr Ziegler speaking at the UN headquarters in New York City, 2007: BBC News (27 Oct 2007) *Biofuels 'crime against humanity'*, available at: http://news.bbc.co.uk/1/hi/world/americas/7065061.stm.

that period, and that the combination of higher energy prices (and subsequent increases in fertiliser and transport costs) and a weak dollar explained 25–30 per cent of the total price rise.[173] Overall, the most important factor was seen to be the large increase in biofuels production in the US and the EU.[174] However, this conclusion was subsequently rebutted by a paper for the World Bank in 2010.[175] It is now apparent from this and many other reports, for example from the UK Government,[176] that the effect of biofuels on food prices was smaller than first believed, and that other factors, such as high energy prices and the weak dollar, were more significant.

2.15 In sum, biofuels, and US corn bioethanol in particular, appear to be one contributing factor to changing food commodity prices, which can affect vulnerable countries and populations. However, there are several other factors which also play important roles in destabilising food prices. Blaming food price spikes on biofuels production alone – a frequent argument in our public consultation – would appear to be one-sided.

Environmental issues

2.16 US production of corn bioethanol has given rise to controversy over its impacts on the environment, including its greenhouse gas (GHG) emissions in comparison with the fossil fuels it replaces and deleterious effects on air quality, soil, health and water resources.

2.17 *GHG emissions from indirect land use change*: Research has raised questions over whether corn bioethanol achieves GHG emissions savings compared with fossil fuel usage.[177] This is mainly because of the release of carbon from land, newly cultivated as an often indirect consequence of increased corn production for ethanol. A well-known yet highly contested study by Searchinger *et al.* (2008)[178] estimated the extent of potential land use change in response to a possible increase in US corn ethanol production of 56 billion litres above projected levels for 2016.[179] This study made the assumption that, as more US cropland is used to support bioethanol production, and given that the US exports corn to countries such as India, China and Brazil, these countries would generally replace their reduced imports of US corn by cultivating more land, including forest and grassland (so-called indirect land use change (iLUC), see Box 2.8). This would release much of the carbon stored in soils and plants through either combustion or decomposition. The analysis found that production of corn bioethanol increases GHG emissions for 167 years, after which point the GHG emissions savings from use of corn bioethanol finally equalises the carbon emissions from land use change. Over the first 30 years, GHG emissions from corn bioethanol are projected to be nearly double those from petrol per kilometre driven. However, the issue of land use change is highly controversial (see Box 2.9), as

[173] Mitchell D (2008) *A note on rising food prices*, available at: http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2008/07/28/000020439_20080728103002/Rendered/PDF/WP4682.pdf, pp16–7.
[174] Ibid.
[175] Baffes J and Haniotis T (2010) *Placing the 2006/08 commodity price boom into perspective*, available at: http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2010/07/21/000158349_20100721110120/Rendered/PDF/WPS5371.pdf. This paper concluded that the dominant influence on food markets was likely to be the strong link between energy and non-energy commodity prices. The paper also argued that the effect of biofuels was not as large as originally thought; instead the price spike for 2007/08 may have been caused in part by financial investors using commodities.
[176] HM Government (2010) *The 2007/08 agricultural price spikes: causes and policy implications*, available at: http://www.defra.gov.uk/foodfarm/food/pdf/ag-price100105.pdf, p114.
[177] While many studies concentrate specifically on GHG emissions, others have taken a broader perspective. For example, for a study that incorporates an economic cost–benefit analysis, see: de Gorter H (2010) Does US corn-ethanol really reduce emissions by 21%? Lessons for Europe *Biofuels* **1**: 671–3.
[178] Searchinger T, Heimlich R, Houghton RA *et al.* (2008) Use of US croplands for biofuels increases greenhouse gases through emissions from land-use change *Science* **319**: 1238–40. For a list of limitations identified in the study, see: Renewable Fuels Agency (2008) *The Gallagher Review of the indirect effects of biofuels production*, available at: http://www.renewablefuelsagency.gov.uk/sites/renewablefuelsagency.gov.uk/files/_documents/Report_of_the_Gallagher_review.pdf, p47.
[179] Searchinger T, Heimlich R, Houghton RA *et al.* (2008) Use of US croplands for biofuels increases greenhouse gases through emissions from land-use change *Science* **319**: 1238–40.

is any calculation of iLUC (see Box 2.8). For example, a subsequent study estimated that the associated GHG release for corn bioethanol production in the US was roughly a quarter of Searchinger's 30 year estimate.[180] This study differed from Searchinger's in that not only did it factor in market-mediated responses to increased biofuels production in the US, but it also accounted for the use of by-products.

Box 2.8: Life cycle assessment of biofuels: nitrous oxide emissions, dLUC and iLUC

Life cycle assessment (LCA) of biofuels considers the environmental and resource impacts associated with: growing the crop (including soil cultivation, fertiliser production, irrigation and harvesting); transporting the biofuels feedstock; converting the feedstock to biofuels (including extraction of sugars/oils, processing and refining); and transporting biofuels to the point of use. Although LCA can also include assessment of specific resources, such as water or energy, that are used throughout the life cycle of a biofuel, most applications currently focus on GHG emissions. Recently, there has been controversy around several areas of scientific uncertainty and debate in LCA, which are important because of the potential size of their contributions to total GHG emissions. Only the basic aspects of these particular issues are introduced here while consideration of how to resolve them is addressed elsewhere (in Chapter 5).

Nitrous oxide emissions from soils: Soil nitrous oxide emissions arise mainly from the application of nitrogen fertilisers to crops. Although the mechanisms for nitrous oxide formation in soils are well understood, the relationship between the rate of nitrogen-based fertiliser application and the soil nitrous oxide emissions depends on a variety of factors that can be difficult to determine. In themselves, soil nitrous oxide emissions can be relatively small but their significance is magnified by the fact that, on an equal weight basis, nitrous oxide is approximately 300 times more powerful than carbon dioxide in terms of the greenhouse effect.[181]

Direct land use change: Direct land use change (dLUC) involves converting land from a previous use (mainly grassland, forest or woodland, peatland and wetland) to the cultivation of biofuels crops. In all such cases, significant carbon stocks can be destroyed and released as carbon dioxide emissions. The connection between these GHG emissions and biofuels production is direct, as both the previous use of the land and its specific conversion to biofuels crop cultivation should be known. Hence, it would seem simple to ensure that estimated additional GHG emissions are attributed to the biofuels produced. However, this requires that we specify the number of years of crop production to which the GHG emissions from dLUC are attributed and this can involve a nominal time horizon which is not justified explicitly.

Indirect land use change: Determining the effects of iLUC is more complicated than for dLUC. Growing biofuels crops on existing agricultural land may result in displacing existing cultivation of food and other crops elsewhere. This displacement, if it involves the destruction of carbon stocks in grassland, forest or woodland, peatland or wetland, will result in the release of substantial carbon dioxide emissions. From an extreme perspective, all these GHG emissions are attributed to the biofuels crop which caused the iLUC. Again, a fixed quantity of initial GHG emissions is attributed to a cumulative amount of biofuels produced over a nominal time horizon. However, the contentious issue is to determine which biofuels crop causes the displacement and what subsequent iLUC actually occurs. There are many factors which cause land use change and these include: increasing requirements for food (e.g. due to a growing world population); changing dietary preferences (e.g. in response to increasing wealth and switches to food products that use proportionally more land); expanding use of land for non-food production (e.g. materials and chemicals as well as biofuels); degradation of agricultural land (i.e. where it is no longer productive); and continued urbanisation (this causes direct and indirect degradation and loss of land for cultivation). Conversely, improvements in crops and agricultural practices can increase yield and reduce pressure on iLUC. Additionally, the inclusion of certain by-products, such as animal feeds, into the evaluation of GHG emissions for biofuels can reduce the impact of iLUC.[182] It is currently extremely difficult to disentangle such factors and, hence, there is much uncertainty over the allocation of GHG emissions from iLUC to the production of specific biofuels. While recent studies have attempted to quantify the potentially significant magnitude of iLUC associated with large-scale biofuels production,[183] considerable uncertainties with current land use change modelling have prevented the official resolution of this issue.[184]

These uncertainties surrounding LCA are reflected in the results of analyses of the impact of current biofuels, which differ significantly. Some recent LCAs have shown that biofuels can have marginal or even negative GHG emissions savings

[180] Hertel TW, Golub AA, Jones AD *et al*. (2010) Effects of US maize ethanol on global land use and greenhouse gas emissions: estimating market-mediated responses *BioScience* **60**: 223–31.

[181] The potency of GHGs is measured by their global warming potential (GWP) relative to CO_2. According to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, GWPs over a 100 year time horizon are such that one kilogram of methane is equivalent to 25 kilograms of carbon dioxide, and one kilogram of nitrous oxide is equivalent to 298 kilograms of carbon dioxide.

[182] See, for example: Taheripour F, Hertel TW, Tyner WE, Beckman JF and Birur DK (2010) Biofuels and their by-products: global economic and environmental implications *Biomass & Bioenergy* **34**: 278–89; Cockerill S (25 Nov 2010) *Biorefining wheat to produce green food and fuel*, presented at: 4th ICIS Bioresources Summit, Gateshead, UK.

[183] See, for example: Institute for European Environmental Policy (2010) *Anticipated indirect land use change associated with expanded use of biofuels and bioliquids in the EU – an analysis of the National Renewable Energy Action Plans*, available at: http://www.ieeplondon.org.uk/publications/pdfs/2010/iluc_analysis.pdf.

[184] European Commission (2010) *Report from the Commission on indirect land-use change related to biofuels and bioliquids*, available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0811:FIN:EN:PDF, p14.

compared with fossil fuels. For example, in the *Science* study by Searchinger *et al.* mentioned above, the authors find significantly negative GHG emissions savings for US ethanol made from corn due mainly to the effect of iLUC.[185] Others, using different models for determining land use change, derive more favourable numbers for overall GHG emissions from biofuels production, including for some types of corn ethanol production.[186] The issue is further complicated by the fact that co-products from biofuels production can affect – indeed in some cases improve – LCA and iLUC outputs.[187]

Box 2.9: Land use change: controversy

On the existence of land use change

"Land use change is a big [myth] invented by [opponents of] biofuels. It simply has to be assured that the feedstock for biofuels is grown in a sustainable way. This is generally the case, only few exceptions exist. It is wrong to concentrate on the few bad exceptions (which of course are not tolerable and have to be avoided)."[188]

"This land use problem is not just a secondary effect — it was often just a footnote in prior papers…It is major. The comparison with fossil fuels is going to be adverse for virtually all biofuels on cropland."[189]

On the calculation of iLUC

"The scientific basis for indirect land use change is extremely weak…ILUC modelling and analysis is the wrong tool for assessing these issues. Rather, better land management is required…"[190]

"The fact that Indirect Land Use change is happening must be taken into account when calculating GHG emissions. However, it is impossible to quantify precisely."[191]

2.18 *Water implications*: A report by the US National Research Council reviewed the water implications of biofuels production in the US, using some data from a study by the Sandia National Laboratories. This study had estimated that the amount of water used by a corn ethanol plant is in the region of 4 gallons of water per gallon of ethanol produced.[192] In contrast, water used in petroleum refining is about 1.5 gallons per gallon of fuel produced.[193] The US National Research Council report additionally calculated that the amount of water required in growing the corn for biofuels is about 200 times greater than the amount needed for processing each gallon of ethanol.[194] It subsequently interpreted these data as showing that biorefineries generated local but intense water supply challenges, and that irrigated agriculture could generate problems for the wider region (depending on whether agriculture is rain-fed or not).[195]

2.19 With regard to water quality, the report considered fertiliser run-off and nutrient pollution, as well as pesticide use. Compared with other feedstocks such as soybean and mixed-species grasses, the greatest application rates of fertilisers and pesticides per acre were for corn.[196] It was noted that, all else being equal, the conversion of land from other crops or non-crop plants to corn would probably lead to much higher application rates of nitrogen. Thus, there was considerable potential for additional corn bioethanol production to increase the severity of nutrient pollution in waterways,[197] such as the Mississippi River system. Nutrient pollution here is already a major

185 Searchinger T, Heimlich R, Houghton RA *et al.* (2008) Use of US croplands for biofuels increases greenhouse gases through emissions from land-use change *Science* **319**: 1238–40.
186 For example, see: US Environmental Protection Agency (2010) *EPA finalizes regulations for the national Renewable Fuel Standard program for 2010 and beyond*, available at: http://www.epa.gov/oms/renewablefuels/420f10007.pdf, p5.
187 Taheripour F, Hertel TW, Tyner WE, Beckman JF and Birur DK (2010) Biofuels and their by-products: global economic and environmental implications *Biomass & Bioenergy* **34**: 278–89.
188 Anonymous respondent, responding to the Working Party's consultation.
189 Dr Timothy Searchinger, Princeton University, quoted in The New York Times (8 Feb 2008) *Biofuels deemed a greenhouse threat*, available at: http://www.nytimes.com/2008/02/08/science/earth/08wbiofuels.html?pagewanted=1&_r=2.
190 BP, responding to the Working Party's consultation.
191 Food Not Fuel, responding to the Working Party's consultation.
192 Sandia National Laboratories (2007) *Overview of energy-water interdependencies and the emerging energy demands on water resources* (Los Alamos, New Mexico: Sandia National Laboratories), p13.
193 Ibid, p8.
194 Committee on Water Implications of Biofuels Production in the United States, National Research Council (2008) *Water implications of biofuels production in the United States*, available at: http://books.nap.edu/openbook.php?record_id=12039&page=51, p51.
195 Ibid.
196 Ibid, p27.
197 Ibid, p31.

cause of the "dead zone" in the Gulf of Mexico – a region where many forms of marine life cannot survive owing to low oxygen levels. The report warned: "If projected future increases in use of corn for ethanol production do occur, the increase in harm to water quality could be considerable."[198] Sedimentation arising from soil erosion into water bodies was also investigated, as sediments can impair water quality and carry pollutants.

Case study II: Bioethanol from sugar cane in Brazil

Policy background

2.20 Bioethanol production from sugar cane in Brazil, one of the longest standing biofuels programmes, has been described as the most successful example of producing and using biofuels on a large scale.[199] Large-scale production started when the Brazilian Government began to promote bioethanol as a transport fuel in response to the energy crisis of the 1970s. In 1975, the Brazilian Government launched the national alcohol programme "PróÁlcool" (Programa Nacional do Álcool). The intention was to phase out fossil fuels and to replace them with ethanol made from sugar cane.[200] By the mid 1980s, around three quarters of Brazilian cars were manufactured with engines that could use ethanol.[201] Flexible fuel cars were introduced in Brazil in 2003, and by 2008 almost 70 per cent of all vehicles produced were flexible fuel.[202]

2.21 Brazil is the world's second largest producer of ethanol fuel after the US (some predict that it will overtake the US in the near future) and the world's largest exporter. In 2008, it produced an estimated 27 per cent of the world's total bioethanol for fuel.[203] Production processes in Brazil are being improved continuously and Brazilian scientists have published a number of academic papers outlining advances in bioethanol production, such as in the use of yeasts or enzymes during conversion or the use of by-products such as molasses for electricity generation. The FAPESP Program for Research on Bioenergy, BIOEN, was launched in 2008 with the aim of integrating Brazilian biofuels research.[204]

2.22 The Brazilian Government encouraged the development of ethanol in several ways. There were guaranteed purchases of ethanol by the state-owned oil company Petrobras. In addition, ethanol prices were both lower than and fixed relative to the price of petrol (ethanol sold for 64.5 per cent of the petrol price at the pump), and agro-industrial firms willing to produce ethanol were offered economic incentives in the form of low interest rates.[205] These initiatives made ethanol economically competitive to produce and attractive to consumers, and have been credited with much of the success of the PróÁlcool programme. It is interesting to note that at the time of the launch of PróÁlcool, concern over energy security and high crude oil prices was the dominant motivation, with economic development running second. There was virtually no interest in lowering GHG emissions, since climate change had only just begun to emerge as an issue of public concern. However, recently the GHG emissions savings that can be generated through the production and use of bioethanol have been discussed as an additional and important driver for Brazilian bioethanol production.

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198 Ibid, p35.
199 Matsuoka S, Ferro J and Arruda P (2009) The Brazilian experience of sugarcane ethanol industry *In Vitro Cellular & Developmental Biology* **45**: 372–81.
200 Ibid.
201 ANFAVEA - Associação Nacional dos Fabricantes de Veículos Automotores (Brasil) (2009) *Brazilian automotive industry yearbook: vehicles – production, domestic sales, and exports*, available at: http://www.anfavea.com.br/anuario2009/capitulo2a.pdf, p64.
202 Ibid.
203 Renewable Fuels Association (2008) *Ethanol industry statistics: 2008 world fuel ethanol production*, available at: http://www.ethanolrfa.org/pages/statistics#E.
204 BIOEN consists of five divisions which focus on: biomass research; ethanol technologies and processing; biorefineries and alcohol chemistry; engines; and social, environmental and economic impacts; see: BIOEN (2011) *FAPESP Bioenergy Program – BIOEN*, available at: http://bioenfapesp.org/index.php?option=com_content&view=article&id=170&Itemid=151&lang=en.
205 Goldemberg J (2008) The Brazilian biofuels industry *Biotechnology for Biofuels* **1**: 6–13.

2.23 The uptake rate of bioethanol in Brazil is unparalleled compared with anywhere else in the world. Bioethanol prices were competitive with gasoline based on international prices for oil in 2004,[206] though oil prices have since risen. Moreover, prices continue to benefit from certain tax exemptions.[207] Some have heralded Brazil as a successful example of an emerging economy using the development of alternative fuels for national economic development, with the added potential benefit of supporting climate change mitigation.

Potential environmental impacts

2.24 Brazilian bioethanol production has not gone unchallenged. For example, it has been claimed that production of ethanol from sugar cane generates GHG emissions savings of about 90 per cent.[208] However, following such estimates, the overall sustainability of bioethanol production from Brazilian sugar cane has been questioned, for example when iLUC or direct conversion of the Brazilian Cerrado are taken into account when estimating GHG emission savings.[209] On the other hand, ethanol made from sugar cane, such as ethanol from Brazil, complies with the EPA threshold for classification as an "advanced biofuel" (50 per cent GHG emission reduction).[210] However, as described above in Box 2.8, calculating GHG emissions remains controversial.

2.25 *Water use*: Concerns regarding water use of Brazilian sugar cane production and possible contamination of water by use of fertiliser, have been raised in the past. Sugar cane production is highly water intensive (using up to 4 litres of water per litre of ethanol produced).[211] A recent study[212] concluded that the amount of water used for ethanol production in Brazil has decreased and water pollution can be avoided, for example by giving up use of agrochemicals and replacing these with less toxic alternatives. However, Brazilian wastewater standards are not as strict as other comparable standards and it seems that some agrochemicals are allowed that are banned in the EU.[213]

2.26 *Deforestation*: There have also been criticisms surrounding the possibility that areas with high environmental value will be cleared for sugar cane production, such as the Pantanal or the Cerrado. These are areas of high biodiversity, and an expansion of agricultural production may destroy these rich habitats and their associated biodiversity.[214] Deforestation in the Cerrado and the Amazon increased rapidly during 2005–2007[215] and through modelling this has been linked – some say incorrectly – to an increased area of sugar cane plantation elsewhere in Brazil.[216]

206 Ibid.
207 Woodrow Wilson International Center for Scholars (2007) *The global dynamics of biofuels: potential supply and demand for ethanol and biodiesel in the coming decade*, available at: http://www.wilsoncenter.org/topics/pubs/Brazil_SR_e3.pdf, p6.
208 European Commission (2007) *Biofuels progress report: report on the progress made in the use of biofuels and other renewable fuels in the Member States of the European Union*, available at: http://ec.europa.eu/energy/energy_policy/doc/07_biofuels_progress_report_en.pdf, p11.
209 Lapola DM, Schaldach R, Alcamo J *et al.* (2010) Indirect land-use changes can overcome carbon savings from biofuels in Brazil *Proceedings of the National Academy of Sciences of the United States of America* **107**: 3388–93.
210 US Environmental Protection Agency (2010) *EPA finalizes regulations for the national Renewable Fuel Standard program for 2010 and beyond*, available at: http://www.epa.gov/oms/renewablefuels/420f10007.pdf, p5.
211 Sawyer D (2008) Climate change, biofuels and eco-social impacts in the Brazilian Amazon and Cerrado *Philosophical Transactions of the Royal Society B: Biological Sciences* **363**: 1747–52.
212 Smeets E, Junginger M, Faaij A, et al. (2008) The sustainability of Brazilian ethanol: An assessment of the possibilities of certified production, *Biomass and Bioenergy* **32**: 781–813.
213 Ibid.
214 United Nations Environment Programme (2009) *Towards sustainable production and use of resources: asessing biofuels*, available at: http://www.unep.fr/scp/rpanel/pdf/assessing_biofuels_full_report.pdf, p69; Martinelli LA and Filoso S (2008) Expansion of sugarcane ethanol production in brazil: Environmental and social challenges *Ecological Applications* **18**: 885–98; Oxfam International (2008) *Another inconvenient truth*, available at: http://www.oxfam.org.uk/resources/policy/climate_change/downloads/bp114_inconvenient_truth.pdf; Sawyer D (2008) Climate change, biofuels and eco-social impacts in the Brazilian Amazon and Cerrado *Philosophical Transactions of the Royal Society B* **363**: 1747–52.
215 Sawyer D (2008) Climate change, biofuels and eco-social impacts in the Brazilian Amazon and Cerrado *Philosophical Transactions of the Royal Society B* **363**: 1747–52.
216 Lapola DM, Schaldach R, Alcamo J et al (2010) Indirect land-use changes can overcome carbon savings from biofuels in Brazil *Proceedings of the National Academy of Science* **107**: 3388–93.

Expansion of agriculture into areas of high biodiversity is neither inevitable nor necessarily due to increased biofuels production. However, rapid scaling up of production in response to increasing worldwide interest in biofuels may cause production to expand into valuable wildlife habitats. In a different example, rapid scaling up of soybean plantation for biodiesel production in Brazil has resulted in direct conversion of forest land in the Amazon into cropland. Biodiesel from this land has been accused of severe environmental effects.[217]

2.27 To avoid the destruction of valuable forest land and in response to international criticism, the Brazilian Government set up in September 2009 countrywide agro-ecological land use zoning, ZAE Cana, to restrict sugar cane growth in or near environmentally sensitive areas.[218] Today, around one per cent of Brazil's landmass, equivalent to 7.8 million hectares (one hectare is roughly the area of a sports field), is used for growing sugar cane (with great regional variation). ZAE Cana includes a set of mandatory environmental, economic, social, climate and soil restrictions, limiting future expansion of sugarcane to 7.5 per cent of the Brazilian territory. Under the criteria, 92.5 per cent of the country is not suitable for planting sugar cane. Projections from the Brazilian Ministry of Agriculture indicate that if Brazilian production doubled by 2017, not more than 1.7 per cent of the land would be used.[219]

2.28 *Field burning*: To facilitate harvesting, sugar cane fields are burned prior to the harvest. This is done to avoid harm to workers from snakes and sharp leaves, but has in the past led to soil contamination and air pollution.[220] A state law came into force which bans burning in sugar cane fields in flat and hilly areas by 2021 and 2031 respectively (agreements with industry exist to stop burning ahead of these targets by 2014 or 2017).[221] In the meantime, advances in fertilisers and mechanisation of farming systems have reduced the need for field burning.

Workers' rights

2.29 Brazil has been accused in the past of not tracking breaches of workers' rights;[222] in addition, there have been reports of contemporary slavery among sugar cane cutters in Brazil. For example, in 2007, Amnesty International highlighted the rescue of more than 2,000 workers from forced labour or conditions analogous to slavery.[223] Owing to a lack of rural jobs for unskilled workers, many of the freed workers will typically later return to the industry. Unhealthy working conditions and even deaths from overwork during sugar cane cutting have also been reported.[224] Sugar cane cutting is extremely demanding. In endeavouring to meet the higher productivity levels set by mechanised sugar cane cutting and to earn as much money as possible (the amount earned depends on the amount cut), sugar cane cutters are estimated to strike a machete up to 12,000 times a day.[225] Field research has revealed that the use of anti-

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217 United Nations Environment Programme (2009) *Towards sustainable production and use of resources: asessing biofuels*, available at: http://www.unep.fr/scp/rpanel/pdf/assessing_biofuels_full_report.pdf, p63.
218 Ministério da Agricultura, Pecuária e Abastecimento (2009) *Zonamento Agroecologico de Cana-de-Acucar*, English version available at: http://www.unica.com.br/downloads/sugarcane-agroecological-zoning.pdf.
219 Ibid.
220 Martinelli LA and Filoso S (2008) Expansion of sugarcane ethanol production in Brazil: environmental and social challenges *Ecological Applications* **18**: 885–98.
221 Reuters (5 Sep 2008) *Brazil SP cane growers to ban burning by 2017*, available at: http://in.reuters.com/article/environmentNews/idINN0439664020080904.
222 Martinelli LA and Filoso S (2008) Expansion of sugarcane ethanol production in Brazil: environmental and social challenges. *Ecological Applications* **18**: 885–98.
223 Amnesty International (2008) *Brazil – Amnesty International report 2008*, available at: https://www.amnesty.org/en/region/brazil/report-2008#.
224 Martinelli LA and Filoso S (2008) Expansion of sugarcane ethanol production in Brazil: environmental and social challenges. *Ecological Applications* **18**: 885–98; Sawyer D (2008) Climate change, biofuels and eco-social impacts in the Brazilian Amazon and Cerrado *Philosophical Transactions of the Royal Society B* **363**: 1747–52; Smeets E, Junginger M, Faaij A *et al.* (2008) The sustainability of Brazilian ethanol: An assessment of the possibilities of certified production *Biomass and Bioenergy* **32**: 781–813.
225 Dr Ben Richardson, responding to the Working Party's consultation; Sawyer D (2008) Climate change, biofuels and eco-social impacts in the Brazilian Amazon and Cerrado *Philosophical Transactions of the Royal Society B* **363**: 1747–52.

inflammatory drugs and painkillers is prevalent among cane cutters.[226] In addition, it was reported that an investigation by the Brazilian Ministry of Labour into the death of a cane cutter found that he had worked a shift lasting 70 uninterrupted days.[227] There is also informal child labour and the number of child workers has been estimated at 3 per cent of the total employed in sugar cane ethanol production.[228] Enforcement of labour laws in Brazil is weak.[229]

2.30 With regard to wages, average wages in the São Paulo region, where production is mainly centred, are now higher than the Brazilian minimum wage, but may still not be sufficient to avoid poverty. Wages in other regions vary and may be even lower than the minimum wage.[230] Difficulties also exist in the method of payment. In sugar cane plantations a system of payment on production exists, in which – in contrast to other analogous forms – the workers do not know beforehand exactly how much they produce. The amount is only known after the work is done and following a measuring process that is kept secret from them. Such practice encourages overworking.[231] Cutters may also have to pay excessive fees for food, housing or return transport when they move to a sugar cane estate.[232] While the early bioethanol industry increased employment opportunities, employment numbers have since fallen owing to increasing mechanisation of harvesting.[233] According to the sugar cane processing union UNICA, around 34,000 net jobs are expected to be lost in São Paulo alone by 2020 (i.e. 114,000 jobs lost and 80,000 new jobs gained).[234] This general trend of job losses is expected to continue, although it is thought that manual cane cutting is unlikely to disappear in the short term (for example, it is expected that it will continue on hillier areas and as the low-risk option for harvest expansion).[235] Displacement of agricultural populations and the use of seasonal labour lead to physical and cultural disruption of multifunction family farms and traditional communities.[236]

2.31 On the other hand, the ethanol production sector maintains social and educational services such as schools and day care and nursery centres. More than 80 per cent of production facilities provide some health and pharmaceutical care, transportation, collective life insurance and meals.[237]

2.32 The Brazilian government has endeavoured to address the issue; it publishes a 'dirty list' of firms that have been cited for the use of slave labour.[238] Addition to this list means that companies lose access to official means of obtaining credit, for example as provided by Brazil's National Development Bank. However, difficulties remain with this approach in that it can take

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[226] Dr Ben Richardson, responding to the Working Party's consultation; Alves F (2008) Work processes and damage to the health of sugar cane cutters *InterfacEHS – A Journal on Integrated Management of Occupational Health and the Environment* **3**: 1–22.

[227] Ethical-Sugar (19 Jun 2007) *IUF – Tuesday 19 June 2007*, available at: http://www.sucre-ethique.org/Brazil-Cane-Cutters-Strike-in-Sao.html.

[228] Smeets E, Junginger M, Faaij A *et al.* (2008) The sustainability of Brazilian ethanol: an assessment of the possibilities of certified production *Biomass and Bioenergy* **32**: 781–813.

[229] Ibid.

[230] Ibid.

[231] Alves F (2008) Work processes and damage to the health of sugar cane cutters *INTERFACEHS – A Journal on Integrated Management of Occupational Health and the Environment* **3**: 1–22; Martinelli LA and Filoso S (2008) Expansion of sugarcane ethanol production in Brazil: environmental and social challenges *Ecological Applications* **18**: 885–98.

[232] Dr Ben Richardson, responding to the Working Party's consultation.

[233] Smeets E, Junginger M, Faaij A *et al.* (2008) The sustainability of Brazilian ethanol: an assessment of the possibilities of certified production *Biomass and Bioenergy* **32**: 781–813.

[234] UNICA (2008) *What will be the social consequences of mechanizing the sugarcane harvest?*, available at: http://english.unica.com.br/FAQ/.

[235] Richardson B (2009) *Sugar: refined power in a global regime* (Basingstoke: Palgrave Macmillan), p187.

[236] Sawyer D (2008) Climate change, biofuels and eco-social impacts in the Brazilian Amazon and Cerrado *Philosophical Transactions of the Royal Society B* **363**: 1747–52.

[237] Smeets E, Junginger M, Faaij A *et al.* (2008) The sustainability of Brazilian ethanol: an assessment of the possibilities of certified production *Biomass and Bioenergy* **32**: 781–813.

[238] Amnesty International (2008) *Brazil – Amnesty International report 2008*, available at: https://www.amnesty.org/en/region/brazil/report-2008#.

up to two years to place a company on the list, and the legality of a public list is frequently challenged, with companies being able to obtain injunctions to their addition.

Effects on food prices

2.33 Like US corn ethanol, Brazilian ethanol production was discussed as a contributor to the spike in food prices, including sugar, experienced in 2008, and was thus a focus of the 'food versus fuel debate'. However, the picture appears to be positive with regard to Brazilian sugar cane. The World Bank paper of 2008 cited above concluded that sugar cane bioethanol did not raise sugar prices significantly.[239] Furthermore, the argument has been made that sugar is in general only regarded as a necessity by those with higher incomes, who are more able to cope with rising food costs.[240] It has also been suggested that the indirect impact of sugar cane bioethanol production on staple foods could be minimal. For example, the projected increase in land area planted with sugar cane by 2020 has been described as having potentially little or no impact on areas used to produce food or areas occupied by natural forest.[241] In addition, a study into the dLUC and iLUC effects of sugar cane production found that between 2002–2006 and in states where sugar cane production increased, the area dedicated to other crops also increased (with the exception of São Paulo).[242] A study by the Brazilian research unit, Fundação Getulio Vargas, on the effects of biofuels on grain prices found that the major reason for the rise in food prices was speculation on futures markets, stimulated by increased demand coupled with low grain stocks due to bad weather conditions and poor harvests. It concluded that there was no significant correlation between Brazilian sugar cane cultivation and average grain prices.[243]

Case study III: Biodiesel from palm oil in Malaysia

Background

2.34 Malaysia is the second largest producer of palm oil in the world. In 2009, it produced approximately 17.6 million tonnes of crude palm oil.[244] The main reasons for biofuels production were both economic and agricultural development, and energy security. To these ends, Malaysia has undertaken research and development on biodiesel derived from palm oil since 1982. The government research agency, the Malaysia Palm Oil Board, is continually improving biodiesel production technologies. The existing research and development capacity, a plentiful supply of palm oil feedstock, the eagerness of the palm oil industry to begin biodiesel production, and foreign investor interest have all supported the Malaysian Government's intention to develop biodiesel,[245] and export is becoming increasingly attractive to domestic palm oil companies.[246]

Legislation and policy

2.35 The Malaysian Government has introduced policies and legislation to encourage both the production and use of palm oil biodiesel (see Box 2.10), and production can be assumed to be increasing. It has been reported that in 2009, Malaysia exported approximately 288 million litres

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239 Mitchell D (2008) *A note on rising food prices*, available at: http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2008/07/28/000020439_20080728103002/Rendered/PDF/WP4682.pdf, p17.
240 Richardson B (2009) *Sugar: refined power in a global regime* (Basingstoke: Palgrave Macmillan), pp181–2.
241 Matsuoka S, Ferro J and Arruda P (2009) The Brazilian experience of sugarcane ethanol industry *In Vitro Cellular & Developmental Biology* **45**: 372–81.
242 Nassar AM, Rudorff BFT, Antoniazzi LB *et al.* (2008) Prospects of the sugarcane expansion in Brazil: impacts on direct and indirect land use changes, in *Sugarcane ethanol: contributions to climate change mitigation and the environment*, Zuurbier P and van de Vooren J (Editors) (The Netherlands: Wageningen Academic Publishing), p89.
243 Fundação Getulio Vargas (2008) *Food price determining factors*, available at: http://virtualbib.fgv.br/dspace/bitstream/handle/10438/6947/326.pdf?sequence=1.
244 Malaysian Palm Oil Board (2009) *Production of crude palm oil for the month of December 2009 Jan – Dec total*, available at: http://econ.mpob.gov.my/stat/web_report1.php?val=200904.
245 Global Agricultural Information Network (2009) *Malaysia – Biofuels annual – annual report 2009*, available at: http://gain.fas.usda.gov/Recent%20GAIN%20Publications/General%20Report_Kuala%20Lumpur_Malaysia_6-12-2009.pdf.
246 Ibid.

of biodiesel. In 2009, 21 biofuel companies were in operation, with several additional plants under construction.[247] However, currently domestic take-up is poor.[248]

Box 2.10: Biofuels policy in Malaysia

In March 2006, the National Biofuel Policy was implemented[249] "to ensure healthy development of the biofuel industry",[250] particularly biodiesel from palm oil. This is in line with Malaysia's Five-Fuel Diversification Policy, a national policy to promote renewable energy as the fifth fuel alongside fossil fuels (oil, gas and coal) and hydropower. The policy has two goals: i) "Use of environmentally friendly, sustainable and viable sources of energy to reduce the dependency on depleting fossil fuels;" and ii) "Enhanced prosperity and well-being of all the stakeholders in the agriculture and commodity based industries through stable and remunerative prices."[251]

The Malaysian Biofuel Industry Act 2007[252] provides for the mandatory licensing of activities relating to biofuels; however, the introduction of a mandatory B5[253] blend has been delayed.[254]

The Malaysian Government also supports the production of biodiesel through the construction of biodiesel plants. Under the Promotion of Investments Act 1986,[255] biodiesel is listed as one of the products or activities to be eligible for consideration for the Pioneer Status or Investment Tax Allowance. Pioneer Status grants the company tax exemption on 70 per cent of the income derived from biodiesel production for 5 years.[256] Subject to meeting certain criteria, biodiesel projects may also be considered for incentives for strategic or high technology projects, or incentives for commercialisation of research and development findings from the public sector in resource-based industries.[257] Furthermore, to encourage the domestic palm oil processing industry, the Malaysian Government taxes exports of crude palm oil but does not tax processed palm oil or biodiesel. For imports, there is a five per cent duty levied on processed palm oil.[258]

Problems associated with palm oil biodiesel

2.36 Palm oil biofuels production in Malaysia has raised significant concerns, both domestically and abroad. Some of the problems are associated with palm oil production in general, including deforestation, loss of biodiversity and infringement of workers' rights. However, recently 95 per cent of the *increased* production of palm oil in Malaysia and Indonesia was attributed to the growing demand for biodiesel[259] and thus, problems prevalent in palm oil production are likely to occur in palm oil biodiesel production as well. Other problems such as impact on food security are also relevant to biodiesel production. It is worth noting that palm oil is used in many types of produce such as food and cosmetics, so that increased demand for palm oil for biodiesel production leads to an increase in price for other vegetable oils also used for these purposes.

[247] Biodiesel Magazine (1 Sep 2010) *Global biodiesel production and market report*, available at: http://www.biodieselmagazine.com/articles/4447/global-biodiesel-production-and-market-report.
[248] Global Agricultural Information Network (2010) *Malaysia – Biofuels annual – annual report 2010*, available at: http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Kuala%20Lumpur_Malaysia_7-16-2010.pdf,
[249] Ministry of Plantation Industries and Commodities Malaysia (2006) *The national biofuel policy*, available at: http://www.americanpalmoil.com/pdf/biodiesel/Malaysia%20Biofuel%20Policy.pdf.
[250] Ibid., p3.
[251] The policy has five strategic thrusts: (i) *Transport*: B5 diesel will be made available for transport throughout the country; (ii) *Industry*: B5 diesel will be supplied to the industrial sector; (iii) *Technology*: R&D and commercialisation of biofuels technologies will be effected and adequately funded by both the government and private sectors; (iv) *Export*: The establishment of facilities for producing biofuels for export will be encouraged; (v) *Environment*: Increased use of biofuels will enhance the quality of the environment. To these ends, the policy outlines short, medium and long term goals. http://www.americanpalmoil.com/pdf/biodiesel/Malaysia%20Biofuel%20Policy.pdf, p4, pp6-7, p9.
[252] Act 666 Malaysian Biofuel Industry Act 2007.
[253] 5 percent processed palm oil and 95 percent petroleum diesel.
[254] Global Agricultural Information Network (2010) *Malaysia – Biofuels annual – annual report 2010*, available at: http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Kuala%20Lumpur_Malaysia_7-16-2010.pdf.
[255] Promotion of Investments Act 1986.
[256] Ministry of Finance Malaysia (2008) *Pioneer status*, available at: http://www.treasury.gov.my/index.php?option=com_content&view=article&id=704&Itemid=201&lang=en.
[257] Ibid.
[258] Global Agricultural Information Network (2010) *Malaysia – Biofuels annual – annual report 2010*, available at: http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Kuala%20Lumpur_Malaysia_7-16-2010.pdf.
[259] United Nations Environment Programme (2009) *Towards sustainable production and use of resources: asessing biofuels*, available at: http://www.unep.fr/scp/rpanel/pdf/assessing_biofuels_full_report.pdf, p64.

This price increase could drive further expansion of production (for example, palm oil in South-East Asia or soybean in Brazil), thus potentially increasing the scale of negative effects.

2.37 *Conversion of forestland and associated loss of biodiversity*: Concern has arisen over the effect of oil palm expansion on Malaysian forestland and its biodiversity. A study in 2008 argued that the conversion of primary forests and some secondary (logged) forests to oil palm plantations may significantly reduce biodiversity, for example by decreasing the species richness of forest birds and butterflies.[260] The same study also found that during the period 1990–2005, between 55 and 59 per cent of the oil palm expansion in Malaysia involved the conversion of forests, most likely secondary or plantation forests. The authors thus concluded that the conversion of secondary forests (or primary forests) to oil palm plantations has detrimental impacts on South-East Asia's biodiversity. The potential impacts of lost forestland and biodiversity in this region are particularly significant given that South-East Asia contains a significant proportion of the world's remaining tropical forests which are home to many rare species.[261]

2.38 There are worries that deforestation in Malaysia, driven by oil palm plantation expansion, could lead to the extinction of rare species such as the orang-utan of Borneo (the island split between Malaysia, Indonesia and Brunei) through loss of habitat. It has been assumed that, concurrent with an annual forest loss of 1.7 per cent in Borneo, there was a loss of orang-utan habitat at an annual rate of approximately 1.7 per cent during 2002–2008.[262] Furthermore, the threat of 'population fragmentation' has emerged.[263] In Borneo, large swathes of jungle have been replaced with oil palm plantations and this has been cited as leading to the orang-utan population fragmentation,[264] giving rise to the risk of inbreeding or orang-utans becoming lost in the oil palm plantations. If orang-utans damage the oil palm fruits, they are also at risk of being hunted and killed by plantation managers.

2.39 *Deforestation, peatland conversion and GHG emissions:* As part of the debate surrounding LCA and GHG emissions from dLUC and iLUC as discussed above, in 2008 a study estimated the extent of 'carbon debts' (the amount of carbon dioxide gas released during the first 50 years of land conversion) and how long it would take to repay these for: i) Indonesian/Malaysian lowland tropical rainforest converted for palm oil biodiesel production; and ii) Indonesian/Malaysian peatland tropical rainforest converted to palm oil biodiesel production.[265] The conversion of lowland tropical rainforest would create a carbon debt that took approximately 86 years to repay. Until this point, the production and use of palm oil biodiesel would actually generate greater GHG emissions than the refining and use of an energy-equivalent amount of petroleum diesel. Owing to the carbon debt from vegetation and peat decomposition, the carbon debt for conversion of peatland tropical rainforest would take approximately 423 years to repay. The authors warned: "Our analyses suggest that biofuels, if produced on converted land, could, for long periods of time, be much greater net emitters of [GHGs] than the fossil fuels that they typically displace." In Malaysia and Indonesia, there is also the wider problem of illegal logging, which at current levels poses significant threats to the environment and local communities.

2.40 *Land rights issues:* There have been accusations of so-called 'land grabs' by palm oil producers leading to the clearing of land and the displacement of indigenous tribes. An investigation into palm oil production in Sarawak, the Malaysian state in Borneo, was carried out in 2009[266] and a

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260 Koh LP and Wilcove DS (2008) Is oil palm agriculture really destroying tropical biodiversity? *Conservation Letters* **1**: 60–4.
261 Indeed, a 'biodiversity hotspot' – that is an area containing high concentrations of endemic species and undergoing severe levels of habitat loss – covers almost all of Malaysia: Conservation International (2007) *Biodiversity hotspots: Sundaland*, available at: http://www.biodiversityhotspots.org/xp/hotspots/sundaland/Pages/default.aspx.
262 Wich SA, Meijaard E, Marshall AJ *et al.* (2008) Distribution and conservation status of the orang-utan (*Pongo* spp.) on Borneo and Sumatra: how many remain? *Oryx* **42**: 329–39.
263 This is when a species population becomes fragmented geographically due to the breaking up of its habitat.
264 The Independent (24 Oct 2009) *Orangutans struggle to survive as palm oil booms*, http://www.independent.co.uk/environment/orangutans-struggle-to-survive-as-palm-oil-booms-1808700.html.
265 Fargione J, Hill J, Tilman D, Polasky S and Hawthorne P (2008) Land clearing and the biofuel carbon debt *Science* **319**: 1235–7.
266 Stickler A (8 Dec 2009) *The end of the jungle?*, available at: http://news.bbc.co.uk/today/hi/today/newsid_8400000/8400852.stm.

member of an indigenous tribe reported: "They just simply come and bulldoze our farm and our coco trees…They never come to us, to talk to us about this. We tried to negotiate with them but what they say to us [is] they have more right than us here." Concerns over the palm oil producer's impact on the local water supply through use of fertiliser, pesticides and herbicides were also voiced. Tribes that have been affected have mounted a legal challenge to regain the rights to their land. However, the Cabinet Minister for Land Development in Sarawak asserted that the land "belongs to the government" but that "if it is indeed their land, the law of the land will take care of that" citing cases where land has been wrongly taken by the Government and returned to those who have the land rights. The palm oil producer IOI[267] has denied the accusations, asserting that it has "never evicted nor forced any natives from their lands. Immediately after taking over the company IOI initiated meetings with the native leaders to resolve the unsettled conflict. Some accepted ex-gratia payments and willingly handed over their land." This is a continuing problem: only recently, tribes in Sarawak reported that forestland was being cleared and felled for oil palm plantations, allegedly without their consent.[268]

2.41 Land rights conflicts lead on to concerns that subsistence economies are being disrupted. In 2008, civil society groups reported that 2.8 million hectares of predominantly forestland in Sarawak had been licensed out to logging groups[269] without taking account of communities who exercise so-called Native Customary Rights (NCRs) to the land.[270] NCRs are important to those who exercise them, since they rely on the land for food, medicines and construction materials.

2.42 There have also been reports that communities in Borneo who decide to become part of the oil palm expansion are being locked into considerable debts to the oil palm companies that come into the area.[271] With few alternative economic opportunities, some are eager to participate and acquire small plots of land. Money is borrowed at high interest rates from the oil palm company for seeds and other agricultural supplies. However, the plots of land take seven years to produce fruit, and during this time further agricultural resources are required, which are purchased from the company. When the land becomes productive, the level of income is low so these small holders, with the large start-up costs, can end up perpetually indebted.

Biofuel policy changes following controversies

> **"…we are disappointed to note that the European Commission recently ruled out imposing binding EU-wide sustainability criteria for biomass, offering member states recommendations for national action instead."[272]**

> **"The EU regulation (RED) is a good first step but without imposing any requirement for social aspects, it remains incomplete. Similarly, the policies developed in the United States lack a lot of requirements re the environment and people."[273]**

2.43 These controversies surrounding biofuels production have in some cases influenced recent biofuels policy making. The Brazilian case shows that some issues, such as land destruction and water pollution, can be tackled by policy initiatives, and Brazilian land zoning today includes rather strict criteria for protection of these resources. Europe also took note of the debates surrounding food security and LCA and an initial – some say rushed – introduction of legislation

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267 IOI Group is a large palm oil producer from Malaysia. IOI Group (2011) *About us*, available at: http://www.ioigroup.com/corporateinfo/corp_aboutus.cfm.

268 WiredGov (9 Dec 2010) *Double 'green energy' threat to Borneo tribes' rainforest*, available at: http://www.wired-gov.net/wg/wg-news-1.nsf/lfi/DNWA-8BYBQG.

269 Friends of the Earth International (2008) *Malaysian palm oil – Green gold or green wash?*, available at: http://www.foei.org/en/resources/publications/agrofuels/2008/malaysian-palm-oil-report, p5

270 World Rainforest Movement (Sept 2008) *Malaysia: Those who lose in the oil palm business*, available at: http://www.wrm.org.uy/bulletin/134/viewpoint.html#-%20Malaysia:%20Those%20who%20lose%20in%20the%20oil%20palm%20business.

271 Mongabay News (2009) *The social impact of oil palm in Borneo*, available at: http://www.mongabay.com/borneo/borneo_oil_palm.html.

272 The Society of Biology, responding to the Working Party's consultation.

273 Anonymous respondent, responding to the Working Party's consultation.

to encourage biofuels within the energy mix was followed by a reassessment, prompted by these multiple concerns about unintended consequences.

2.44 In the UK, the 2008 *Gallagher Review*,[274] commissioned by the UK Government, highlighted the uncertainties surrounding the environmental and social impacts of biofuels production (including dLUC and iLUC, and food security), and urged the Government to proceed with caution. The Renewable Transport Fuel Obligations (Amendment) Order 2009 (RTFO (Amendment) Order 2009)[275] subsequently came into force. This slowed the rate at which target levels – set out by the RTFO – increased, with the date for achieving the target of five per cent replacement of road vehicle fossil fuel moving from 2010 to 2013.

2.45 European policy making was similarly affected by concerns over environmental impacts, food security, human rights violations and, in particular, the debates over LCA. The Renewable Energy Directive (RED)[276] was adopted in recognition of these concerns, repealing the 2003 Biofuels Directive.[277] It set a mandatory target for each Member State (10 per cent of final energy consumption in transport by 2020) but set out some mandatory sustainability criteria. These included achieving GHG emissions savings[278] and not making use of raw materials that originated from land of high biodiversity value.[279] Furthermore, raw materials should not originate from either land with a high carbon stock[280] or land that was once peatland.[281] The European Commission (EC) is still working on a proposal for inclusion of iLUC into LCA of overall GHG emissions.[282] The RED also placed a requirement on the EC to report every two years on the sustainability in Member States and third countries[283] of increased biofuels demand, as well as on the impact of European policy on the availability of food (particularly in developing countries) and wider development issues including land and labour rights.[284]

2.46 US legislation has undergone a similar process. The RFS program, as required by EISA of 2007,[285] stated that biofuels must account for at least 36 billion gallons (approximately 136 billion litres) of annual US fuel supply by 2022, with 21 billion gallons from lignocellulosic biofuels[286] (the annual consumption of motor gasoline (petrol) in the US in 2007 was approximately 625 billion litres[287]). These numbers represent a nine-fold increase from the amount of biofuels produced in 2006. Following the debate around iLUC, the RFS program was reconsidered, and the EPA recently stated that "significant" effects of iLUC should be part of the LCA of biofuels.[288]

274 Renewable Fuels Agency (2008) *The Gallagher review of the indirect effects of biofuels production*, available at: http://www.renewablefuelsagency.gov.uk/sites/renewablefuelsagency.gov.uk/files/_documents/Report_of_the_Gallagher_review.pdf.

275 Office of Public Sector Information (2009) The Renewable Transport Fuel Obligations (Amendment) Order 2009, available at: http://www.opsi.gov.uk/si/si2009/uksi_20090843_en_1.

276 Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC [2009] OJ L140/16.

277 Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport [2003] OJ L123/42.

278 Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC [2009] OJ L140/16, art 17.2.

279 Ibid., art 17.3.

280 Ibid., art 17.4.

281 Ibid., art 17.5.

282 Recently, a report has been published, discussing some future policy options, see: European Commission (2010): *Report from the Commission on indirect land-use change related to biofuels and bioliquids*, available at: http://ec.europa.eu/energy/renewables/biofuels/doc/land-use-change/com_2010_811_report_en.pdf

283 That is countries which are neither Member States nor Associated States (a country that contributes financially to the Community's research programme, and in return receives funding similarly as Member States).

284 Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC [2009] OJ L140/16, art 17.7.

285 Energy Independence and Security Act of 2007.

286 Currently, the lignocellulosic mandate is not enforced.

287 US Energy Information Administration (2010*) International energy statistics*, available at: http://tonto.eia.doe.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=62&aid=2&cid=regions&syid=2005&eyid=2009&unit=TBPD.

288 For example, see: US Environmental Protection Agency (2010) *EPA finalizes regulations for the national Renewable Fuel Standard program for 2010 and beyond*, available at: http://www.epa.gov/oms/renewablefuels/420f10007.pdf, p5.

2.47 The landscape of biofuels policy is not static, however, and these policy changes by no means represent the conclusion of the debate.[289] More evidence is required before the effectiveness of the policy changes can be adequately assessed. In addition, there continues to be political scrutiny of the effectiveness of policy, as illustrated by responses to the Working Party's public consultation.

Current biofuels: the promise and the problems

2.48 When they were first discussed following growing awareness of climate change and dwindling oil supplies, biofuels appeared to promise a great deal. Indeed, the expectation was that they would solve some of the greatest challenges of today's world. In particular, it was thought that they would provide a source of fuel that is renewable and carbon neutral and which would provide a source of revenue for farmers. In the imagination of some, they were thus going to provide significant revenue from a 'clean' technology, as well as endless sources of fuel without emitting the GHGs co-responsible for climate change. If not a magic solution, they were certainly regarded by some as a 'green' answer to many problems. Even the former US President, George W. Bush, not known to be a strong champion of green issues, was entranced by the expected possibilities of biofuels and promised his fellow Americans that: "the best way and the fastest way to replace oil is to expand the use of ethanol. Ethanol is good for our rural communities. It's good for economic development for rural America. You know, new bio-refinery construction creates jobs and local tax revenues…Ethanol is good for the environment. I keep emphasizing that we can be good stewards of our environment and at the same time continue with our economic expansion."[290]

2.49 Our case studies also show vividly that there were powerful incentives for each of the governments to support the introduction of the particular biofuel in their country. The promises regarding energy security, climate change mitigation and economic development offered by the biofuels were seen to justify policy instruments, standards and subsidies that supported commercial biofuels production, and there is little doubt that, in all three cases, biofuels can be seen as an example of policy-driven economic development.

2.50 However, experience has shown that the promise is less certain than was once thought, and biofuels involve significant problems. As demonstrated in the case studies, claims about carbon neutrality are contested, and this continues to pose challenges to developers and producers. There are also concerns over food security and food prices. The scale of these is, however, debatable. Biofuels appear to be one contributing factor to changing food commodity prices, affecting vulnerable countries and populations. As shown above, there are several other factors which also play important roles in destabilising food prices. Blaming food price spikes on biofuels production alone – a frequent argument in our public consultation – would appear to be one-sided. That said, there is clearly a potential for more serious effects as biofuels production increases. Moreover, the rights of farmers, farm workers and land holders, particularly for vulnerable populations, have already been threatened or violated: this is likely to continue. There have also been severe environmental consequences, including pollution and the destruction of biodiversity through, for example, the destruction of rainforest, following large-scale implementation of biofuels production. Conversion of existing agricultural land to biofuels has led in some cases to iLUC, involving deforestation and depletion of scarce water resources, and air pollution has been a problem in some cases.

2.51 These problematic effects have had major political and social repercussions, with protests against biofuels sometimes involving violence in the streets (e.g. the tortilla riots mentioned above). For some commentators and activists, the backlash against the use of biofuels has

[289] Ninni A (2010) Policies to support biofuels in Europe: The changing landscape of instruments *AgBioForum* **13**: 131–41.
[290] The Washington Post (25 Apr 2006) *Bush delivers speech on renewable fuel sources*, available at: http://www.washingtonpost.com/wp-dyn/content/article/2006/04/25/AR2006042500762.html.

been severe. The technology heralded as a potential all-round solution to many problems has been accused of harms ranging from extinguishing the orang-utan to pushing the poorest even further into poverty, thus "driving a global human tragedy".[291] While some of this criticism is as one-sided as the enthusiastic approval of the early days, there have no doubt been many harmful effects.

2.52 In view of this recent history of biofuels production, there is an urgent need to look at the issues openly, in the light of new technical developments, and with a clear statement of principles governing any future implementation and expansion. In Chapter 3, we discuss new biofuels, involving improved technologies for production, processing and distribution, which are being developed with a view to mitigating the problems associated with current biofuels. We then go on to propose an ethical framework to guide improved decision-making processes at government, industry and societal level, both for the development of new biofuels and for continuing production and use of current biofuels without harming people or the environment.

[291] Cited in The Guardian (15 Feb 2010) *EU Biofuels significantly harming food production in developing countries*, available at: http://www.guardian.co.uk/environment/2010/feb/15/biofuels-food-production-developing-countries.