

**DSA/DFID Policy Forum: International Development in the Face of Climate Change:  
Beyond Mainstreaming?**

**University of Greenwich, Maritime Greenwich Campus, Monday 02 June 2008**

**Discussion Group**

**Biofuels**

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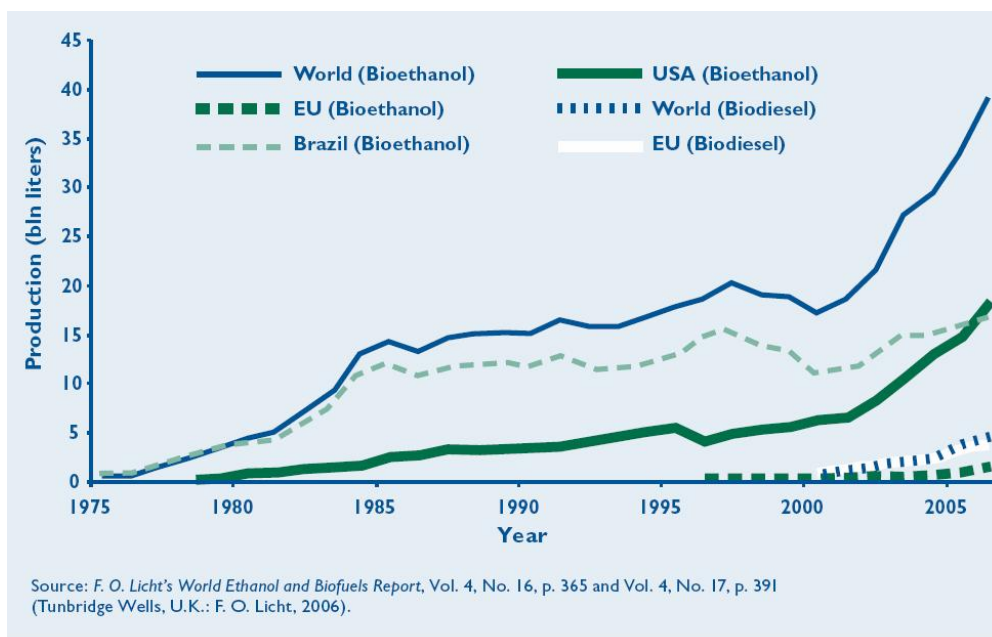
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**Introduction**

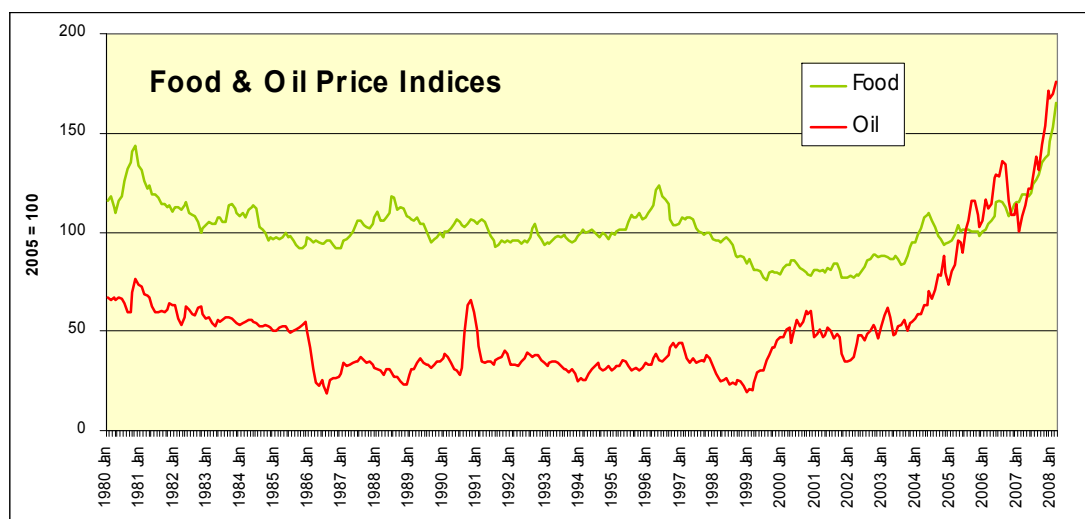
The production of biofuels, mainly bio-ethanol and biodiesel, has increased greatly during the last five years, see Figure 1, spurred by rising oil prices — see Figure 2 — and policy to encourage their use, see Box A below.

Biofuels are currently produced as follows: either as ethanol distilled from any crop that contains sugars and carbohydrate, such as maize, wheat, sugar cane, and sugar beet; or as biodiesel processed from vegetable oils, including those from oil palm, rape seed, and jatropha.

**Figure 1: Production of biofuels, 1975 to 2006**



**Figure 2: Rising oil prices, 1980 to 2008**



Source: IMF commodity indices

Moreover, production is expected to increase since many of the world’s largest economies have plans to expand output, implemented either by mandatory targets for the use of biofuels as a substitute for fossil fuels for transport, or with tax incentives and grants to encourage their use — see Box A.

In most cases, the main reason for these policies is to cut greenhouse gas (GHG) emissions to mitigate climate change. Biofuels promise low emissions compared to fossil fuels since any carbon released in use of the fuel should be just the carbon that the feedstock absorbed during plant growth. But there are additional motives of trying to save on the cost of imported fossil fuels; and, above all in the case of the USA, the desire for ‘energy security’ — that is, sourcing an increasing fraction of energy from within national territory and thereby lessening dependence on imports.

**Box A: Biofuels targets and policies**

Countries	Targets
EU	5.75 percent by 2010, 10 percent by 2020 <ul style="list-style-type: none"> <li>• France: 5.75% by 2008, 7% by 2010, 10% by 2015</li> <li>• Germany: 6.75% for 2010, 8% 2015</li> <li>• Italy: 5.75% by 2010</li> <li>• UK: 5% by 2010</li> </ul> 2020 target subject to sustainability rules as well as commercial availability of second generation biofuels
Russia	No targets
Australia	1 percent by 2010 — or at least 350 million litres of ethanol or biodiesel
Japan	To use 500M litres of fuel derived from biomass in fuel for transport by 2010, through promoting the use of E3, as a prelude to a national E10 blend standard by 2010.  Ethanol dominates biofuels in Japan. Currently, fuel-use ethanol is not made or used commercially in Japan while only about 2000kl of biodiesel is produced annually.
China	Biofuel development policies are aiming to increase ethanol

	production to 6M tonnes by 2010 and 15M by 2020. <sup>1</sup> 15% of transport energy from biofuels by 2020. Until September 2007, main biofuel produced was ethanol from maize. Since then "Agriculture Biofuels Industry Plan" announced that shifts away from food grain feedstock to non-food crops such as sweet sorghum and cassava.
Thailand	Targets for biofuel use in 2010 equate to 2% of projected energy needs.
Malaysia	Target for biodiesel incorporation to reach 5% standard diesel
India	2007 new biofuel policy set mandatory ethanol blend will rise from E5 to E10 by October 2008. Sugar mills permitted to convert cane juice directly into ethanol — previously molasses were the only permitted feedstock. Target of 20% of diesel from biodiesel by 2011/12.
USA	US Energy Bill, ratified August 2005, sets quantity of renewable fuels for 2012 at 7.5 billion gallons (28G l). 2007 act requires 15G gallons fuel ethanol by 2015 and 36G gallons (136G l) fuel ethanol by 2022. Given WEO projections of US fuel consumption of more than 900G l by 2020, the US targets equate to around 15% replacement. Under new act, 21G gallons of the 36 stated by the act will need to be produced by advanced biofuels by 2022
Canada	5% renewables in gasoline by 2010; 2% renewables in diesel by 2012
Mexico	Blending to begin from 2010 2012 target of 300k ha of feedstock to produce 13.2M tonnes of biomass <sup>2</sup>
Argentina	5% by 2009
Brazil	All gasoline sold in Brazil must contain 20–25% ethanol blend An incorporation rate of 2% for biodiesel by 2008, 5% by 2013.
South Africa	Up to 8% by 2006, 10% target being considered

Sources: DEFRA 2008, FAO 2008

Although most of the targets do not contemplate more than 15% of transport fuels coming from biofuels by 2020, the amounts of biofuels required are large and imply substantial quantities of land being used to grow feedstock. For example, if the entire production of seven of the main crops in the world — wheat, rice, maize, sorghum, sugar cane, cassava and sugar beet, planted on 500M ha or 42% of cropland, were used to produce ethanol, this would still only cover around 57% of petrol used currently in the world. Switching one quarter of these crops to produce ethanol would allow 14% of petrol to be substituted by biofuels. (Rajagopal et al. 2007)<sup>3</sup>

An uncertainty is the emergence of 'second generation' technology that would allow ethanol to be produced from cellulose and lignous (woody) matter at a cost competitive with current biofuels, thereby potentially allowing all kinds of low value biomass such as grasses, shrubs,

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<sup>1</sup> F.O. Licht (2007). World Grains Markets Report, September 2007.

<sup>2</sup> Source: <http://www.eleconomista.com.mx/articulos/2008-05-07-62201>

<sup>3</sup> The oil economy is worth a similar amount to the world agricultural economy. For 2002/04 the latter was worth, net in 2000/01 prices, US\$1.4T (FAOSTAT archives). In 2005 the world consumed over 83M barrels of crude oil a day (WEO 2006). If valued at US\$50 a barrel, this equates to US\$1.5T.

residues and waste matter to be used as feedstock. With this technology in place, the economics of biofuels could change substantially. Pilot plants exist. But it is unknown just when this will be commercially viable: estimates range from 2015 to 2030.

### **Key questions about biofuels**

The expansion of biofuels production prompts four key questions, namely:

- Will it harm the poor by pushing up the price of food?
- Will it lead to removal of tropical forest and other environmental damage?
- Will it save on GHG emissions?
- Do biofuels represent an opportunity for poor farmers in developing countries? How do biofuels compare to other energy alternatives in the developing world?

These will be reviewed in turn.

### **Biofuels, the price of food, poverty and hunger**

The emergence of a major new demand for land and other factors of production is likely to drive up the costs of production of other agricultural outputs. But how strong is this effect? Considerable work has been done to model the impacts of expanded biofuels production, studies varying in the scenarios they consider, and whether they use partial equilibrium models of agricultural markets or general equilibrium models of the economy as a whole.

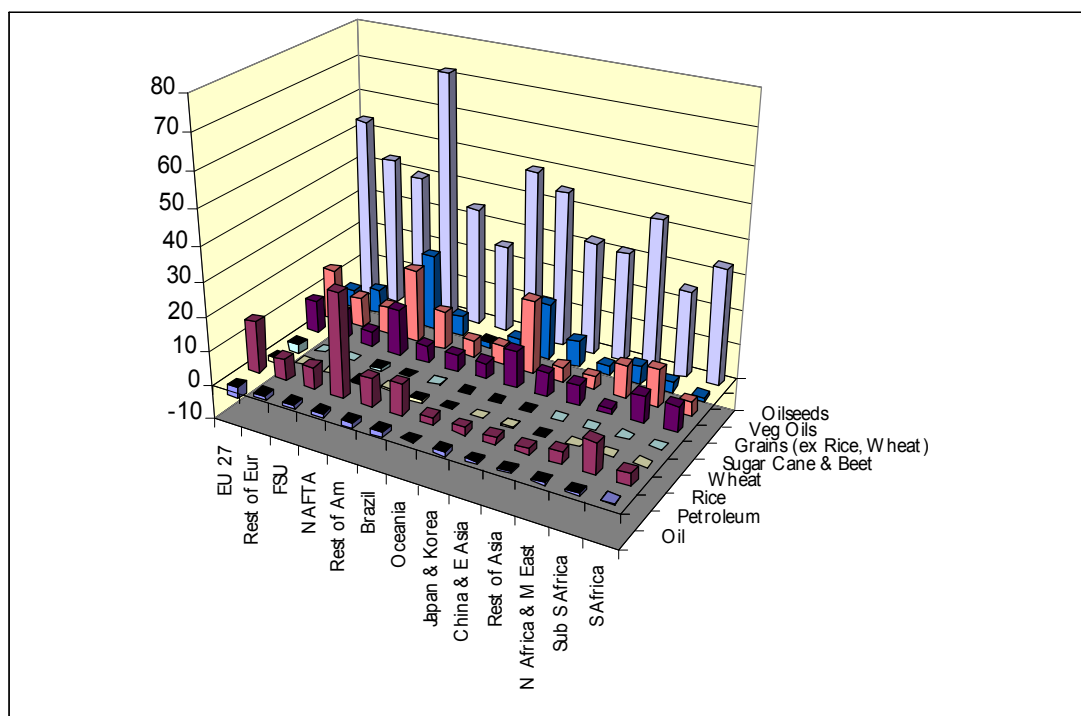
IFPRI's IMPACT model is a good example of a partial equilibrium. Posing the question of how much the prices of other key foodstuffs might be affected by reaching targets set in the USA, Brazil and China, and assuming 20% replacement of fossil by biofuels elsewhere by 2020, Msangi et al. (2007) estimated the impact of biofuels on prices of maize, oilseeds, sugar cane and wheat. The results, see Figure 3, show large increases in prices — even allowing for second generation biofuels technology to come on-stream in 2015, and for improvements in yields (the 'plus' in the third scenario in Figure 3).

### **Figure 3: IFPRI estimates of changes in world prices from major expansion of biofuels in 2020**

Source: Msangi et al. 2007

An alternative view comes from general equilibrium modelling, using a lesser expansion of biofuels, in this case North America and the EU replacing 10% of their fossil fuels by biofuels (McDonald & Levy 2008 in Wiggins et al. 2008).<sup>4</sup> This generates the results seen in Figure 4.

**Figure 4: CGE estimation of price changes from the EU and North America replacing 10% of transport fossil fuels by biofuels:**



In this case the price increases are less and essentially restricted to feedstock: oilseeds, maize, sugar cane and beet. Wheat and rice prices are little affected in this model.<sup>5</sup>

The impact of the increased prices of agricultural commodities on prices paid by poor consumers in the developing world depends in part on the degree to which world commodity prices affect local retail prices for staple foods. Processing, transport, and distribution costs should not rise in response to biofuels, so some dampening will be seen. For some landlocked countries, especially in Africa, the local price of staples is for most of the time insulated from the world market price by high transport costs and depends more on domestic supply and demand.

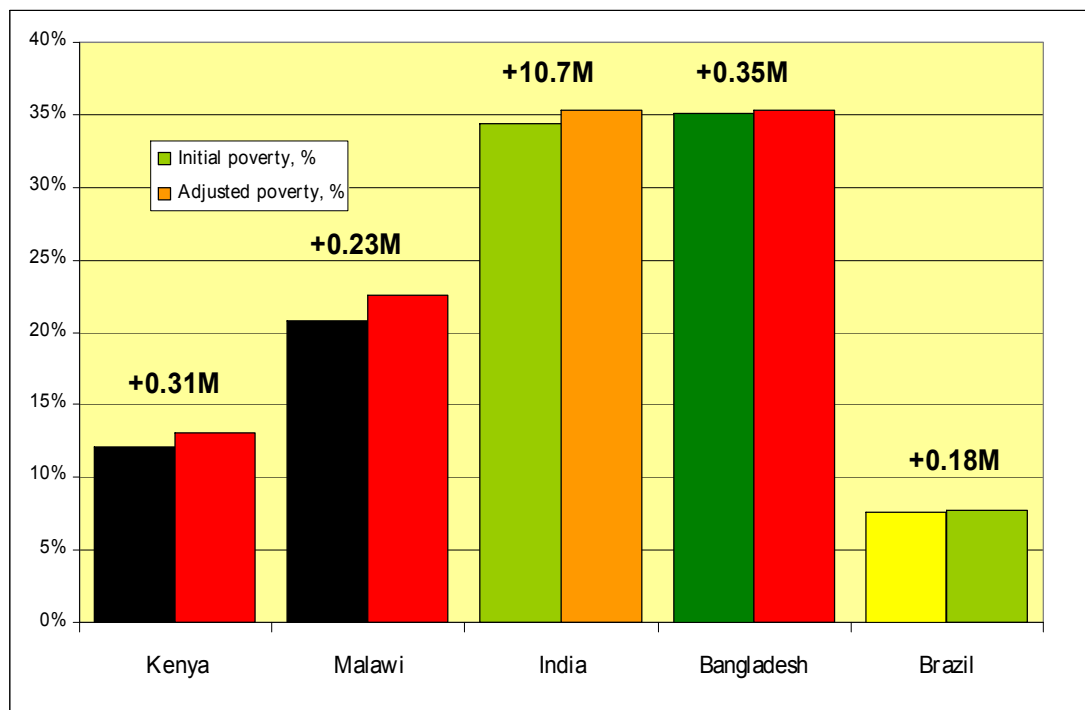
Predicting with any degree of precision the impact on poor consumers would thus require sophisticated and detailed models that by and large do not exist. But a simple calculation can set some bounds to the impact. Suppose that transmission was not muted and that a 10% rise in the world commodity price was reflected entirely in local retail prices; and suppose that consumers continue to eat the diet they always have, with no adjustment in the composition of the food budget in response to changing prices; then what would be the impact in terms of reduced real incomes and the increased numbers living in poverty? The two assumptions will overstate the impact, so the result of this calculation gives a high-side estimate. The results for five representative developing countries, based on the price increases predicted by the general equilibrium model, appear in Figure 5.

<sup>4</sup> Using a global equilibrium model with GTAP database, augmented with biofuels data from LEI, NL.

<sup>5</sup> An interesting outcome of general equilibrium modelling is that replacing crude oil by biofuels depresses the oil price.

As Figure 5 shows, poverty headcounts rise in all cases, although in most cases by less than one percentage point. The absolute numbers in poverty as a result in most cases is few hundred thousand, although in India the number is 10.7M. The impacts are unwelcome, but small: small enough to be countered in most countries by feasible social protection measures.

**Figure 5: Impact of projected price rises on poverty in selected developing countries**



Source: Based on FAO data on food budgets and the World Bank's PovCal. The numbers show the absolute increases in the numbers living in poverty.

### Biofuels, land use and greenhouse gas emissions

Growing biofuels does not result in zero emissions of greenhouse gases (GHG). Machinery used in cultivation and processing often uses fossil fuels. Nitrogenous fertiliser tends to lead to emissions of nitrous oxide, a particularly powerful greenhouse gas, from cropped land. Hence savings over use of fossil fuels are less than 100%: for most feedstock emissions relative to fossil fuels lie in a range between 30% and 60%; but there are some cases where the emission may even be more than 100%, implying not saving at all.

Savings on emissions decline further if the effect of land use change are taken into account. If the land used to grow biofuels is converted from another use — for example, set-aside fallows in the EU, tropical forest for palm oil, grasslands for soy, etc. — large amounts of carbon (C) may be released.<sup>6</sup> This effect can be both direct and indirect, as for example, when switching between crops in one country leads to expanded production in another — the most cited example being US maize replacing soybeans in the USA that are then made up by increased planting of soy in Brazil.

Assessing the net outcomes of such land use changes is not easy. Controversy has broken out over the degree to which produce from land being switched into biofuels can and will be replaced by, on the one hand, increased yields; or, on the other hand, by expanding the

<sup>6</sup> Particularly alarming emissions occur when tropical forest is cleared and when peatlands are brought into cultivation.

cultivated area and in the process converting grasslands and forest into arable land. Searchinger et al. (2008) claim that US biofuel production from maize will lead in large part to expanded plantings of soy in other countries, notably Brazil, and that the carbon released from conversion of land in these countries will completely wipe out any GHG savings from biofuels. But others are less convinced and argue that increased land productivity will make up the deficit.

Table 1 shows an attempt to estimate the range of savings. In roughly half of the cases seen, there are no net savings on emissions — only the cells with minuses show net savings. But the range of estimates is quite wide, and in two cases the range runs from net savings to net additions. The science is as yet inexact.

**Table 1: GHG Emissions including indirect land use change**

Biofuel	Feedstock	Origin	Kg CO <sub>2</sub> eq/GJ			Saving relative to petrol/diesel		
			Max	med	min	max	med	min
Biodiesel	OSR	EU	117	89	60	38%	4%	-30%
Biodiesel	palm oil	Indonesia, rain forest	180	142	103	112%	67%	21%
Biodiesel	palm oil	Brazil, tropical	199	154	110	135%	82%	<b>29%</b>
Bioethanol	sugarcane,	Brazil, tropical	60	48	37	-30%	-43%	-56%
Bioethanol	maize	USA	89	73	57	5%	-14%	-33%
Bioethanol	maize	EU	69	60	50	-19%	-30%	- <b>41%</b>

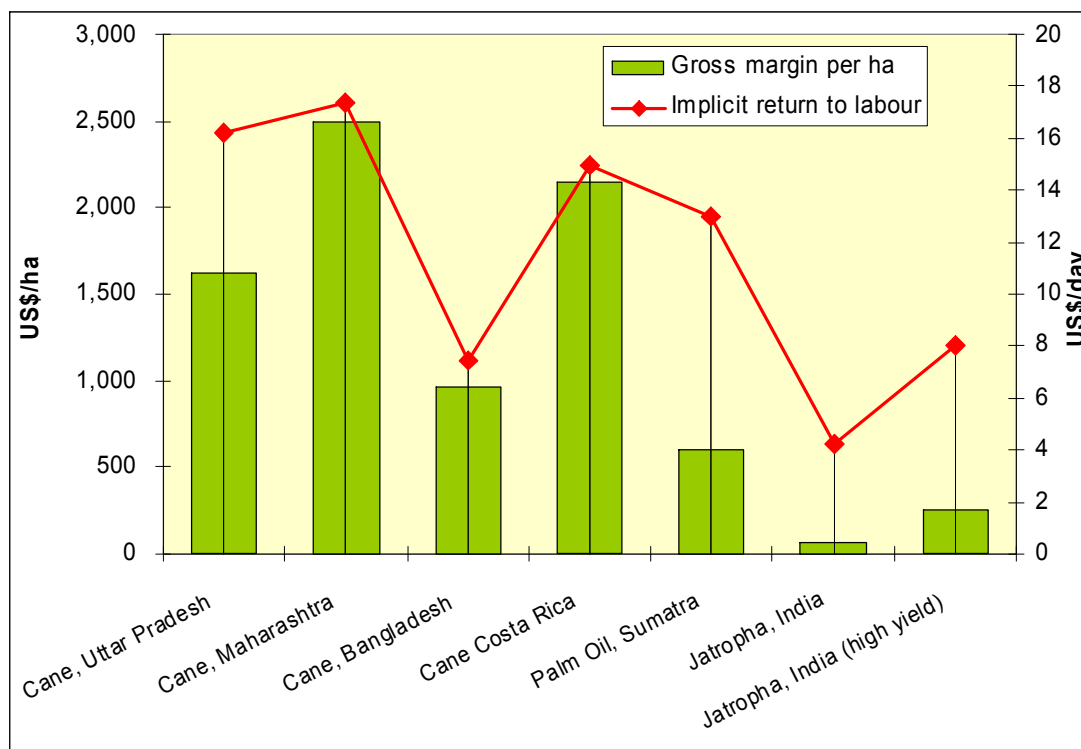
Source: Estimate by Fritsch and colleagues, 2008

To some extent net emissions may be reduced if processing produces valued by-products (co-products) that thereby do not have to be produced elsewhere and thus save on any emissions incurred in their production. For example, feed wheat distilled into ethanol in the UK will produce a protein meal which is a good substitute for soybean meal that would otherwise be imported from Brazil. Hence distilling wheat could save on emissions from soybean fields in the Cerrado.

### **Biofuels and opportunities for the poor in developing countries**

Given few existing studies, one way to approach this is to look at the gross margins per hectare that smallholders growing feedstock — for example, sugar cane for ethanol; palm oil and jatropha for biodiesel — might obtain. To do this, it was necessary to calculate a farm gate parity price for feedstock, and this depends on the assumed price of crude oil — taken as US\$66.5 a barrel, USDA's forecast for 2016/17, in 2006 values. The results are summarised in Figure 6.

**Figure 6: Gross margins and returns to labour in biofuel feedstock production**



Sources: Diverse, see Wiggins et al. 2008

Growing sugar cane to ethanol potentially gives excellent returns. In countries with spare land suitable for cane, there may be great opportunities for the poor either as small farmers or as labourers on the fields or downstream in processing.

Oil palm similarly gives attractive returns, but it may be that the parity price for oil palm for biofuel lies below the price offered for other uses in industry. Either way, it is no surprise that oil palm is such a boom crop. Opportunities for smallholders are limited by the fairly demanding requirement of oil palm for rainfall or irrigation.

Jatropha, sometimes seen as an ideal feedstock since it can grow on marginal land and so does not compete with food crops, shows more marginal returns. Much depends on the yields obtained, and experience so far has been that yields achieved in practice have been below those expected. It is difficult to see how this crop will be of such benefit to the poor, although in some niches it may have a role — possibly in serving local energy needs.

The general equilibrium modelling provides some support to the existence of opportunities, since returns to unskilled labour rise slightly.

Ideally it would be useful to take the gross margins and estimate the number of hectares and farmers who might be able to take advantage of demand for biofuels. Needless to say, accurate data on land apt for growing feedstock and the numbers of farmers living in such areas are lacking.

In getting the poor to benefit, much depends on getting the biofuel system up and running, including large-scale investments in processing, collection and distribution networks, and vehicle adaptations. Governments need to establish consistent and coherent policy and establish a framework of regulations

A key challenge is to link the big investors to small rural producers, with contract farming very much indicated. It is similarly important that biofuel initiatives be sensitive to conditions of local level governance — rights to land, crops and trees, especially for females; and that they take into account the views of local stakeholders — enthusiastic promotion of biofuels can lose sight of the wider system and the views of key players within it. Above all, there will need to be much learning: it is very difficult to design functioning schemes as a blueprint.

Consideration of country cases show considerable variation in the potential to grow biofuel feedstock, depending in part on the extent to which there is unused or underused potentially arable land.

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### **Recommended readings:**

ODI (2008b) Biofuels and Development: will the EU help or hinder? ODI Briefing Paper January 2008, <http://www.odi.org.uk/publications/briefing/bp32-jan08-biofuels.pdf>

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