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GROWING PAINS: THE POSSIBILITIES AND PROBLEMS OF BIOFUELS

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Front cover photo: palm oil – a key source of biodiesel – in production at a Colombian palm-oil processing factory

The term 'biofuels' can describe a wide variety of energy sources derived from organic material, but the production of bioethanol and biodiesel from agricultural products has dominated. Such fuels – and the crops grown to make them – vary dramatically in their carbon savings. However, ethanol from maize (referred to as 'corn' in the US) and sugar cane, and biodiesel from soya, rapeseed and palm oil, dominate – largely because of significant public incentives. For example, the US spent between US$5.8 and US$7 billion in 2006 in support of maize-based ethanol production and use, increasing to between US$9.2 and US$11 billion in 2008.

One new crop of particular interest to African governments is *Jatropha curcas*, or jatropha – a hardy plant that can grow on marginal lands (poor quality land that is difficult to cultivate) and produces oil that is easily converted into biodiesel.

Cutting carbon

The carbon savings of biofuels need to be analysed over their entire life cycle. Results from such analyses indicate that current biofuels can vary from saving around 80 per cent of the carbon emitted by fossil fuels to emitting 30 per cent more. Two major sources of uncertainty for such analysis have been identified. First, the emissions associated with nitrogen fertiliser may have been dramatically underestimated. Second, the emissions associated with land-use change – both direct and indirect – have been effectively ignored. Including either source of uncertainty wipes out the carbon savings of many crops. In a worst-case example, the carbon debt from clearing Indonesian peatland to produce biodiesel from palm oil would take 420 years to pay back.

In addition, it should be noted that biofuels are not the cheapest or most effective way of cutting the carbon emissions of transport. Governments have a number of other options for cutting transport emissions, and investment in public transport and efforts to manage demand should be more of a focus. Technical and policy constraints also limit the use of biofuels in road transport. However, transport is the fastest growing source of man-made carbon dioxide emissions, and now accounts for 20 per cent of the global share of such emissions. Action in this area will not be simple or easy.

Fuelling poverty

Industrial-scale biofuel production has been linked to human rights abuses, and has been one cause of the recent spike in food prices. Like other monoculture plantations, biofuel production threatens biodiversity. Christian Aid partners and research have documented links between biofuels and environmental impacts, such as deforestation, as well as human rights abuses and food shortages.

Observed impacts include:

- environmental damage, including widespread deforestation and pollution of local water sources
- forced displacement of small farmers from their land in countries such as Colombia
- poor labour rights – for example on sugar plantations in Brazil
- food price increases, particularly in Central America.

In each case it should be noted that biofuels production is not necessarily the sole or even main factor. But biofuels production is significantly worsening these problems.

In Africa, the problems associated with biofuels are not yet as apparent; however, if major jatropha plantations delivering significant yields are to be established, the signs are that the story will be repeated.

New opportunities

As well as examining the problems caused by expanded biofuels use, Christian Aid also looked at potential benefits for poor people. Obviously one key benefit is the prospect of preventing catastrophic climate change, but the proponents of biofuels also claim they can offer new livelihoods and an answer to energy poverty.

Globally, some 2.4 billion people do not have secure supplies of fuel for cooking and heating. This lack of energy is a hallmark of the world's poverty crisis. Examples such as the Mali Folkecenter (MFC) 'jatropha system' offer one way to tackle this. This combination of support for small-scale farming, local food production, and decentralised energy is unique and offers a good example of how to approach biofuels.

Other governments have sought to use biofuels to insulate their economies from fluctuating oil prices. This has been the key aim of Brazil's strategy, and has been adopted by Honduras, Bolivia and Senegal, among others.

There have also been claims that biofuels production will create jobs, although most significant examples of biofuels production are monoculture plantations that do not create many jobs in relation to the amount of land used. However, evidence shows small-scale biofuels production can offer better benefits.

There are examples from Brazil, Colombia, Mali, Senegal, Tanzania and Burkina Faso, all showing how cooperatives or outgrower contracts (individual farmers growing crops under contract to a company) can allow small farmers to work together to deliver biofuels production. The best benefits occur when local needs and control are prioritised.

Land use

Land is finite. In 2004, author and environmental campaigner George Monbiot calculated that replacing 20 per cent of the UK's transport fuel demand with domestically grown biofuels would require almost all viable UK cropland. He concluded: 'If the production of biofuels is big enough to affect climate change, it will be big enough to cause global starvation.'

Examining scenarios of increased land demand and availability indicate that biofuels demand is likely to present a significant, but not impossible, stress on land use. Biofuels production to replace ten per cent of global transport fuels would require seven per cent of the world's arable land. Given growing pressures on land due to climate change, population growth and changing consumption patterns, biofuels use on such a scale is a cause for concern.

Jatropha has been suggested as a route out of this problem because it can be grown on marginal land with minimal water. However, the evidence from Africa is that to grow jatropha with the yields needed for commercial viability requires good land and significant irrigation or rainfall. In addition, land that might be regarded as 'marginal' will often be of value to rural communities, particularly pastoralists.

The power imbalances that come into play around land issues mean that poor people's rights are intrinsically under threat by increased demand for land. A number of companies and governments are buying up significant swathes of land in what has been described as a new 'scramble for Africa'. Similarly, concentration of land ownership is at the heart of much of the problems in Latin American countries such as Colombia and Brazil. If poor people's rights and needs are to be respected, biofuels will almost certainly never be able to provide ten per cent of global transport fuel demand.

Conclusions

Arguments around biofuels often seek to identify 'good' or 'bad' biofuels but, while some are self-evidently more useful than others, the solution cannot be presented so simply. The problem is not with the crop or the fuel – it is with the policy framework around biofuel production and use.

So far, it is evident that most of these policies have been mistaken – leading to biofuels that increase carbon emissions, drive up food prices, encourage the displacement of farmers, provoke conflict and labour abuses and damage the environment, all at great financial cost.

Christian Aid believes that biofuels production needs a new vision, one that does not focus on supplying significant quantities of transport fuels for industrial markets. Instead, production should be geared towards energy self-sufficiency, rural development and a shift towards decentralised, clean energy for the energy-poor in developing countries.

INTRODUCTION

Biofuels have gone from being seen as a potential saviour of the environment to a bogeyman that threatens to starve the poor to keep the cars of the rich running.

Many industrialised-country governments see them as indispensable – the only realistic option for a liquid fuel to displace the use of oil. Some developing country governments see a major opportunity for export or a path to their own increased energy security. Business has moved in to exploit an investment opportunity and a growth market. Transport companies reach for biofuels as a way of delivering on green promises while maintaining some semblance of 'business as usual'.[1]

Environmentalists, development activists, indigenous peoples' groups and other stakeholders, are, however, greatly alarmed that the dramatic dash for biofuel production is leading to numerous problems: deforestation and the consequent emission of carbon stored in forests, the spread of monoculture plantations, rising food prices, the displacement of family farmers from their land and heightened pressure from governments that further marginalises vulnerable communities. They question whether – given uncertain benefits and significant costs – biofuels have any role to play in the energy revolution the world must undergo.

The debate is in flux. Action by governments – particularly the US and in the EU – has leapt ahead of analysis of the contribution biofuels should make. The backlash against biofuels seriously questions their credibility as a potential solution.

Make no mistake – the world faces a climate emergency of epic proportions. It would be simpler and safer in the short term to declare biofuels nothing more than a short-lived distraction from action to tackle this crisis. But the scale of response required is such that the option of choosing between routes out of the crisis may now be a luxury we cannot afford. An emergency situation demands an emergency response and if biofuels can help us bring down our carbon emissions safely and sustainably then they must be used to do so.

But along the way we must not countenance any weakening of either safety or sustainability. Christian Aid is dedicated not to preventing climate change for its own sake, but to the higher goal of poverty eradication. It is the poorest who are feeling the impacts of a changing climate even now, and who are most vulnerable to the changes that are coming. The benefits of biofuels, where these are proven, must therefore be weighed both in terms of their potential contribution to emissions reductions, and also their immediate, direct impact on poverty.

So what contribution can biofuels make to a low-carbon future? And how can that contribution be made to work best for poor people?

This report aims to answer these questions by analysing the impact of the current approach to biofuels and setting out the basics of what an approach that has poor people at its heart might look like. It will examine the types of biofuels that have come to dominate and summarise the latest scientific evidence on the carbon savings offered by such biofuels. It will then go on to cover the problems and benefits of some biofuels that Christian Aid partners and researchers from Latin America and Africa have documented. The implications of land-use issues around biofuels are examined in more detail before setting out Christian Aid's conclusions about the potential of biofuels.

POWER FROM PLANTS – WHAT ARE BIOFUELS?

The world is on the brink of an energy revolution – hunting for new ways to keep civilisation turning that do not push us into a climate change catastrophe. In response, one of the 'renewable' technologies that has seen the quickest and widest adoption is that of biofuels. 'Biofuels' as a term can refer to a broad range of energy derived from organic material or biomass, but in practice bioethanol and biodiesel from cultivated plants have come to dominate. The biofuels that are currently most widely used are produced from conventional food crops – most commonly maize, sugar cane, sugar beet, soya, wheat, palm oil and oilseed rape.

The relative economics of biofuels means that global production currently sinks or swims on the basis of public subsidy – justified because of the potential contribution of biofuels to the public good, including assisting in the struggle against climate change.

Biofuels offer an apparently low-carbon energy resource that can be immediately substituted – to an extent – for standard liquid fossil fuels. This is particularly useful for road transport, where other renewable technologies would require a reworking of basic infrastructure before they could be used.

Bio-energy

In many ways biofuels draw on the oldest form of energy available to humanity. Ever since people have burnt wood for heat and light they have been unlocking the energy potential of biomass. And of course people still obtain energy in this way. Many of the communities with which Christian Aid works rely on it – burning wood or coal to provide heat for cooking and warmth. This use is unlikely to decrease significantly in the short term, and Christian Aid gives some support to organisations that provide stoves to burn fuel in ways that cut carbon emissions, minimise fuel use and reduce smoke pollution, which can damage people's health.[2] Boilers and advanced stoves can also offer prospects for significant commercial heat generation that can be used in a variety of ways.

Biomass digesters, producing biogas on a village level, have become reasonably common in countries such as China and India, where they transform waste into locally derived energy. Biogas can be used for transport in specially designed vehicles as well.

Biomass also offers some interesting prospects for power generation at a large scale. It can be converted into a mixture of carbon monoxide and hydrogen and burnt, although this technology has yet to be proved commercially, and it can be burnt together with a fossil fuel. Such prospects may open the door to an increasingly decentralised, off-grid energy supply. What is more, the heat generated by producing power in this way can also be put to work. Combined heat and power from biomass are both used in paper and sugar industries worldwide.

However, despite this variety of technologies offering opportunities for biofuel use at scale, bioethanol and biodiesel, while not the cheapest, most low-carbon or most effective options, have become the most significant. Many governments are interested in such fuels because of their multiple benefits: as well as apparently delivering reduced greenhouse gas (GHG) emissions and providing a source of more secure energy, they also help provide alternative markets for rural producers.

This triple package – energy security, climate change benefits and rural support – has been key to the government subsidies and targets that have fuelled their quick adoption in countries such as the US and Brazil. These forms of biofuels production have tripled between 2000 and 2007.[3] But groups representing small farmers and indigenous peoples in developing countries have pointed to significant problems caused by this dash for biofuels, while at the same time many environmentalists and scientists have questioned the claimed benefits.

The critics of biofuels have generally sought to single out the agro-industrial production of bioethanol and biodiesel in particular and separate them from positive implications of the prefix 'bio' which derives from the Greek for 'life'. They prefer the term 'agrofuels', defined by the Food and Agriculture Organisation of the UN (the FAO) as 'fuels obtained as a product of agriculture biomass and by-products…'[4] In this report we shall use the more general and common (in the UK) term 'biofuels', although the analysis is focused on production of liquid biofuels from agriculture.

Types of fuels, sources and support

Ethanol

By far the biggest and most significant biofuel currently on the world market is ethanol produced from fermenting plant sugars or starches, known as bioethanol. According to figures quoted by the UK's Renewable Fuels Agency, almost 50 billion litres of bioethanol were produced globally in 2008.[5] Most is consumed in the country of production. Ethanol can be used in small amounts mixed with petrol in modern cars, although some new vehicles have been developed that can run on almost any mix of ethanol and petrol.

The USA has set in place measures to ensure its domestic maize producers have access to a large market for maize-based ethanol. The highly industrial production methods – and the very carbon-intensive energy supply in the US – mean that US maize-based ethanol has one of the lowest carbon savings of any biofuel.

> ‘The fuel of the future is going to come from fruit like that sumach [a shrub] out by the road, or from apples, weeds, sawdust – almost anything… There’s enough alcohol in one year’s yield of an acre of potatoes to drive the machinery necessary to cultivate the fields for a hundred years.’
>
> Henry Ford, 1925

On the other hand, Brazil has set out on an ambitious programme to effectively corner the market in ethanol from sugar cane – which it produces in an efficient and low-carbon way – delivering one of the greatest carbon savings. However, Brazilian bioethanol is controversial because of the vastly inequitable land distribution in Brazil, poor labour standards on sugar plantations and damage to vital ecosystems such as the Amazon rainforest and the Brazilian Cerrado.

Brazil’s sugar-based ethanol is very competitively priced, thanks to its low production costs and the efficient development of the industry. Brazilian bioethanol can compete against oil when oil prices are between US$25 and US$30. However, US bioethanol only becomes competitive when the oil price reaches US$50 to US$60 a barrel and the EU’s sugar-beet ethanol only becomes competitive when oil prices reach US$70.[6]

China and India, respectively, are the next largest bioethanol producers after Brazil and the US but their production is significantly lower, if increasing.[7]

Biodiesel

The other major biofuel on the world market is biodiesel. About 10 billion litres were produced in 2007. Biodiesel is produced from plant oils, such as those derived from oilseed rape, soya and palm oil. The biggest global market for biodiesel is currently the EU, which has set major targets for its use and where biodiesel represents about 82 per cent of the biofuel market. Europe also accounts for about 95 per cent of global production.[8]

Between 80 and 85 per cent of EU biodiesel production comes from rapeseed oil.[9] The US produces biodiesel from soya beans, and a number of other countries are rapidly increasing production. Brazil is expected to overtake US and EU production in 2015, while Malaysia and Indonesia are leading the rapidly increasing production of biodiesel from palm oil.[10]

This diversion of Europe’s edible oil production into biodiesel is increasing demand for imported oils as a subsitute. Increases in production and export of palm oil from Malaysia and Indonesia to the EU is taking place to meet this demand.

Africa and the jatropha rush

The latest oil crop to be put forward as a biofuels feedstock is *Jatropha curcas*, or jatropha – a hardy perennial plant that can survive drought and grow in very poor quality soils. Jatropha oil is easily processed into biodiesel and the plant

‘King corn’ – The US and maize-ethanol

Undoubtedly one major factor in the rise and rise of biofuels is the US push to keep its petrol pump prices down and its maize growers in business. Ethanol production is on the rise in the US, which has recently become both the largest producer and the largest consumer of ethanol in the world. In 2008, the US consumed roughly 9.6 billion gallons of ethanol, most of which was produced in the Midwest and some of which was imported from Brazil.[11]

The US has set a number of targets for increased biofuel consumption. The 2007 Energy Independence and Security Act (EISA) requires fuel producers to supply 36 billion gallons of biofuels by 2022. Of this, maize-based ethanol supply should hit 15 billion gallons a year in 2015, where it will be capped to allow for increased support to next generation biofuels.

The EISA requires that US maize-ethanol that has been processed in new facilities should achieve at least a 20 per cent GHG emissions reduction over its life cycle. This tiny benefit can be further reduced to a ten per cent saving by the US Environmental Protection Agency (EPA) administrator if it is determined that the requirement is ‘not feasible’.[12]

As well as targets, the US also encourages the use of biofuels with a variety of tax credits, import tariffs and subsidies,[13] along with considerable investment in research and infrastructure.

An analysis of total support for biofuels in key OECD countries estimated that the US spent between US$5.8 and US$7 billion in 2006 in support of ethanol production and use, increasing to between US$9.2 and US$11 billion in 2008.[14] This support has come under fire for encouraging the development of an industry that is completely divorced from market forces, inefficient and uncompetitive.

Maize-based ethanol’s rise, despite questionable efficiency and carbon savings, is no surprise given the power of the maize lobby and the efforts of companies such as Archer Daniels Midland (ADM) and VeraSun, which dominate ethanol production. For many commentators the electoral significance of the Midwestern maize growers is directly linked to this support.[15] Indeed, in recent US elections the candidates’ positions on ethanol subsidies has been a matter of vital interest to that region of the US. The lobby for ethanol subsidies is clearly a powerful one, and will remain so: President Barack Obama has strong links to this lobby himself.[16]

Maize-based ethanol production also raises many environmental concerns, particularly given the fact that maize cultivation in the US causes significant water contamination due to the run off of fertilisers and pesticides into streams and other surface waters.

will grow on marginal lands that would not support other crops. Because of this there are plans for major investment in jatropha in Indonesia, India, China and a number of countries in Africa.[17] Several concerns have been identified with jatropha, including the plant's toxicity, invasiveness and water demand.

Christian Aid has recently commissioned several studies about the potential for sustainable development of jatropha in Africa, and many of the key findings are documented in this report.

Jatropha is widely grown as a hedge around fields, where it protects crops from animals. It is also planted with low-growing crops such as groundnuts, or around such fields, to increase the soil's water absorption. In Senegal, Mali and Burkina Faso, jatropha hedges have been used successfully to fight deforestation and desertification, allowing farmers to reclaim land that was previously unsuitable for growing crops. Some projects have worked with women in these countries on using jatropha oil to make soap, which has increased their income considerably. After pressing the oil to make the soap, the remaining jatropha cake has been successfully used as organic fertiliser for small-scale market gardens – it has more nutrients than cow dung.

African governments, aid donors and biofuel and energy producers have been increasingly 'hyping up' the potential of jatropha to meet European targets for cleaner transport fuels and the possibilities of selling to the huge markets such targets could create. Given that the plant grows naturally in semi-arid and tropical areas, the claim is that jatropha for fuel can be grown in conditions unsuitable for other forms of agriculture, and so it will not compete with food crops in the way that maize, sugar, cassava and other biofuel crops do.

This has led to a rush of biofuel companies keen to acquire land rights to grow jatropha plantations in a number of African countries, including Tanzania, Mozambique, Ethiopia, Kenya, Burkina Faso, Senegal and Zimbabwe.

However, jatropha has yet to deliver on its promises. While companies claim high oil yields, this is not backed up by scientific evidence. Successful examples of jatropha plantations, especially on degraded soils, are very scarce. This is due in part to the fact that jatropha has not been cultivated on an industrial scale in Africa before, and scientific experiments are in the early stages. But initial research suggests that economically viable large-scale production does require irrigation and good quality soil to deliver reasonable yields.

Green intentions – the EU and biofuels

The EU climate and energy package – a combination of directives and regulations designed to provide a comprehensive EU-wide response to the challenges of energy security and climate change – includes a mandatory European Commission target that ten per cent of the energy in the transport sector should be derived from renewable sources by 2020. Even within the text of the relevant EU directive this target is taken as essentially a biofuels target.

This will replace the 2003 EU renewable fuels directive (also known as the biofuels directive),[18] which proposes that 5.75 per cent of transport fuels (calculated by energy and equivalent to about seven per cent by volume), should be replaced by a renewable fuel by 2010. Interestingly, EU fuel quality specifications allow up to only 5 per cent by volume, so this target is currently unachievable.

The EU's new target for ten per cent biofuel use by 2020 does include sustainability criteria demanding a carbon saving from each biofuel of at least 35 per cent, rising to 50 per cent by 2017, and a ban on biofuels planted on land such as protected areas, forests, wetlands and 'highly biodiverse' grasslands. The impact of indirect land-use change is not currently included.

In the UK this biofuels directive has been put into operation as the Renewable Transport Fuel Obligation (RTFO), which mandates that suppliers of fuel for transport must ensure that, by 2011, five per cent of their fuel by volume should be from a renewable source. If fuel suppliers are unable or unwilling to meet this obligation they can buy themselves out at a rate of 15p per litre of fuel. This is coupled with an actual biofuel subsidy of 20p per litre.[19] The UK government claims this will prevent annual emissions equivalent to 2.6 to 3.0 million tonnes of carbon dioxide by 2010.[20] Friends of the Earth published research early in 2009 that claimed that this policy has instead effectively increased emissions by 1.3 million tonnes of carbon dioxide.[21]

The International Institute for Sustainable Development (IISD) estimates total biofuels support in 2006 in Europe to be worth at least €3.7 billion, €2.4 billion of which is focused on biodiesel.[22]

While the EU is explicitly attempting to achieve GHG reductions with its policies, the way in which it has expanded biofuels demand has probably increased emissions. This is due both to the relatively high carbon footprint of its domestic biofuel production and the damaging effects of its increased vegetable-oil demand on Asian land use.

The next generation

New technologies offer exciting prospects for a new generation of biofuels derived from new and different feedstocks: dedicated energy crops, domestic vegetable waste, forest waste, marine algae and others. These 'cellulosic' biofuels involve the processing of the plant material itself – specifically the lignocellulose that makes up a plant's cell walls – into bioethanol or biodiesel, through a variety of processes.

These new fuels – while not yet within the scope of commercial development – do offer a variety of interesting prospects. The suggested carbon saving over their lifecycle is greater than almost all first-generation biofuels. Where plants provide a feedstock, more of the plant is used – so less land is required to provide similar amounts of fuel. Another suggested benefit is that these technologies open the door for dedicated energy crops that could be bred to deliver higher energy yields, greater carbon savings and, in general, more efficiency. Some proponents claim a role for genetic modification (GM) to maximise results.[23] A recent interesting development was the discovery of a rainforest fungus that does the job of processing lignocellulose into biodiesel all by itself.[24]

Such prospects should be explored. But lessons from the first generations of biofuels must be learnt. Non-food crops may not directly impact on food prices in the same way as food crops, but they are likely to compete with food crops for land and so lead to other indirect consequences. A marine algae feedstock may provide a source of biofuels that does not depend on land, but with what impact on the marine environment and biodiversity? Forest waste, or domestic vegetable waste, may seem to be the ultimate green option, but there are limits to the scale of such supplies and there are often other uses or benefits associated with such items.

Analysis commissioned by the European Commission indicates that such fuels will not be competitive with 'first-generation' biofuels until 2020.[25] Careful weighing-up of the potential impacts of any of these new feedstocks will be required before they can be used at scale. It will be especially important to be clear on the potential impacts of new crops if they use controversial technologies such as GM. It is sensible that research in this area should be supported as a matter of priority – particularly where such crops do not require changes in land use. However, whatever the benefits or otherwise of such new fuels, policies today need to look more closely at whether the current crop can deliver.

In conclusion…

Ethanol and biodiesel have been adopted in a major way because of policies by Brazil, the US and the EU to encourage their use. It is clear that the world of biofuels has been shaped by government interventions. The potential expansion of jatropha in Africa is also being driven by the choices of governments. The impact of such interventions needs clear analysis.

SAVING CARBON?

The most interesting claim made for biodiesel and bioethanol is their potential to cut carbon emissions dramatically, and help the world prevent climate catastrophe. This claim is increasingly challenged. As with fossil fuels, burning biofuels causes carbon emissions. Unlike fossil fuels, the increase in atmospheric carbon is, in theory, minimised as carbon dioxide is soaked up in growing more crops to produce more biofuels. As long as the demand for biofuels means that crops are maintained, then the carbon cycle should ensure that the emissions associated with biofuels are only transitionally in the atmosphere and that they are effectively carbon neutral.

But greenhouse gases (GHGs) are produced in the process of growing the crops, processing them and transporting them to where they are used. The emissions associated with mechanised farming, the use of nitrogen fertilisers and the infrastructure of the supply chain all chip away at the carbon savings.

Add to that the massive carbon emissions that result when land providing a valuable carbon sink, such as tropical rainforest, is cleared for biofuels, and it becomes obvious that biofuels can be worse for the environment than the fossil fuels they are meant to replace.

Calculating the savings

When calculating the avoided GHG emissions associated with biofuels, it is not simply a question of looking at which crops are used, but also of how and where, and with what sources of energy the crops are grown and harvested. Once a biofuel crop is grown and harvested it needs to be processed into a fuel and transported to the point of use. The full picture requires a systematic analysis of the impacts of biofuel production all the way down the production chain – such as is employed in life-cycle assessment (LCA) analysis.

Figure 1 summarises some well-established LCA results for key biofuels, as compiled by the UK Renewable Fuels Agency (RFA), and illustrates the range of possible savings available from each feedstock compared to petrol or diesel. It shows how varied the potential savings can be with a single feedstock. Ethanol from sugar cane can offer the best potential carbon savings of any ethanol feedstock, and the worst. The best is from production in Brazil: with high yields and where co-products are burnt to provide heat and power for the production process with such efficiency that some mills export electricity to the grid. The worst include examples such as some South African methods that use large amounts of electricity sourced from coal, and are responsible for more emissions than equivalent energy from oil-based fuel.[27]

However, even bearing in mind such variety, it is worth noting that ethanol from maize gives carbon savings of less than 40 per cent in its best case, and biodiesel from oilseed rape gives a less than 50 per cent saving. Given the relatively small amounts of biofuels that it is feasible to use in road vehicles at the moment, neither feedstock looks like a cost-effective choice for cutting carbon emissions on this basis alone. However, it is these (domestically produced) crops on which the EU and US have tended to focus. The paucity of the US ambition in this area is demonstrated by its target of ensuring that any use of maize-based ethanol delivers only a 20 per cent emissions saving over gasoline.

Finally – although the results are to a certain extent speculative – it is worth noting that biofuels produced from new feedstocks with new technologies, so-called 'second-

Life-cycle assessment

LCA is a key tool for evaluating the impacts associated with biofuel production. In theory this technique evaluates the complete impact over the whole life cycle of a product or service. In practical terms it usually focuses on the most prominent impacts involved – usually land use, energy requirements and GHG emissions. More qualitative impact-assessment techniques are better at examining local environmental impacts such as air pollution or impacts on biodiversity.

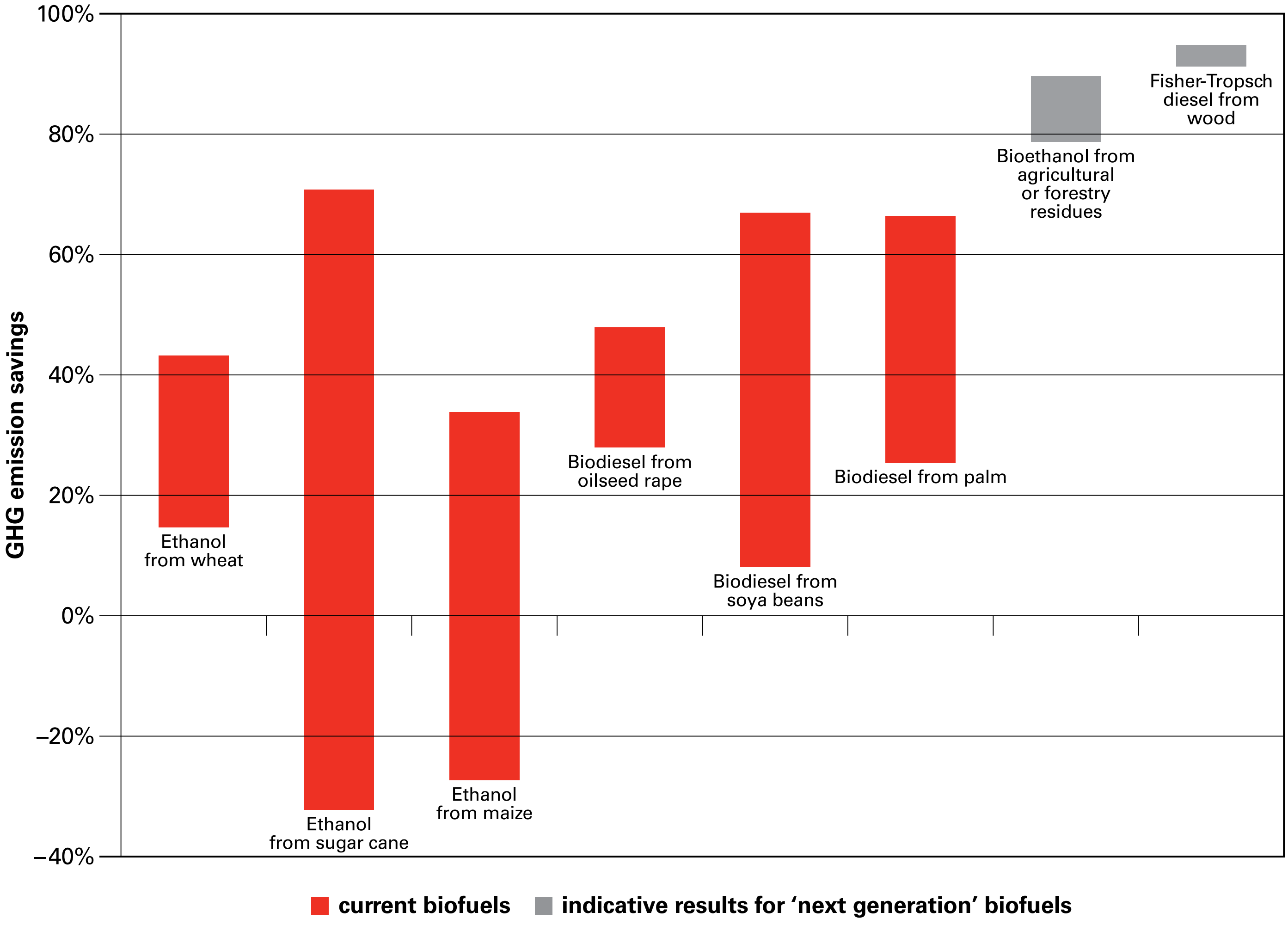
According to the Royal Society, LCA is 'a highly effective means of estimating total GHG emissions and energy resource associated with production and utilisation of biofuels'.[28] By comparing a particular biofuel's LCA with a similar 'well-to-wheels' assessment of the conventional oil-based fuel that the biofuel replaces, one can get an estimate of the saving in GHG emissions.

The Royal Society goes on to note some limitations and problems with the LCA approach. For example, the lack of hard scientific data for some sources of GHG emissions involved in biofuel production means inexact estimates must be used, and the variety of different ways of allocating GHG emissions across different products produced by a single crop can give dramatically different results. There is still a lot of variation between the results of different LCA studies of the same crop, and the Global Bioenergy Partnership[29] – launched at the Gleneagles G8 in 2005, and comprising a number of major countries, UN agencies and industry bodies – is currently working to harmonise the analysis of biofuel GHG savings.

> ‘It would obviously be insane if we had a policy to try and reduce greenhouse gas emissions through the use of biofuels that’s actually leading to an increase in the greenhouse gases from biofuels.’

Robert Watson, Scientific Advisor to DEFRA and former Chair of the Intergovernmental Panel on Climate Change[26]

Figure 1: Estimated GHG emission savings of selected biofuels compared to fossil fuels



Source: *The Gallagher Review of the Indirect Effects of Biofuels Production*, UK RFA

generation’ biofuels, do offer far greater emission savings.

Limitations of life-cycle assessment

While LCA has provided a lot of useful analysis on the carbon balance of biofuels, it is limited by the boundaries to the analysis (that is where the life cycle starts and ends) and the quality of the data used. This has given rise to some major challenges.

One issue was documented in a recent academic paper published by Paul Crutzen, a Nobel prize-winning chemist, and concerns the emissions associated with nitrogen-fertiliser use. The use of nitrogen fertiliser leads to the emission of nitrous oxide – a gas with 296 times the global warming potential of CO_2. Crutzen and his co-authors suggested that release rates for nitrous oxide were some three to five times higher than had previously been assumed – potentially increasing the LCA figures for some biofuels by a factor of six or more.

For biofuel crops that are produced with significant nitrogen fertiliser use – which includes almost all – this can wipe out any GHG-savings benefits. Many such crops would become worse than the fuels they are intended to replace.

For instance, a revised LCA for biodiesel made from EU oilseed rape predicts emissions 1-1.7 times larger than saved CO_2 emissions, while US maize bioethanol predictions are for 0.9-1.5 times its saving. Sugar-cane bioethanol, with predictions for emissions of 0.5-0.9 times its savings, still looks like it has potential.[30]

However Crutzen's paper, while clearly causing debate, has not been universally accepted. Coverage in *Chemistry World* in 2007, documents a number of scientists who disagree with Crutzen's assumptions.[31] The UK RFA commissioned an analysis of this paper as part of the *Gallagher Review* of the indirect impacts of biofuels.[32] This analysis identified a number of issues with the methodology, but did acknowledge that this area needed greater analysis and that in some cases nitrous oxide emissions had been underestimated. Worryingly, it added that it was not possible to estimate in how many cases this was true.

Without seeking to arbitrate on this scientific debate, it is clear that a greater degree of certainty in this area is needed urgently, with more research required. Whatever the case with Crutzen's research, the emissions associated with fertiliser use are considerable and Christian Aid supports less input-intensive agriculture. It is obvious that biofuels with significant carbon savings and minimal inputs are preferable, and that the data used in analysing biofuels must be as reliable as possible.

Carbon emissions from land-use change

The most significant source of GHG emissions, neglected by traditional LCA analysis, is land-use change. Land plays a vital role as a major carbon sink – absorbing a fifth of man-made emissions each year.[33] As new land is put into production, significant GHG emissions can be caused – through cutting and burning trees or grasses (or leaving them to rot) and ploughing up soil, releasing underground carbon – the extent depending on the nature of the land.

Existing LCA analyses of the carbon footprint of biofuels have assumed that the land on which the biofuel feedstock was grown was previously 'maintained set-aside' – essentially negating any significant emissions from the change in land use. However, where the land was previously a significant carbon sink, clearly major GHG emissions can arise.[34]

For example, drainage of peatland, and then burning the peat can lead to emissions of hundreds of tonnes of carbon from every hectare. Emissions from peatland in southeast Asia in this way have been estimated at about two billion tonnes of carbon a year – equivalent to eight per cent of global emissions from burning fossil fuels.[35] One of the great drivers behind the clearing of peatland in countries such as Indonesia – a country that is losing an average of two per cent of its forests a year, the fastest rate of deforestation in the world – is the push to grow palm oil, driven by demand for biodiesel.

Fargione et al[36] took the amount of emissions caused by clearing a variety of types of land and compared it with the emissions-saving offered by the biofuel crop. In one example, regarding palm oil grown in Indonesian peatland, it is stated that it will take 420 years to pay back the carbon debt incurred in clearing the land. Figure 2 summarises this analysis.

Growing biofuels on land that has significant carbon stocks is highly undesirable and absolutely unaffordable in the light of the climate crisis. Such land is precious and must be protected. Even using agricultural land that has been set aside releases enough emissions that it can halve the GHG savings of some crops.[37] Biofuels grown on rotational agricultural land, or land with low carbon content, do offer some prospect for GHG savings, but in these cases fuels that offer significant GHG savings should be preferred. So, too, should fuels from perennial plants, such as palm or sugar cane, which offer some carbon-storage prospects.

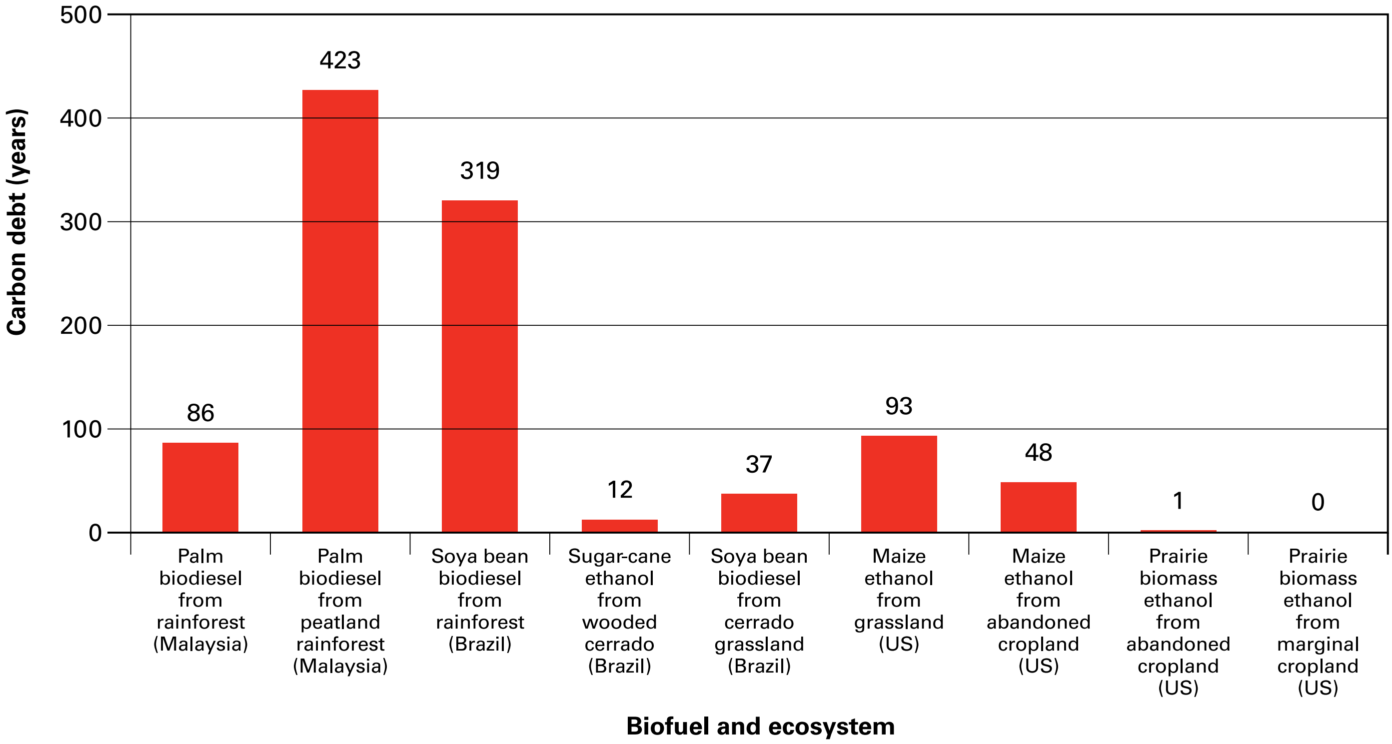
Indirect land-use change

Raising the issue of land use opens up concerns around the indirect impacts of biofuels production. Wherever a biofuels feedstock crop is grown on land that was or would otherwise have been put to an alternate use, an additional demand for land is created. Even where the change in land use to grow a new biofuel feedstock can be shown to be perfectly carbon neutral based on that particular field, miles away the impact of the change in land availability could be driving the displacement of small farmers, the loss of vital carbon sinks or increases in the cost of food.

To quantify the land-use emissions of biofuels properly it is necessary to look at not only where the biofuel crop is grown, but also what the increased demand for land is and what land-use change will result from this demand. This is plainly difficult to quantify. Two different approaches have been tried so far.

Searchinger et al used an agricultural land-use model to estimate the effect on crops and cropland of increased US use of maize-based ethanol. The results indicate that, compared with petrol, maize-based ethanol moves from a 20 per cent saving in GHG emissions in a best case to an estimated 93 per cent *increase* in emissions in a worst case. These results are applicable to other agricultural sources of ethanol.[38]

Figure 2: Years to repay the carbon debt incurred in clearing land to grow selected biofuels



Source: *Land Clearing and the Biofuel Carbon Debt*, Fargione et al

Alternatively, the Öko-Institut has looked at land-use change in terms of international trade – assuming that changes in agricultural production take place as a response to global supply and demand, and so the scale of any change depends on the amount of land used locally to produce products for export. This work estimates that, including indirect land-use change from EU rapeseed oil, biodiesel could cause a 200 per cent increase in GHG emissions compared to diesel, while US maize-based ethanol gives emissions 50 per cent higher than petrol. On the other hand, Brazilian sugar-cane ethanol still gives a 44 per cent emissions saving.[39]

Work in this area is clearly filled with uncertainty, but will have to be included in any estimate of the true GHG impacts of biofuels. The implications of significant indirect land-use impacts are such that it is not enough to ensure biofuels do not displace land with major carbon stocks – we must also ensure minimal displacement of other agricultural production by biofuels.

Overall impacts of land-use change

Land-use calculations are difficult and as yet imprecise, however the initial work clearly suggests that the impacts of increased land use undermine the carbon-saving benefits. Some crops, notably efficiently produced sugar-cane bioethanol, do demonstrate some carbon savings. Where possible, it is apparent that biofuels production should be on marginal land that does not have other uses.

On the road

It is hoped ethanol and biodiesel will contribute most in the transport sector – particularly road transport, although potentially also in aviation. Transport is the fastest growing source of man-made carbon dioxide emissions, and now accounts for 20 per cent of the global share of such emissions, and 25 per cent of UK emissions. What's more, transport, which is almost entirely dependent on oil, is the main direct driver for increased oil demand, accounting for some 60 per cent of the increase.[40]

Road transport is some 86 per cent of this figure in the UK, and road freight accounts for much of the increase in emissions. Without new decisions and actions, emissions from domestic transport are predicted to increase by 10 million tonnes of carbon by 2022.[41]

However, while some carbon savings may be available in substituting oil-based fuels with some biofuels, there are real restrictions to using more than very limited amounts of biofuels in most modern vehicles.

Using biofuels

Ethanol and biodiesel are physically and chemically very similar to petrol and diesel, but there are differences – in viscosity, vapour pressure, corrosive impact and energy content, among other issues. These differences can lead to performance problems if too much biofuel is mixed with conventional fuels. This is particularly true of ethanol.

Current EU fuels standards state that these fuels may not be blended with conventional fuels at any higher than five per cent by volume. Vehicle manufacturers rely on fuel standards to be sure of engine performance and to have the confidence to provide warranties. The EU is currently reviewing its Fuel Quality Directive to address this issue.

If higher proportions of ethanol are to be used, then manufacturers will have to develop changes in engine models – particularly because ethanol corrodes many of the components in car engines. Biodiesel should be usable, but some manufacturers have reported problems.

One option for ethanol is the use of 'flex-fuel vehicles' (FFVs), used particularly in Brazil. These vehicles can alternate between petrol and ethanol.[42] Today, almost 85 per cent of cars in Brazil are FFVs[43] and Brazil has become a world leader in designing technology for car engines.

Advancement through technology?

Car technology is developing all the time. The increased power and safety of new cars mean bigger, heavier vehicles, which use more fuel. But improvements in efficiency have offset this. So while the power of cars in Europe has increased by around 30 per cent over the ten years to 2005, their average CO_2 emissions have declined by almost 20 per cent. The average 'tailpipe' emissions of cars in the EU in 2005 was around 160g of CO_2 for every kilometre driven, while in 1995 it was more like 185g/km. On average, UK cars are slightly less efficient.[44]

The EU had set a voluntary target that this average efficiency should reach 140g/km by 2009 and 120g/km by 2012 for new passenger cars, but the industry is a long way from these targets. As part of its climate and energy package, EU decision makers have set a new mandatory target of 95g/km by 2020.[45] This proposal alone, it is claimed, will deliver a third of the emissions savings in the EU from sectors not included in the EU's Emissions Trading Scheme.[46]

The European Commission originally proposed tougher targets but these were watered down in response to pleas from the car industry. This is unfortunate, as improved efficiency is a very cost effective way of cutting emissions.

In the long term it has to be assumed that the significant emissions cuts necessary will require a genuine low-carbon way of providing road transport, and need an alternative fuel source. At present, the preferred policy option seems to be decarbonising road transport by moving to electrically powered vehicles – based on the assumption that increasing amounts of electricity can be generated from low-carbon, renewable sources. This could be through the use of batteries or hydrogen fuel cells.

Facing down demand

Improved technology and alternative fuels will always be counterbalanced by the increasing demand for transport unless policy measures are introduced that tackle this directly. A recent report by the European Environment Agency[47] says increased transport volume has 'more than offset' any cuts in emissions obtained under current approaches. Transport demand must be addressed, and to do this 'measures and policy instruments must go beyond the transport sector itself and be introduced into sectors of the economy such as households, industry and service, within which the demand for transport actually originates'.

Politicians who are serious about facing the climate challenge will have to grasp this thorny rose. Policies will have to be introduced to reduce freight, to encourage walking and cycling, to support public transport and car sharing, and to limit aviation usage. In this sense, planning policy that can organise cities and services in such a way so that people need to travel less and use less transport has the potential to deliver much greater savings than biofuels policy and must be treated this way. This has notably not been the case to date. Many governments have neglected such steps in favour of supporting expensive, ineffective biofuels.

Making progress?

There are around half a billion cars on the road around the world at present.[48] Improving the efficiency (and ability to use alternative fuels) of new cars will bring emissions down in the medium to long term. Research by the International Energy Agency (IEA) suggests that the widespread use of fully hybrid vehicles by 2030 would cut the demand for transport fuel by ten per cent, but increased travel would leave the demand for transport fuels 40 per cent higher than today.[49] If road transport cannot cut its emissions then other areas will have to deliver much greater cuts to make up for it.

Even given the other options available and the problems in guaranteeing real emissions cuts, biofuels may be needed to play a transitional role in bringing down road-vehicle emissions. Research commissioned by the UK RFA indicates that – if issues around land-use change were resolved – biofuels could prevent the equivalent of 338 to 371 million tonnes of CO_2 emissions a year.[50] The IEA estimates that by 2050 biofuels and efficiency measures should save 7 billion tonnes of CO_2 a year.[51] NGOs and campaign groups tend to be more critical of biofuels, but there is still recognition of a role. For example, the Campaign for Better Transport, in recent proposals to reduce UK transport emissions, said biofuels may be needed to bring down shipping emissions.[52]

And such a role can be cost-effective. When the business consultancy McKinsey compared the relative cost of various GHG-abatement options, biofuels were included in the package as part of a cost-effective way of achieving GHG stabilisation at 450ppm (of CO_2 equivalent atmospheric concentration), still a long way from the more desirable 400ppm[53] but a move in the right direction.

Biofuels have very different cost profiles depending on where and how they are produced. Some, such as sugar-cane bioethanol, are effectively cheaper than alternatives (oil-based fuels) in the medium term, and are predicted to actually save money. Others are more expensive than options such as transport-demand management and vehicle efficiency. The International Energy Agency lists the long-term (by 2050) cost of biofuels as greater than any of the other sources of renewable energy.[54] The heavily subsidised biofuels currently produced in the US and EU are clearly inefficient and expensive, especially given the questionable GHG savings.

The vision promoted by many governments that biofuels could be a silver bullet to bring down transport emissions is clearly wrong. Instead, a more clear-eyed view of the limited and transitional role some biofuels might play must be put forward.

FUELLING POVERTY

Industrial-scale biofuel production has been linked to human rights abuses, and has been one key cause of the recent spike in food prices. Like other production on monoculture plantations, biofuel production threatens biodiversity. Christian Aid partners and research have documented links between biofuels and deforestation, human rights abuses and the food crisis.

Local environmental impacts

A variety of environmental impacts – damaging the natural resources vital to poor communities – go hand in hand with increasing monoculture plantations of biofuel crops such as sugar cane, soya and palm oil. In particular, monoculture expansion implies rapid destruction of the well-established forests that act as huge carbon sinks.[56]

Both the Brazilian savannah region called the Cerrado (said to be biologically the richest savannah in the world) and the Amazon, have been affected by expansion of such crops. Sugar-cane plantation expansion has led to a rapid destruction of the Cerrado, forcing cattle ranching into new areas both there and in the Amazon. The Amazon is also under threat from soya production.

Sugar-cane and soya production also threaten the Pantanal – the world's largest inland wetland area, it spreads between Brazil, Bolivia and Paraguay – and comprises a sensitive ecosystem of tropical forests, savannah, rivers, lakes and swamps. It was reported in February 2007 that the government of the Brazilian state of Mato Grosso do Sul had authorised the construction of new ethanol distilleries in the Pantanal.[57] Similar expansions are also taking place in the Atlantic coast forests. Sugar cane was grown here in the past and production is now returning to this area and increasingly endangering forests and biodiversity.

In Bolivia, cultivation of soya and the process of deforestation are inextricably linked. According to Christian Aid partner CIPCA (the Centre for Research and Training of Peasant farmers), more than 700,000 hectares of forest in Bolivia have been cleared to make way for soya cultivation.[58]

There are, of course, other environmental impacts apart from deforestation and loss of habitat. The growth of such plantations goes hand in hand with the increasing use of fertilisers and pesticides and the pollution of soil and water resources with a huge negative impact on biodiversity.

Local pollution is a major issue. Excessive use of nitrogen fertiliser not only has significant climate impacts but can also threaten native plant species unused to high nitrogen levels and lead to eutrophication – where the environment becomes over enriched with nutrients.

The mills producing palm oil also produce a residue effluent that includes fat and fibrous material, which can cause organic pollution of water sources, killing off aquatic life.[59]

Communities in the Chocó, Colombia, which have seen a dramatic increase in African Palm cultivation, can give first-hand accounts of livestock dying due to excess pesticide getting into the water, and the reduction of viable water sources for other crops. They also tell of the vast reduction in the numbers of wild animals and insects.[60]

Most biofuel crops are produced on monoculture plantations that depend on the mass aerial spraying of pesticides, threatening the health of workers and farmers and nearby populations. The heavy use of chemicals also brings more contamination of the soil, rivers and subterranean waters. In Brazil, a key problem with sugar plantations has been the discharge of waste from ethanol production (vinasse), which has contaminated streams and soils. There is also a generalised practice of burning sugar cane before harvest as this makes cutting easier.

These practices are widespread in the Brazilian sugar industry. As well as causing environmental damage, they increase air pollution, leading to a high incidence of respiratory illness.

A Christian Aid partner, the Centre for Black Culture (CCN-MA), works in the Brazilian state of Maranhao, in an area where poor, rural, black communities – the Kilombolas or Quilombolas – have been fighting for 20 years to gain titles to the land. These communities have suffered extensively due to expanding soya production – some of which is used for biodiesel production. Some of the communities in which CCN-MA works are now completely surrounded by soya. The impact has been devastating, particularly with health problems resulting from the widespread use of pesticide. People can no longer use the river water and their animals are dying.[61]

Another major issue is water use. African Palm and sugar cane require significant amounts of water in their cultivation, and large quantities of water are used in processing crops into biofuel. For example, ethanol processing plants in the US use four times as much water as the quantity of fuel produced.[62] In semi-arid countries, water extracted for biofuels production leaves less available for people living downstream, such as small-scale farmers, which can cause conflict.

Fuelling conflict in Colombia

Colombia suffers from an internal armed conflict between left-wing guerrillas, the Colombian state and right-wing

> **'Biofuel use is gonna make food more expensive.
> Deforestation is gonna mash up our nation.
> Evil men, you have a wicked intention.
> I say what is your plan... is it life or destruction?'**
>
> From the lyrics to 'Biofuel… crazy idea' by Livebroadkast[55]

paramilitaries, fuelled in part by the desire for control of land and resources. In this context, agro-industries that require large areas of land, resources such as water and fertiliser, readily available low-wage labour and unrestricted access via roads can, either advertently or accidentally, exacerbate the conflict. Unfortunately, Colombia is a perfect example of how biofuel production can lead to human rights abuses, displacement and violence.[63]

One example is the Chocó region, where farming communities were violently displaced from their land in 1997 by the Colombian military together with local paramilitary groups. The area was subsequently developed for palm-oil production. Attempts by farmers to reclaim their land or even access it have resulted in murder, violence, intimidation and threats that continue to this day.

Don Enrique Petro, a local farmer, was told to leave by paramilitaries who threatened to kill him. After he left they tried to buy his land, threatening that if he refused to sell they would buy it more cheaply from his widow. When he tried to return to his farm he found it riddled with bullets, and with death threats painted on the walls. They had taken his animals.

In 2001 a palm company called Urapalma began to plant African Palm on the land belonging to the peasant farmers who had been displaced. When Don Petro tried to get his land back he received threats, and was eventually called to the office of the army commander in that area where he met with the head of the palm company and was forced to sell his land at a knock-down price to be paid in three parts. He never received any money.

Another local farmer, Luis Obilio, and his family had to leave their farm and land: 'Anyone caught crossing the river back into that land was killed or disappeared. They were considered a guerrilla.'[64] Many people lost family, including Oriel, whose father was killed by paramilitaries who then prevented the family from retrieving the body.

Through work with Christian Aid partner the Inter-ecclesiastical Commission of Justice and Peace (CIJP) the communities have successfully petitioned the Inter-American Court of Human Rights to require the Colombian government to report regularly on measures taken to uphold human rights and protect communities. International support has been vital in assisting those trying to reclaim their land. As it is, palm continues to be a source of conflict, and people continue to be killed.

The nature of the Colombian conflict, including both the high level of impunity for murder and human rights abuses and the economic factors driving armed groups, means that biofuel production is linked to the dynamics of the conflict itself. Palm plantations and agro-industry is seen by some as a way to control areas of the rural countryside and bring them into the economy and by others as the way the state can impose a particular kind of development model on rural areas of Colombia without consultation with the communities most affected.

An added dimension is the particular impact such land conflict has on indigenous communities and their descendents in rural areas. They have particular communal rights to land, recognised perhaps most strongly through the 1991 constitution. However, in Colombia, as in countries such as Indonesia and Malaysia,[65] the customary laws of indigenous peoples are regularly violated or come under tremendous pressure from businesses interested in gaining from lucrative crops such as biofuel feedstocks. Traditional ways of life are significantly threatened and social and cultural rights abused along with other human rights.

Labour rights

The labour situation in agro-industry across the globe is well documented and biofuels production offers more of the same. Large-scale, mono-crop plantations require a mostly seasonal workforce, so working conditions are often deplorable, labour rights non existent, and pay is low.

Anecdotal evidence from Chocó tells of low-paid labour being shipped in from far-off towns to work on land controlled by paramilitaries, to which displaced farmers were forbidden to return. The same paramilitary force that controlled the lands was said to control the labourers, making sure that they did not organise themselves to demand higher wages or better working conditions. Payment was largely in the form of credit at a shop owned by the palm company.[66]

Similarly, in Brazil the plight of the estimated 1 million sugar-cane workers is a major issue. Around 511,000 of them work cutting cane, as most Brazilian sugar cane is cut by hand.[67] According to civil society groups, payment is based on how much cane is cut, with wages withheld if they fail to meet a pre-established production quota.

Given the heat, and the long hours of work necessary to meet quotas, it is perhaps not surprising that deaths from exhaustion on the sugar plantations have been recorded – at least 14 people died during the harvests of 2004 to 2006.[68]

In the south of the country, the cutters are often migrant workers from the impoverished northeast. On arrival they find conditions extremely harsh. They live on farms with no beds, no water and no stoves on which to cook. Some report being paid in coupons by the company, which can only be used at the farm's supermarket.

Brazilian non-governmental organisations (NGOs) have described cane cutting as 'one of the most degrading types of work in the country'.[69] Media stories in the UK attest to the hardship. In 2007, the *Guardian* described a destitute migrant workforce in the sugar plantations of São Paulo effectively working as slaves.[70] In the same year, the *Independent* reported that the Brazilian authorities had released more than 1,000 enslaved workers after a police raid on Para Pastoril e Agricola SA's sugar-cane plantation in the Amazon.[71]

Evidence about abuses of the rights of sugar-cane workers has been gathered by the government, which has set up an inspection team in the Ministry of Labour and Employment to monitor labour conditions. Created in 1995, the team has 'rescued' thousands of sugar-cane workers – in its first year alone 8,700 were released.

The team visits the areas where the cane cutters – who include men, women and children – live and work. They meet with company owners, landowners and employers and gather information about payment of wages and contracts. Companies and employers who are found to be breaching rules are fined, or face further prosecution. In just one investigation, 11,087 workers working in unacceptable conditions were 'rescued' by the investigating team working with the public prosecutor and the federal police.

Investigations have found:[72]

- living accommodation with no toilets, no tables and chairs, and no beds
- overcrowded living quarters with open sewers
- drinking water that consisted of irrigation water unfit for consumption
- poor quality food that caused nausea and diarrhoea
- workers often having to walk as far as 40km from their living quarters to the cane fields because of lack of transport
- false promises about salaries and working conditions being used to lure new employees.

The Brazilian government publicly recognised the problem when, in 2007, President 'Lula' da Silva pledged to bring industry leaders and workers together 'to discuss the humanisation of the sugar-cane sector'.[73] It is still to be seen what the impact of this promise will be, but the Brazilian government is currently involved in talking to African governments about sharing Brazilian ideas for improving working conditions on sugar-cane plantations.

The food crisis

'We are expecting corn, sugar and African Palm produced for energy to displace local food production, which will cause problems for the basic food-basket prices. The African Palm invasion is now happening in protected areas in the humid tropics and displacing livestock farming and basic grain.'

Interview with Mauricio Diaz, national coordinator of Christian Aid partner Foro Social de la Deuda Externa y Desarrollo de Honduras (FOSDEH), on 19 March 2007.

Christian Aid has previously documented its analysis of the various causes and impacts of the global spike in food prices in the 2008 report *Hungry for Change*.[74] Among the causes listed is biofuel production – both as a driver of increased prices through increased demand for food-crop feedstocks such as maize, but also as a driver of demand for the most fertile land, which often has the impact of displacing vulnerable small-scale subsistence farmers.

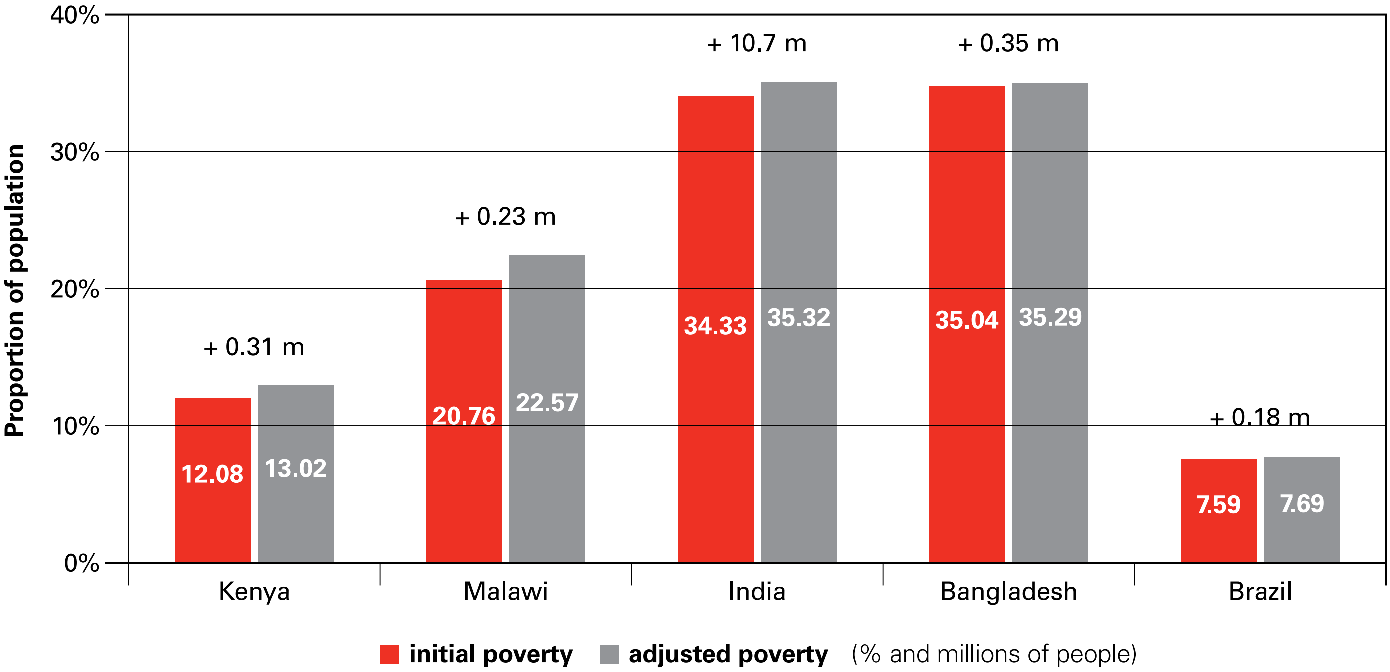
Indeed, a note prepared for the World Bank identified biofuel production as the 'most important' cause of increased food prices,[75] although this seems to vary from region to region. Research by the Overseas Development Institute (ODI) has modelled the medium term (to 2020) impact of projected biofuels production on the prices of a variety of commodities (oil, rice, wheat, oilseed and sugar cane among others). This has identified some significant price increases which, the ODI predicts, would put millions of people into poverty. Figure 3 summarises the projected poverty impact of these biofuel-driven price rises.[76]

Central America – going hungry

One area where food shortages and price rises related to biofuels production has been most prominent is Central America. The boom in US maize-ethanol production has had a particular impact on food security there. As the US is a key maize exporter and accounts for around 40 per cent of global maize production,[77] changes in US production levels and prices have a huge impact on world market prices. The enormous growth of the ethanol industry in the US has meant less and less US maize is being sold on the global market.

The price of yellow corn – a variety of maize – went from US$1.98 per bushel in January 2006 to US$3.90 per bushel in March 2008, an increase of more than 90 per cent. Wheat and rice prices have also increased as those grains are used as substitutes for maize. Rising feed prices

Figure 3: Impact of projected price rises, due to biofuels demand, on poverty in selected developing countries



Source: Research by the ODI for *The Gallagher Review of the Indirect Effects of Biofuels Production*, UK RFA

also affect livestock producers and the US Department of Agriculture forecast in March 2007 that demand for ethanol would push up prices of poultry, pork and beef.

Even small increases in the prices of staple crops can, of course, have a devastating impact on the poor in developing countries. In the case of Central American countries the price of maize is critical. Guatemala, Costa Rica, El Salvador and Honduras all import substantial amounts of US maize and are vulnerable to such price changes.

Guatemala is by far the biggest Central American importer of maize, and its imports of US maize have been steadily rising, from 463,000 tonnes in 2000 to 747,000 tonnes in 2006 – an increase of 61 per cent.[78] The US supplies almost all of Guatemala's import needs, although Guatemala is also a substantial producer. Maize is a staple food in Guatemala, providing around 40 per cent of the daily caloric intake per person in the country – greater than any other single food source.[79] Maize price rises, therefore, have a dramatic impact on the local population. As in the US, however, price rises do not just stop at maize – Guatemala's livestock and snack food industries, which depend heavily on imported maize, reported an increase in operating costs of 15 to 20 per cent in 2007.[80]

According to UNICEF, 49 per cent of Guatemalan children under five have stunted growth.[81] The stunting rate is a critical indicator of childhood malnutrition and points to serious deprivation in feeding and care in children under five. In such a context, maize price rises have a hugely negative impact, particularly when families run out of food reserves from the previous harvest, and the 'annual hunger season' comes around. This can begin as early as April, with the critical months being June to September. During these months families have to turn to the market to buy their food with rising prices testing their very limited budgets.

The worst-hit areas are currently the highlands and the east, where chronic malnutrition has been identified.[82] The situation is further exacerbated by the impact of climate change on local agriculture. Changed rainfall patterns, and their impact on sowing and harvesting have prolonged the annual hunger season by an extra month. One family that Christian Aid interviewed, in Jocotán in Guatemala's eastern highlands, the poorest area of the country, had just 2½p per person per day to spend on food.

The staple food in the region is the maize tortilla. In the worst months of hunger this is all the poorest families have to eat. The daughter of the family, Chelda, was admitted to a Christian Aid-supported malnutrition clinic with a high fever, her body swollen with kwashiorkor, a potentially fatal illness caused by a lack of protein.

Hope or hype? Jatropha plantations in Africa

As part of the push for jatropha production, a number of companies have sought to set up plantations in Africa. Christian Aid is concerned that the prospective biofuels industry in Africa should not cause the same problems – damage to the environment, human rights abuses and worsening food security – that followed commercial biofuel production in Latin America.

Christian Aid has supported a number of pieces of research on jatropha in Africa. One study looked at the experience of Kikuletwa Farm in Manyara region, Tanzania, to explore this further.[83]

Kikuletwa is on fertile land and has been a commercial farm since colonial times – so jatropha cultivation displaces other crops, although there are no current concerns about communities being moved or loss of biodiversity. The farmer initially planned to plant 500 acres of jatropha. However he discovered that high yields from jatropha require heavy use of labour and major inputs of fertiliser and water, so he has scaled back to a small plot. Even with careful tending he has achieved only an average of 4kg of seeds per tree per year, instead of the projected 8-10kg. Irrigation is crucial to achieving such jatropha yields.

The experience at Kikuletwa has illustrated some of the issues facing large-scale investments, the communities around them and the workers who are employed by them. First, it is clear that the need to maximise returns on land will necessitate the use of irrigation, fertiliser and fungicide. In dry areas this will require large-scale mechanised irrigation. This, together with the use of fertilisers and other mechanisation, will add significantly to the emissions associated with production, while the use of fungicide could damage the health of workers. However, Tanzanian government policy, such as it is, is centred around just such examples of large-scale intensive production in a way that may negate any potential carbon savings or social benefits from the biofuel.

Similarly in Dagana, a semi-arid province of Senegal, a private Belgian foundation, Durabilis, has been piloting a six-hectare jatropha plantation since November 2007. The foundation aims to show local farmers the potential of jatropha as a cash crop in the local sandy soils, and ultimately aims to bring 5000 hectares under cultivation. As the area receives less than 200mm of rainfall a year, drip irrigation with water from the nearby Senegal river is being used. If the community were to adopt jatropha as a crop it would have to prioritise the available water for jatropha rather than food crops.[84]

In Burkina Faso, large-scale commercial production started in 2007 and has met with a mixed response. Most farmers interviewed around one area where jatropha was being grown said they preferred to grow jatropha in the form of hedges around their existing fields, rather than in plantations.[85]

Biofuel companies need maximum yield if production is to be economically viable. Recent agronomic studies have confirmed that to achieve optimum yields commercial producers will need to plant geographically concentrated hedges or plantations, install irrigation and use chemical fertilisers. Thus the use of jatropha hedges for ecological reasons – to control desertification and reclaim soil – cannot co-exist with large-scale industrial production for the national or international biofuel market.

If inputs are minimised, much more land will be required to produce the same amount of jatropha, thus further reducing biodiversity. It is also difficult to see investors being drawn to marginal lands where jatropha will survive but will only provide low yields. It is inevitable that a country's most fertile and moist areas will be targeted.

The issue of labour will also need careful attention from investors and governments alike, as jatropha cultivation is, at present, very labour intensive. Given the need for large amounts of seasonal labour there will be issues around wages, working conditions and the effects of migration to plantations at certain times of the year. Large-scale migrations of workers put pressure on food supplies and prices, medical facilities and schools, in addition to potentially increasing the incidence of disease transmission.

Complicating the problems

Christian Aid partners in Latin America have documented a number of serious problems caused by increased production and diverted consumption of crops used as biofuels feedstocks. In Africa the same problems are not yet apparent; however, if major jatropha plantations delivering significant yields are to be established the signs are that the story will be repeated.

Biofuels – much like climate change itself – have the potential to exacerbate existing problems. Environmentally damaging monoculture plantations, deforestation, abuses of human rights driven by demand for land and unstable commodity prices – all already exist in Africa. Major biofuels production will simply worsen existing power imbalances and environmental and social abuses. Biofuels cannot be proposed as a sustainable solution to the climate problem if these impacts are not addressed and prevented.

NEW OPPORTUNITIES FOR POVERTY REDUCTION

As well as examining the problems caused by expanded biofuels use, Christian Aid is concerned with their potential benefits for poor people. One key poverty-reduction benefit associated with biofuels is the prospect of preventing catastrophic climate change. However, the proponents of biofuels claim they can also offer new livelihoods and an answer to energy poverty.

Tackling energy poverty in Mali

In rich countries a reliable source of energy is taken for granted. Energy allows us to cook, pump water, access modern communications and information and provide mechanised power. It provides heating, refrigeration and lighting.

However, 2.4 billion people globally do not have secure supplies of fuel for cooking and heating, and 1.6 billion people have no electricity. The energy that these people have access to is often dirty and polluting – solid fuels, the use of which gives rise to health problems from smoke inhalation and other issues. This lack of energy is a hallmark of poverty. It limits an individual's ability to make a living, restricts education and healthcare and isolates people from the wider community.

Tackling energy poverty is vital and the potential that biofuels have to offer here is exciting. For instance, the Mali Folkecenter (MFC) has pioneered the 'jatropha system' in Mali. This concept draws on the United Nations Environment Programme's multifunctional energy platform – where a village generator fuelled by renewable energy can be used to operate a number of other appliances such as tractors, stoves and lights.

The MFC Garalo Bagani Yelen project, started in 1999, aims to provide 10,000 villagers around Garalo in Mali with electricity: three generators, which will be fuelled by jatropha oil, and currently run on diesel, power lights, stoves, batteries and grain mills. Among other benefits, this has considerably reduced the time and energy required of women to perform daily tasks. MFC has provided jatropha seeds and cultivation advice to producers. They, in turn, are organised into committees that sell the fruits to a cooperative based in Garalo. The jatropha plants are currently immature but the cooperative will press the oil and sell it to a company that runs the generators. The organic residue will be given back to producers to use as fertilisers for the jatropha plants.

According to MFC calculations, this system can produce 750 tonnes of crude jatropha oil for every 1,000 hectares planted with jatropha. It will do so without compromising the food security of households, as jatropha is intercropped with groundnuts or grown in hedges around food and cash-crop fields. As biofuel production is on intercropped land, with minimal inputs, environmental impacts are low and the communities will be empowered to control their own energy supply.

The Malian government is actively supporting such a model with its new National Strategy for Biofuel Development, which eventually aims to replace fossil fuel imports with local biofuels. This national programme aims to popularise the energy uses of jatropha as part of a commitment to rural electrification through clean and decentralised energy provision. The Mali National Centre for Solar and Renewable Energy, through its jatropha programme, has supplied 700 communities, comprising 12,000 villages, with biofuel generators.

At the same time, the Malian government has adopted food sovereignty as its overall food and agricultural policy framework. This signals a commitment to small-scale farming and the promotion of local food systems – explaining why the Malian government has not so far courted foreign investment in large-scale industrial jatropha projects. It has also banned jatropha exports until the country is fully energy self-sufficient.[87] This combination of support to small-scale farming, local food production (as opposed to food imports) and decentralised energy would appear to be unique.

Moving away from oil and towards growth

While the Malian example is a case in which biofuels production has focused on community needs, a number of countries have gone into biofuels production for domestic use in order to protect their economies from oil-price fluctuations.

For example, most of Brazil's sugar-cane ethanol production is used domestically, the result of a specific government strategy to reduce the country's dependency on imported oil. The government has set a target that all petrol sold should include a minimum of 20 per cent ethanol. This, and the large number of Brazilian flexible fuel vehicles, which can run on any blend of petrol and ethanol, means that ethanol now represents 40 per cent or more of Brazilian petrol usage.[88]

Honduras' plans to produce palm-oil biodiesel reflects the fact that at present it imports all of its oil. High fuel prices have had a major impact on the cost of living in the country. However, some estimates indicate that if the 70,000 hectares of palm oil planted in Honduras were all used to produce biodiesel – instead of exported for food products and other uses – Honduras would satisfy around 20 per cent of its national demand for diesel fuel.[89]

> ## 'Energy independence for Mali starts right here, in this field.'
>
> Hamed Diane Semega, minister of mines, energy, and water for Mali at a ceremony to celebrate local production of energy from jatropha biofuel in Garalo, Mali, October 2006[86]

Similarly, Bolivia since 1992, has suffered from an acute shortage of diesel oil, which has forced the government to import it in larger volumes. Coupled with rising oil prices (which have made it necessary for the government to subsidise diesel oil, especially for those living below the poverty line) this has substantially increased government expenditure and has placed a strain on the state's resources.

The 2008 budget saw more than £115 million[90] allocated to diesel-oil subsidies, although more recent reports from the press suggest that the real figure was closer to £305 million.[91] Biofuels may have some potential to alleviate this problem but it very much depends on the nature of their production.

Some in Bolivia hope that biofuels production will significantly boost the economy. One business association claims that biofuel production could create up to 1 million direct and indirect jobs in agriculture, industry, services and transport over ten years.[92] Biofuel production and export is seen as a potential buffer to any loss of preferential markets due to trade liberalisation. However in making this case for agro-industry, the trade association failed to take into account trade barriers preventing access to key markets. Current policies in the US and Europe are designed to facilitate domestic production of biofuels, and significantly limit foreign penetration of these lucrative markets.

The Colombian government estimates that farming families who produce for the biofuels industry will earn two to three times the Colombian minimum wage every year through bioethanol production,[93] while the pro-biofuel quango CORPODIB has estimated that 150,000 new jobs would be created, both directly and indirectly.[94]

In Africa the Senegalese national biofuel programme aims to support the production of 1.12 million litres of jatropha biodiesel by 2012. The aim is to ensure future energy self-sufficiency in view of rising international oil prices through a mix of industrial and small-scale cultivation. At present a pilot project has been set up to grow a million plants.

The Senegalese biofuels programme also forms part of the government's programme to revive agriculture. However, the government is not as explicitly committed to small-scale and sustainable farming and local food production as that of neighbouring Mali. It is trying to attract large investors to start up mega-projects, and is at present negotiating land deals with Dutch, Italian and Brazilian companies who want to grow jatropha or other crops for biofuel production.[95]

Plantation work

Claims that large-scale biofuel production creates new jobs need to be carefully examined. Most significant examples of biofuels production are monoculture plantations that are not famed for their generous job creation or the quality of such jobs.

For instance, the production of soya requires between one and four workers per 200 hectares, while the production of tomatoes or grapes on the same area of land require 250 or 113 workers respectively.[96] And although jobs may be created on new and expanding plantations, other jobs may be displaced if the land used for the plantation was previously farmed. Net job gains may be minimal, or possibly more jobs may be lost than created. In addition, newly created jobs are often of a much poorer quality in terms of wages and conditions.

In Brazil, for every 100 unused hectares planted with sugar, ten jobs are created; for soya two jobs are created.[97] However, as soya production has boomed in Brazil the number of jobs it supports has actually fallen because of increased mechanisation. Production increased from 18,278 million tonnes in 1985 to 49,792 million tonnes in 2004, while jobs fell from 1,694,000 to 335,000 – a drop of 80 per cent.[98] The Centre for Sustainable Development at the University of Brazil affirms that when soya displaces other agricultural activities more jobs tend to be lost than created.

On the other hand, research from Tanzania suggests that jatropha may be different. Mechanised harvesting is inefficient because the fruits on each tree do not ripen at the same time, and therefore have to be selected individually for picking. As a result jatropha plantations could provide a significant source of employment.[99]

Small farmers

In contrast to the problems associated with biofuels production on monoculture plantations, small-scale production is better for biodiversity and ensuring communities capture more of the economic benefits of production. In addition it empowers rather than displaces farmers. High production costs for biofuels mean that for small producers to achieve the necessary scale of production they need to either function as outgrowers – growing the crop with the support of a company that buys up some or all of the harvest – or organise together as cooperatives.[100]

Outgrowing schemes and cooperatives have also been involved in the new efforts to produce jatropha in Africa. Christian Aid-supported research[101] investigated whether growing jatropha as part of an outgrower scheme was an option for small farmers in Engaruka village in the Arusha region of northern Tanzania. Jatropha had previously been grown by villagers as a hedging plant but is now also actively cultivated and grown for its oil seeds. Most jatropha is inter-cropped but there are a few dedicated fields. Between 60 and 100 tonnes of seed are produced annually, worth between US$7,500 and US$12,500 at the time of the research.

In Tanzania only three per cent of smallholder farms are irrigated. In Engaruka one constraint on growing more jatropha is the reluctance of farmers to grow a non-food crop on the small area of irrigated land. This limits possible yields and economic returns and has meant the crop is of limited interest.

In Senegal, a company called SOCCIM Industries runs a cement factory in the Senegal River Valley. It began jatropha cultivation in 2007, using an outgrower model, with the aim of running the factory on locally produced jatropha biodiesel, rather than the fuel it currently imports from South Africa. According to the company's calculations, local farmers selling jatropha to the company will receive 60 per cent more than they could get selling groundnuts or tomatoes. So far, outgrowers are cultivating 300 hectares, which the company aims to extend to 11,000 hectares. The company selects producers according to a sustainability charter, which stipulates how far they should live from the factory (not more than 150km) and whether their land can be used for jatropha. This is to avoid competition with food production, and GHG emissions from transportation of the seeds to the factory.

In Burkina Faso, an association called the National Union for the Promotion of Jatropha (UNAPROFIJA) runs male and female village groups, which in turn are organised into community-level unions. At the village-level, UNAPROFIJA gives advice to producer groups to help them start up jatropha nurseries. The association then buys the seeds from the producer groups, to sell on to companies for local or international transformation into biodiesel or jatropha oil.

In Mali the MFC project relies on cooperatives of small farmers, who are encouraged to intercrop jatropha with millet and sorghum. This shows that, if cultivated in a sustainable way by small farmers who are integrated

Brazil – a different path for biodiesel?[102]

Brazil is generally considered a biofuels success story. It produces plentiful, cheap, energy-efficient and (land issues aside) apparently low-carbon, sugar-based ethanol. But to date, biofuel production in the country has mainly taken place on large-scale monoculture plantations controlled by large agribusinesses.

It is possible that the development of biodiesel could follow a different path. The National Programme of Biodiesel Production and Use (PNBP) has the potential to involve small farmers because it provides tax incentives to biofuels processors that buy castor beans, palm, sunflowers or jatropha from small farmers. The production of soya oil was originally excluded, but there is currently pressure for it to be included in an expanded programme. Soya is a monoculture crop that has questionable energy efficiency and carbon savings, and has been seen as a direct cause of loss of rainforest.

When the biodiesel programme was launched it was expected that some 100,000 farming families would participate.[103] Currently, the scheme is said to include around 26,700 families – a number that has decreased in the past two years. This represents less than one per cent of national biodiesel production – which is dominated by soya. This programme has been criticised for reducing small farmers to raw material suppliers. Specifically the companies involved have imposed conditions demanding commitments of the farmers' time and insisting that land must be used for cultivating biofuels crops as opposed to food crops.

This approach has worsened indebtedness and food insecurity among participating farmers. A better approach would be to focus on the organisation of cooperatives in order for poor people to become actively involved in the higher value parts of this biodiesel production.

In 2005, Brazil's first biofuels cooperative – Cooperbio – was formed by the Movement of Small Farmers (MPA) and Christian Aid's partner the Movement of Rural, Landless Workers (MST). It was created in the northwestern state of Rio Grande do Sul and involves around 20,000 families across 63 municipalities. Cooperbio works with the poorest family farmers, helping them become more self-sufficient in the face of agribusiness dominance.

Its energy strategy involves both ethanol and biodiesel, with state energy company Petrobras as the principal partner and financer.[104] One of the cooperative's priorities is to ensure that biodiesel feedstocks – including jatropha, castor beans and sunflowers – are produced under a diversified regime to ensure soil quality is preserved. There are plans to build a biodiesel plant to produce fuel for the farmers' cars, tractors and machinery.

Ethanol production is more advanced and is decentralised in nine micro-distilleries, each supported by a producer association. It is estimated that some 20 hectares of sugar cane are needed to feed each distillery. To ensure that the food supply is not prejudiced each producer is allowed to plant only two hectares.

into a local energy supply chain, jatropha can increase rural incomes, provide energy to rural communities off the national grid, and increase soil fertility and moisture retention, without compromising food security.

The GHG savings to be had by combining small producers with local processing is considerable. This is because:

- the cultivation process uses no chemical fertiliser, so avoiding the release of nitrous oxide and other GHGs
- there is only a short distance between producers and the oil press, and MFC cars have been converted to run on jatropha oil
- there is no GHG-heavy chemical process involved in converting the jatropha into crude oil (as is the case with biodiesel)
- the seed residue is used as organic fertiliser, and the jatropha trees sequester carbon.

Christian Aid is involved in a number of projects that seek to allow small farmers to benefit from the growing biofuels market. For example, Christian Aid partner the Proyecto de Paz Magadalena Medio (PDPMM) works with rural communities in the Magdalena region of Colombia – an area affected by conflict. The organisation has helped small-scale farmers working in cooperatives to access support for small-scale African Palm production. This project has had some success in developing production, but challenges still remain; a key one being whether the crop itself is viable as a small-scale product without subsidy. Another is the presence of armed groups in the region and their ties to traditional economic interests.

A new model for poor people?

The examples Christian Aid has uncovered indicate there are opportunities for using biofuels to tackle energy poverty and – to an extent – to improve livelihoods. Such results are not a given, however. Global markets are focused on biofuels feedstocks produced on large-scale plantations. Such production generally offers few jobs and limited benefits for people, although it may help generate some growth and energy security.

Far better results for poor people are gained when small-holder farmers are put at the heart of biofuels production. Working as part of cooperatives, small farmers can sustainably produce biofuels for their local energy needs or for the market. Outgrower schemes may also provide a model of cooperation for small farmers, although the community will have less control over their crops.

LAND WRONGS

It is impossible to examine the impact of biofuels without looking at land. The carbon footprint of any biofuels production ultimately depends on which land is used and what impact that has on the world's carbon sinks. Worsening food security reflects in part the pressures on land for food production. In addition, the driving force behind many of the abuses of human rights associated with biofuels is control of land and displacement of small farmers. In many ways, therefore, the key questions around biofuels are: is there enough land to meet increased demand, and what impact will this have?

The land crisis?

Land provides a limit to aspirations for biofuels. Land is finite. In 2004 the author and environmental campaigner George Monbiot calculated that for the UK to replace 20 per cent of its transport fuel demand with domestically grown biofuels would require almost all viable UK cropland. He concluded: 'If the production of biofuels is big enough to affect climate change, it will be big enough to cause global starvation.'[105]

A more recent analysis by the UK's Renewable Fuels Agency, as part of the *Gallagher Review* indicates that there were around 10.8 million hectares of unused arable land within the EU that could help meet the projected EU biofuels demand. However, the EU itself has indicated that between 22 and 54 per cent of the EU biofuels targets will be met through imports and a further 37 per cent will be met by diverting land for other uses – displacing production to land outside the EU. This could lead to between 5 and 10 million hectares of land-use change outside the EU depending on the level of the EU target[106] – a dramatic increase in biofuels-related land use.

Oxfam has examined the projected impacts of the new EU targets, given current palm-oil production trends in Indonesia and Malaysia. It predicts that GHG emissions equivalent to 3.1 billion tonnes of CO_2 would be released by indirect land-use change in the palm-oil sector due to the EU's targets. This carbon debt would take 46 years of *global* biofuels production, at 2020 levels, to repay.[107]

Similarly, Christian Aid-supported research into the options for growing jatropha in Tanzania concluded that to replace 20 per cent of Tanzania's diesel fuel needs alone would require 56,000 hectares of jatropha, picked by 280,000 workers. To meet all the UK's demand for diesel would take 26 million hectares of land (11 per cent of Tanzanian total land area) and 52 million workers (greater than the Tanzanian population).[108] Such figures challenge the feasibility of large-scale biofuels. However, some estimates indicate that Tanzania has 55 million hectares of land suitable for crop production but currently unused.[109]

It is important to analyse how much biofuels production the world can support, particularly as increased biofuel demand will not take place in isolation – UN Secretary General Ban Ki-Moon warned a global food summit in June 2008 that global food production must rise by 50 per cent by 2030.

Promoters of biofuels like to talk about the prospects of increased agricultural yields, particularly as a result of new technologies, but research commissioned by the UK RFA indicates that different yield scenarios only vary land demand by 10 per cent either way, and that yield trends have become less strong in recent years for a number of reasons, including increased climate instability.[110] A return to strong improvements in yield will require a concerted push for increased investment and support for agriculture. With increased demand, more land will clearly be needed.

One study commissioned by the UK RFA estimated the total additional demand for land by 2020 for food and animal feed (excluding pasture land) globally as being between 200 and 400 million hectares, even taking into account improvements in yield. This is a much more ambitious increase than the 34 million hectares increase in cropland since 1990 – during which time forestland has declined by 80 million hectares.[111]

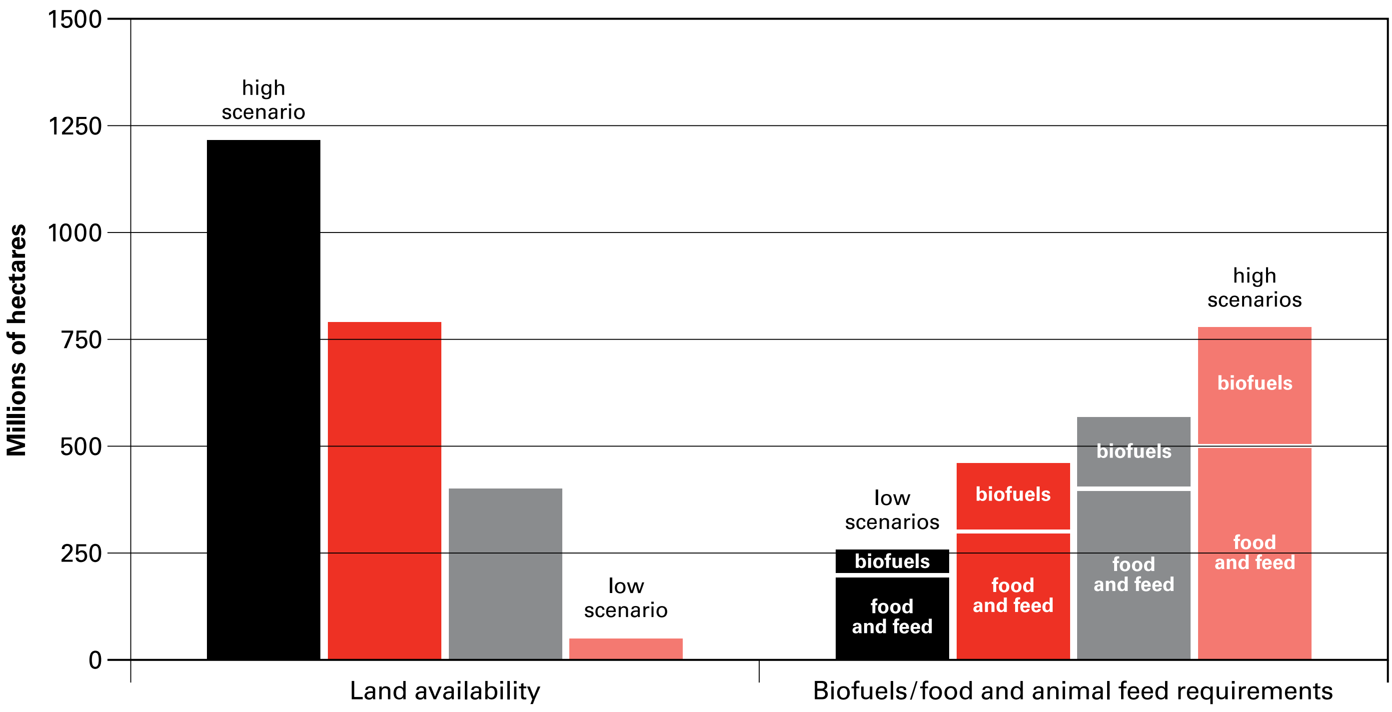
Current estimated total cropland in use is 1.5 billion hectares – biofuels feedstocks take up around 13.8 million hectares or just under one per cent of this total. If major biofuels targets are to be met this would increase to between 56 and 166 million hectares by 2020 – a major proportional change. Focusing on those biofuels that deliver the best carbon savings will put the world at the upper end of that range because such crops demand more land.[112]

This provides a valuable reality check for any proposals for using biofuels as a method of decarbonising the world's economy. The IEA's vision of the potential of biofuels sees it providing 10 per cent of global petrol demand in the future.[113] Substituting 10 per cent of global transport fuels would require seven per cent of the world's arable land.[114] To put it mildly this is likely to have a substantial impact on global food supply and trading patterns.

Just how much land is available for agriculture, but currently unused, is a key question. Regions such as North Africa, South Asia and to some extent East Asia are already using most of the available land, but there are considerable reserves of land in sub-Saharan Africa and Latin America that could be used. However, much of this expansion is expected to be at the expense of forests.[115] As well as sub-Saharan Africa the *Gallagher Review* also points to the

> ‘Buy land, they’re not making it anymore.’
> Mark Twain

Figure 4: Comparing different scenarios of possible future land availability against different scenarios of increased demand for land use



Source: Research commissioned for and summarised by *The Gallagher Review of the Indirect Effects of Biofuels Production*, UK RFA

former Soviet Union as an area where there are significant tracts of unused agricultural land.[116]

Globally the statistics seem uncertain but tend to indicate that idle and fallow land can play a major part in meeting increased land demand, but this is unlikely to prevent the need for land-use change.

There are also possibilities for meeting increased demand for land by making use of degraded, marginal or disused land. However, estimates of the scale of such stocks of land are varied and controversial. One person’s marginal land is another’s vital grazing territory. It is crucial that an international definition of marginal land is agreed and that it is one that focuses on land that is low in carbon stocks and ecological significance, but also one that respects the rights of indigenous peoples and their claims to the land.

Figure 4 contrasts the different scenarios of potentially newly available land and increased demand for land for both food and feed and for biofuel production in 2020. This analysis was compiled for the *Gallagher Review*, based on figures from the European Environment Agency, the International Institute for Applied Systems and research they commissioned from CE Delft.[117]

Comparing the extremes of such analysis, the implications, at their worst, are that we don’t have enough land to meet projected food needs, let alone additional biofuels production needs. In most combinations the projected implications of biofuels’ demand for land is considerable, and dramatic, but not impossible. Given that what is at stake is the ability of the planet to feed itself – particularly in the case of those people who are most vulnerable and have the least power over their own lives – an element of caution is warranted.

It cannot be assumed that land that can support agriculture will be put to use. All the constraints that prevent the use of the land at the moment – whether instability, conflict or lack of capacity – will generally still exist. The international community must identify new resources and find new political will to address such constraints before making plans to use such land.

Even when such 'safe' land is available, there is no guarantee that biofuel and other agricultural production will be directed on to it rather than carrying on with current practices of displacing small farmers and destroying carbon sinks. Changing this will require positive policy choices. A key element of this is accounting for the emissions that arise from land-use change. While macro-calculations about the availability of land can be reassuring, the implications of current misdirected biofuels policies should not be ignored.

Whose land?

Although land has always been bought and sold, a new development in Africa that is a particular cause for concern is the manner in which foreign governments are buying up huge areas for their own purposes.

Recently, South Korean company Daewoo announced that it was to lease 1.3 million hectares of Madagascar for 99 years, to grow maize and palm oil for food and biofuels. There was widespread resentment at the plans, which were labelled as 'neo-colonialism' and have now been put on hold. But similar deals that have been completed by China, South Korea and a number of Middle-Eastern countries have led to talk of a 'new scramble for Africa'[118] and a 'land grab'.[119]

As land becomes increasingly scarce through pressure for food production and other land use, the rush for biofuels will only exacerbate matters. The rush for jatropha in Africa is clearly part of this and is leading to significant acquisition of new land by many companies. For example, in Tanzania the Dutch company Bioshape has bought up 80,000 hectares of woodland for a new jatropha plantation. The company apparently plans to develop only 60 per cent of the land in order to retain biodiversity.

Similarly, UK company Sun Biofuels has been given – apparently for free – 8,000 hectares of land in Tanzania on a 99-year lease. This land is in close proximity to 11 villages and initial reports accused the company of displacing 2,840 households, or 11,277 people. Independent commentators indicate this is not the case but that the company has acquired uncultivated land used as a source of firewood, fruit and herbs. The impact on local livelihoods is as yet unclear.[120] Sun Biofuels also recently purchased seven former tobacco farms covering 5,000 hectares in Mozambique, to develop jatropha plantations.[121]

D1-BP[122] has an interest in approximately 257,000 hectares of planted jatropha, as of 31 December 2008, mostly in India and southern Africa.[123] Some reports have indicated that

Jatropha and the myth of marginal land

Jatropha's ability to grow on marginal land not fit for any other purpose seems to suggest an answer to the land debate. However, if jatropha is to be commercially grown then marginal land is not suitable. For the yields required for commercial use, jatropha plants need fertile soil and rainfall of between 500mm and 600mm a year.

For example, jatropha trees grown in plantations in Senegal's Touba zone, which receives below 500mm rain a year, were carrying very few fruits in the summer of 2008. The areas with the greatest potential for economically viable production in Senegal are in the east and in the south, both averaging more than 800mm of rainfall a year. There, plantations will compete with existing food production.[124] In addition, these monoculture plantations will increase the danger of soil erosion, nutrient and groundwater depletion, and threaten biodiversity. They may also displace communities and deprive them of their livelihoods without adequate compensation.

Burkina Faso meanwhile has, according to the UK biofuels company D1-BP Fuel Crops in Burkina Faso, an 'abundance of semi-arid land' suitable for jatropha. However, jatropha production is already taking place in the southern and southeastern areas of the country, which are more fertile and have a higher rainfall. D1-BP, which is piloting jatropha cultivation in Burkina Faso, is planning to build a dam to supply water to some of its production schemes.[125]

In Tanzania, a study undertaken by a Ministry of Agriculture research institute listed jatropha as a suitable crop in the coastal areas, the lowland hinterlands and in the western highlands close to Lake Tanganyika. The drier areas at the centre of the country were not recommended as suitable. The coastal hinterland has easier access to infrastructure and to export markets and is also the area in which European companies such as Sun Biofuels and Bioshape are planning to invest.[126]

Overall the picture is vastly different to that painted by some African governments and biofuel companies, who claim that they will produce jatropha in the vast areas of 'wasteland' they believe are available across Africa. The concept of 'wasteland' itself is highly disputed, given that pastoralists use some of this land for grazing, and other rural dwellers have a variety of uses for such land.

D1-BP's parent company D1 Oils plc had reached an agreement with the Burkina Faso government to acquire 999,000 hectares of land earmarked for future jatropha production.[127]

The impact of this land acquisition is as yet unclear and may well depend on the terms under which such land is acquired. However, some of the potential problems caused by unfair land distributions can be seen in Latin America. For example, the Honduran government wants to extend palm-oil plantations to 200,000 hectares to satisfy the national demand for biodiesel.[128] The African Palm can live in flooded areas and palm-oil production actually increases if the trees are grown in land that is flooded at certain times of the year. Communities supported by Christian Aid in the village of Panama, in the Tocoa region, report that palm-growing companies are digging channels between rivers to increase water to the plantations, but this is also increasing the risk of flooding in nearby communities.

Shortage of land is already forcing some families to grow their crops on small islands in the river that are inevitably submerged several times a year.[129] When asked by Christian Aid why they were choosing to plant in such locations – given the likelihood that they will lose their crops 50 per cent of the time – they were told that palm-oil producers take all the good land. On visits to these areas the expansion of palm-oil plantations is clearly visible and communities can be found entrenched in small areas between them.

Similarly, one of the bitterest and most important issues to poor communities in Brazil is land reform. Land ownership is largely in the hands of the wealthy: according to INCRA, Brazil's national land reform body, three per cent of rural properties have more than a thousand hectares and take up 56.7 per cent of the agricultural lands in Brazil.[130] Christian Aid's partner MST campaigns for large-scale land reform and recently organised protests and occupations of INCRA buildings in eight states. Protesters called for urgent action on behalf of the 150,000 families, camped under plastic tarpaulins alongside the highways throughout Brazil, awaiting settlements of land.[131]

Brazilian NGOs such as MST are concerned that biofuel production is leading to further concentration of land ownership. Land reform seems to have become the forgotten issue in the development debate, with major donors preferring to concentrate on private sector promotion measures.

There is real concern that more sugar cane and soy will inevitably lead to further large expansion of the monoculture plantations that already dominate the production of these two crops. This would have direct impacts on both the likelihood of effective agrarian reform and the livelihoods of communities who are caught up in the expansions. The 2005-06 figures for the area cultivated for sugar cane show around 6.2 million hectares planted. This is expected to rise to 9 million hectares – with some predicting this will happen by 2011-12[132] and others by 2013[133] or 2015.[134] The government has reportedly said there is currently up to 90 million hectares of unused agricultural land.[135]

Land and biofuels

The absolute limitations on available land provide a limitation to any proposed use of biofuels. And the power imbalances that come into play when land issues come up mean that poor people's rights are intrinsically threatened by increased demand for land.

Previous chapters have established that biofuels do exist that provide income or energy for small farmers, and some small sustainable carbon savings. But producers of such biofuels will need to be sensitive to the issues around land. While there seem to be stocks of available land that are suitable for expanding agricultural production (for both food and biofuels production) any such expansion will need to be actively and sensitively directed. Present biofuels policies do not address this. At the very least, industrialised country governments and the various private sector groups supporting biofuels expansion must dramatically scale down their ambitions. It is virtually certain that biofuels will not be able to provide ten per cent of global transport fuel demand except at massive cost to poor people and the environment.

CONCLUSIONS AND RECOMMENDATIONS

Many biofuels emit more carbon than the fossil fuels they are intended to replace. But carbon savings are possible with some select biofuels, produced in certain ways, on certain types of land. Policy makers need to examine carefully what cost-effective carbon savings can be realised from biofuels and how.

Many biofuels worsen serious social and environmental problems. But there are biofuels projects that deliver small-scale production, safeguarding food supplies, the environment and local people's rights.

Biofuels compete with other crops and therefore directly impact on global agricultural markets. And because key resources such as land and water are finite and under pressure, there are very real limits to any potential benefits that biofuels can bring.

Arguments around biofuels often seek to identify 'good' or 'bad' biofuels, but while some are self-evidently more useful than others, the solution cannot be presented so simply. The problem is not with the crop or the fuel – it is with the policy framework around biofuel production and use.

Without active and expensive government support, biofuels would be little more than vanity projects. Such policies shape the types of fuels that are produced and used. So far, most policies have self-evidently been mistaken – leading to biofuels that increase carbon emissions, drive up food prices, encourage the displacement of farmers, conflict and labour abuses and cause environmental damage, all at great financial cost.

Is there a 'good' – sustainable, pro-development, low-carbon – policy framework for biofuels? Christian Aid believes that there is. This chapter will attempt to set out the basic shape of such an approach. Nothing less than a new vision of biofuels is required, and one with poor people and small-scale, multi-crop producers at its heart.

The vision required is not one that is geared to supplying significant quantities of transport fuels for industrial markets. Instead it will be geared towards providing clean decentralised energy, self-sufficiency, and rural development in the developing world.

A limited role

The increasingly ambitious claims made for the potential of biofuels by many governments do not ring true. In a world where agricultural production is being increasingly squeezed – and where climate change impacts are becoming more and more apparent – there simply isn't enough land to imagine biofuels being a long-term sustainable option for providing for the world's transport needs.

Moreover, biofuels are not particularly cost-effective. Industrialised countries have sunk huge amounts of money into subsidies, or effective subsidies, for biofuel production while ignoring other, more effective and cheaper carbon savings. Biofuels cannot be the only or even the main way of addressing emissions from transport. Industrialised countries have to bite the bullet and urgently address the emissions of this sector in a realistic and cost-effective way – through demand management and other options like increasing electrification of transport, not through biofuels. Sustainably produced biofuels that can be certified to deliver real emissions savings may play a limited role in helping bring down emissions.

The impact of significant market intervention by rich countries in the commodity markets on which poor people depend can be seen in the rising food prices in Central America. The result is dramatic price changes that poor people are ill equipped to bear. And now, any sudden cessation in such market interventions itself has the potential to cause further changes, and these may also see poor people losing out, albeit producers rather than consumers.

Numerous powerful civil-society voices – including major groups such as Via Campesina, the international peasants movement – have called for a moratorium on biofuels support from industrialised countries.[136] They want the immediate removal of EU and US targets and subsidies. Christian Aid strongly agrees that the current approach behind biofuels expansion is fundamentally mistaken. However, the sudden removal of such targets and subsidies would be likely to cause further instability in commodity markets such as maize, sugar cane and vegetable oil.

As a result Christian Aid believes industrialised countries should not abandon their support for biofuels (whether subsidies or targets) but should freeze them at current levels and abandon all plans to scale up.

They should then re-design their biofuels programme so that they only support fuels that deliver real carbon savings and real social benefits without significant costs to the environment. In doing this they should respect the right of developing countries to prioritise biofuels use for domestic markets. When this is done it may be possible to gradually increase the levels of biofuels used – but it is still highly unlikely that biofuels would be able to match the levels claimed for them by groups such as the IEA.

Real carbon cuts

EU and US subsidies and quotas have tried to hit three targets simultaneously – cutting GHGs, ensuring energy security and delivering rural development. In response to the climate crisis, cutting GHGs should be the priority – but it is the target that has been least addressed. In fact, as biofuels targets from industrialised countries have favoured local production, and kept competitors such as Brazil out of markets by imposing high tariffs, they have often been a cover for the same protectionism by industrialised countries that has sunk trade talks and damaged poor people's livelihoods in the developing world.

Given the huge spending needed to tackle climate change and support sustainable development, the sheer waste of money associated with much current support of biofuels is nothing short of an outrage.

Industrialised countries should replace blunt biofuels quotas and subsidies with targets for cutting the GHG emissions from the transport sector, and proposals to certify the GHG savings of biofuels where they exist. Any GHG analysis of biofuels must take into account the whole life cycle, including all land-use change impacts.

There has been a collective move to adopt sustainability standards for biofuels to ensure that environmental benefits are real. Such standards schemes have been criticised as being incomplete – for example, few map the impact of biofuels on soil degradation or water use, and none address social problems caused by biofuels.

Groups backing the moratorium on biofuels have rightly criticised this entire approach as failing to tackle the structural impacts – such as distortion of commodity markets and the shift in the balance of power between agro-industry and small farmers. Even if biofuels were sustainable and fairly produced, other crops would not be and would be put under extra pressure by biofuels production.

Such standards will not solve all the problems associated with biofuels and should not be seen as a quick fix that could allow their massive expansion. They do not justify a production model of biofuels that is essentially unsustainable. However, certifying the real carbon saving over the life cycle of any biofuel, including direct and indirect land use, is essential for judging whether any biofuel has anything to contribute in the battle against climate change.

It may be that some specific biofuels are cost effective in bringing down GHG emissions – but the initial form of the technology is well established and should be allowed to compete with other options without government subsidy. Some government support for research and deployment of 'next-generation' biofuels may be appropriate.

A local role

Solutions to climate change that are based on maintaining lifestyles in rich industrialised countries at the expense of poor people's rights are not only unjust, but also unlikely to gain the wide legitimacy required of a global solution. Current biofuels production can partly be characterised as global production to rich country demand. Such an approach has very little to offer the increasing numbers of people in the developing world who aspire to a better life.

However biofuels can be produced from an increasing variety of plant-based sources – creating an opportunity for many countries to produce a local source of energy. Sustainable production for local use has the potential to create localised economic benefits while minimising environmental impacts. But this will only take place if the policies to encourage such production are put in place.

Such production is not intrinsically low-carbon or environmentally or socially sustainable. However, where biofuels feedstocks are sustainably grown on small-scale farms without interfering with food production, with sensitive land-use policies, and farmers can obtain fair prices for their crops, then the environmental and social problems can be minimised and benefits maximised.

Small-scale family farmers cannot afford to damage their local environment – they rely on it for their livelihood. They rarely have a big carbon footprint and they will not grow anything that does not bring them and their communities some benefits.

Possibilities to scale up such small-scale production through cooperatives or, possibly, fairly organised outgrower schemes, should be investigated.

Recommendations

1. Biofuels should not be included in any UNFCCC agreement regarding coordinated global action to tackle climate change.
2. The EU should freeze current levels of support for biofuels and should bring forward the review of its biofuels policies currently scheduled for 2014.
3. The UK should ensure any support for biofuels used within the UK is focused on biofuels with significant carbon savings (of at least 50 per cent, after factoring in indirect land-use emissions).

BIOFUELS PRODUCTION – SOME KEY PRINCIPLES

Christian Aid believes that biofuels production:

- can be only a very limited part of the global economy and offers limited benefits in tackling climate change
- can deliver carbon savings – but such savings are not guaranteed and need to be clearly identified, including allowing for all land-use impacts
- should be subsidised only on the basis of self-sufficiency, support to small farmers and a shift towards decentralised clean energy for the poor.

Based on the above analysis, the core principles guiding our approach to biofuels production, support and use are:

Biofuels production

- Small-scale production mobilised through cooperatives to maximise benefits to poor communities and minimise environmental impacts is clearly our preferred option.
- Any use of land that has high levels of embedded carbon – such as rainforest or peatlands – must be avoided. New biofuel crops should be grown on idle and marginal land. Land use should be minimised.
- Energy and carbon inputs should be as low as possible. In particular, efforts to ensure that any power used is as low-carbon as possible are likely to pay off in cutting carbon emissions associated with biofuels production.
- Use of nitrogen fertilisers and other high GHG-emitting inputs should be minimised.
- Full use should be made of co-products of biofuel production (or biofuel co-products of other agricultural production).

Research needs

- Further analysis of carbon emissions of nitrogen fertilisers is required and where such fertilisers are used their GHG emissions must be taken into account.
- Holistic analysis of the environmental impacts of any biofuels production is vital – especially on water and land use.
- Life-cycle analyses of biofuels impact must be improved and made more reliable. They must include direct and indirect land-use change impacts.

Developing countries that produce biofuels

- Christian Aid believes that countries should generally prioritise feeding people and providing local energy needs over producing biofuels for export. This means much more attention needs to be paid to small-scale localised approaches, and land and water impacts of growing new crops such as biofuels should also be taken into account.
- Attempts to take advantage of the market opportunities of biofuels should be subject to assessments of the proposed project's impact on land use, groundwater use, soil structure, water pollution, biodiversity, GHG emissions, as well as the incomes and livelihoods of surrounding communities. If such sustainability impact assessments show threats to the natural resources on which communities depend for their livelihoods and food, Christian Aid believes they should not be approved.
- Land rights must be respected, including the rights of indigenous people and pastoralists who may depend on land for their livelihoods but who may lack a recognised formal claim to the land.
- There should be national debate and community participation in any move to identify biofuel production as a national strategy.

Industrialised countries

- Industrialised countries should focus on the most cost-effective ways of bringing down transport emissions, such as promoting the use of public transport, walking and cycling and imposing tough carbon efficiency standards for cars.

- In the longer term, industrialised countries should look carefully at what might be the most appropriate technology to provide low-carbon transport. It seems likely this will involve the electrification of the transport sector.
- The EU and the US should urgently scale down their ambition for biofuels – freezing their support at current levels and reconsidering their entire approach to biofuels before contemplating any further increase.
- Market interventions, whether through subsidy or quotas or other methods, should be carefully designed to be proportionate to the real contribution that biofuels can make and should be targeted at real GHG savings.
- Volume or energy quotas for biofuels should be replaced with carbon-saving targets or efficiency standards, with accurate carbon-certification of biofuels used to meet those targets.

Global policy

- Any significant public support for biofuels must be based on real carbon savings – ultimately, mandatory carbon certification must be introduced.
- Taking a scaled-down approach to biofuels should reduce the pressure on both food prices and land changes. However, in both cases biofuels production is just one factor among many and should be treated in this way. Efforts to address wider pressures on land use must be brought forward.
- Any new agreement under the UN Framework Convention on Climate Change (UNFCCC) must include strong measures to stop deforestation and protect carbon sinks such as tropical rainforests, wetlands and peatland.
- Ultimately any international approach to climate change should seek to ensure the costs of different solutions are comparably priced so the most cost-effective approach to the issue can be adopted.

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