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Are Biofuels Good for African Development?

An Analytical Framework with Evidence from Mozambique and Tanzania

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Abstract

Many low income countries in Africa are optimistic that producing biofuels domestically will not only reduce their dependence on imported fossil fuels, but also stimulate economic development, particularly in poorer rural areas. Skeptics, on the other hand, view biofuels as a threat to food security in the region and as a land-grabbing opportunity for foreign investors. As a result of this ongoing debate, national biofuels task forces have been asked to evaluate both the viability of domestic biofuels production and its broader implications for economic development. To guide these complex evaluations, this paper presents an analytical framework that prioritizes …./

Keywords: biofuels, economic development, food security, poverty, Africa

JEL classification: Q56, Q42, O44, O55

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different aspects of a comprehensive national assessment and identifies suitable evaluation methods. The findings from recent assessments for Mozambique and Tanzania are used to illustrate the framework. While these two country studies found that biofuels investments could enhance development, their experiences highlight potential tradeoffs, especially at the macroeconomic and environmental levels, where further research is needed.

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1 Introduction

The recent spike in fossil fuel prices and concomitant increase in global demand for biofuels has prompted many developing countries to consider establishing domestic biofuels industries. Many governments in developing regions like Africa view biofuels as an opportunity to reduce dependence on imported fuels. At the same time, they also hope that biofuels will stimulate economic growth, create jobs and improve rural incomes. It is in rural areas where most of Africa's poor populations reside and where their livelihoods depend heavily on agriculture. Biofuels are expected to provide a new market and income opportunity for these farmers (see FAO 2008). A number of African governments have responded by establishing task forces to assess their countries' potential to competitively produce biofuels, to interact with foreign investors and to help draft biofuels policies.

Optimism over biofuels is, however, matched by skepticism. Some development specialists worry that biofuels are a potentially grave mistake. First and foremost, they view biofuels as a potential threat to food security. Given limited land resources and low farm productivity in developing countries, biofuels could displace food crop production and reduce already inadequate food supplies. Biofuels are also viewed by skeptics as a 'land grabbing' opportunity for foreign speculators. The threat of higher oil prices could prompt governments to sign long term leases for large amounts of (often state-owned) land. Once the leases are signed, speculators may employ inappropriately capital-intensive production techniques or simply use their position to curry further political favour with local elites. In the end, biofuels may never even be produced. The 'food versus fuel' debate and the danger of 'land grabbing' have captured the attention of the development community and local and international media. As a result, national task forces have not only been asked to look at issues of private sector competitiveness and market access, but also at broader development concerns, such as food security and poverty.

Evaluating the long term development implications of producing biofuels is both complex and technically challenging. In this paper, we present an 'analytical framework' to guide researchers in their national biofuels assessments. Key considerations are discussed at the firm/farm, macroeconomic and household levels. To illustrate these, we draw on the findings from two recent studies for Mozambique and Tanzania (Arndt et al. 2010a, 2010b). We discuss suitable analytical methods for evaluating the socioeconomic impacts of biofuels expansion within these countries and, finally, consider some implications for the environment. The rest of the paper proceeds as follows: in the next section we review the state of the biofuels sector in our two case study countries, and present the analytical framework in the subsequent section. A final section summarizes our findings and observations and provides suggestions for future research.

2 Biofuels in Mozambique and Tanzania

Mozambique and Tanzania have much in common with other low income African countries. As shown in Table 1, a majority of their populations are smallholder farmers living in rural areas, where they rely on rainfed agriculture and are subject to frequent weather shocks and food shortages. The main food crops are maize and cassava, which

Table 1: Key statistics for Mozambique and Tanzania

	Mozambique	Tanzania
Population (millions)	22.4	42.5
Rural share (%)	63.2	74.5
GDP per capita (US$)	439.9	496.4
Poverty rate (US$1.25 per day)	74.7	88.5
Share of total GDP (%)	100.0	100.0
Agriculture	25.9	31.8
Food crops	18.2	19.1
Export crops	1.1	3.2
Other agriculture	6.7	9.6
Industry	23.2	23.1
Services	50.9	45.1
Agriculture's share of exports (%)	22.0	47.9
Crops	5.4	33.1
Other	16.6	14.9
Total land area (millions hectares)	78.6	88.6
Arable land	48.8	34.2
Currently cultivated land	4.5	9.0

Notes: Poverty rates are for 2003 and 2000 for Mozambique and Tanzania, respectively, and show the share of the population with expenditure below the poverty line. Agriculture's export share is of total goods exports (excluding services).

Source: World Development Indicators (World Bank 2010). GDP and export shares from Arndt et al. (2010a, 2010b).

are grown using traditional inputs and rudimentary technologies. Production is mainly for subsistence, especially since market access is constrained by inadequate road networks. Ensuring household food security therefore features prominently in these countries' national strategies. Smallholder's access to foreign markets is particularly limited, with most export crops either grown on large estates/plantations (e.g., tea and sugarcane) or via outgrower schemes (e.g., cotton and coffee). Average per capita incomes are low and poverty is high in both countries, reflecting their common challenge of generating pro-poor growth, particularly in rural areas.

Favourable agro-climatic conditions are a prerequisite for a domestic biofuels industry. Mozambique and Tanzania are both well-suited to growing a range of feedstock crops, including sugarcane and cassava for ethanol and oilseeds for biodiesel. Moreover, only a small share of arable land is currently cultivated. Mozambique, for example, uses less than 10 per cent of its potential agricultural land. The country also has untapped water resources for irrigation, and deep-water ports that provide good access to both Asian and South African markets. However, despite these conditions, Mozambique has a far smaller export crop sector than Tanzania. Almost half of Tanzania's export earnings come from agriculture, compared to only a fifth for Mozambique. Moreover, two thirds of Tanzania's agricultural exports are from crops, whereas ocean fisheries dominate in Mozambique. Thus while both countries are well-endowed with natural resources, Tanzania has taken greater advantage of its export crop potential.

Both countries have received considerable interest from foreign investors wanting to establish biofuels processing facilities and feedstock production. Investors are particularly interested in Mozambique. By 2009 the country's government had received requests for 12 million hectares of state-owned land to produce feedstock, of which two million hectares of requests were considered credible (Arndt et al. 2010a). By contrast, the interest in Tanzania has been more modest. The country's five largest biofuels investors submitted requests to the government for almost 400,000 hectares, of which only about 75,000 hectares were granted (Cleaver et al. 2010). Since all land in African countries like Mozambique and Tanzania is state-owned, it is the government that decides which requests are granted.

To some extent, investors' differing levels of interest in the two countries reflect the status of their biofuels policies. Mozambique's government established a task force in 2006, which drafted biofuels policy and had it passed by parliament by early 2009. By contrast, Tanzania's task force, which was established in 2005, had only completed a set of 'biofuels guidelines' by early 2010 as a forerunner to fully fledged legislation. Without formal legislation, producers in Tanzania can only produce for export markets, despite high transport costs in reaching foreign markets and considerable domestic demand for alternative fuels.

Mozambique and Tanzania therefore provide good case studies for examining the potential impacts of biofuels investments in Africa. Both countries have favourable conditions for growing feedstocks and their governments have identified biofuels as a potential growth sector for rural farmers. However, they also have concerns over the implications for national food security and poverty, which has prompted the broad mandates of their respective biofuels task forces. The two countries differ in the role that export crops currently play in their economies, the amount of foreign interest they have received and their progress towards enacting biofuels policy.

3 Evaluating the suitability and economic implications of biofuels

We present an analytical framework that can guide national task forces as they evaluate the economic implications of proposed biofuels investments. Various elements of this framework, which are shown in Table 2, have been used in the Mozambique and Tanzania case studies. The framework lists seven key areas of concern for policymakers separated into four levels of analysis (i.e., farm/firm, macroeconomic, household and environment). At the first level, we consider the main factors influencing the private sector's decision to produce biofuels, such as competiveness and world prices. At the second level we explore the implications that biofuels may have for the broader economy, including its effects on resource constraints and fiscal and external balances. Third, we consider how biofuels may ultimately influence household incomes and welfare, focusing on poorer households. Analysis at each level is sequential (i.e., builds upon each other) and can be done using a range of methods, although the most appropriate methods generally become more complex as one moves down the list of considerations. However, as will be seen, the importance of conducting more complex analyses increases with the scale of biofuels proposals. Larger investments are more likely to have economywide implications, and so their evaluation requires

Table 2: Framework for evaluating biofuels investments

Level of analysis		Consideration
Farm or firm	(1)	Production costs and international competitiveness
	(2)	Profitability and world price volatility
Macroeconomic	(3)	Taxes, public investments and fiscal balances
	(4)	Growth linkages, employment and resource constraints
	(5)	Exports, exchange rates and external balances
Household	(6)	Income, poverty and food security
Environment	(7)	Greenhouse gas emissions and water use

more comprehensive and sophisticated methods. Finally, we consider the environmental implications of expanded biofuels production. Here, relatively little is known and the area is principally flagged as an important topic for future research.

3.1 Production costs and international competitiveness

The first consideration that requires detailed evaluation is whether or not biofuels can be profitably produced by the private sector within a country or subnational region. Production costs depend on a range of factors, such as workers' wages, farm productivity, biofuels processing technologies and local energy and transport prices. Production costs will vary according to the type of feedstock used to produce biofuels. For example, transport costs may be higher for heavier feedstocks, such as sugarcane and cassava, compared to lighter oilseeds like jatropha. Similarly, processing plants that use more advanced technologies may achieve higher biofuels yields than less efficient facilities, implying that less feedstock and farm labour is needed per litre of biofuels produced. Larger and more efficient processing facilities may, however, incur higher transport costs than smaller facilities situated closer to feedstock farmers. Overall, the suitability of different feedstocks and the availability of and capacity to run more advanced processing technologies varies across countries, thus making it difficult to draw on production cost estimates from other countries.

Another important factor influencing production costs is the type of institutional arrangement used to produce feedstocks. Many foreign investors, particularly those wanting to grow traditional field crops like sugarcane, prefer to adopt a plantation approach to feedstock production. Under this arrangement, rural households supply labourers to large scale estate farms in return for wages. The estates then supply feedstock to biofuels processing facilitates (possibly onsite). An alternative to a plantation approach is an 'outgrower scheme', under which smallholder farmers are subcontracted by large wholesalers or biofuels processors to produce feedstock using their own land and labour. Inputs, such as fertilizer, may be provided by the contractor, and crops are then purchased from smallholder farmers at agreed upon prices.[1]

[1] Input provision via some form of vertical integration has the potential to overcome market failures with respect to information and contract enforcement that pervade rural areas of many developing countries. Because many biofuels feedstocks, such as sugarcane and jatropha, have limited value unless locally processed, an exchange involving inputs now in exchange for a fixed price transaction of cash for feedstock at a later date has the potential to occur.

Successful outgrower schemes operate in many parts of Africa and involve a wide range of export crops, such as coffee in Southern Uganda and cotton in Eastern Zambia.

Production costs are heavily influenced by the choice of production arrangement. Outgrower schemes are typically less mechanized and more labour-intensive than plantation approaches, and therefore they tend to generate more jobs for rural households, albeit at lower wages. For this reason, governments often prefer outgrower arrangements. However, there are a number of constraints to these schemes. First, they are often less efficient than plantations, especially from a production per hectare perspective. In other words, smallholders may obtain lower yields and thus require larger amounts of land and labour (but usually less capital) to produce the same amount of feedstock. Second, outgrower schemes may prove less reliable in supplying feedstock to processing facilities, which often prefer to operate continuously in order to reduce costs. A compromise between government and investor interests is a 'mixed approach', whereby governments agree to investors producing an initial amount of feedstock on large estates, after which any additional feedstock is produced via smallholder outgrower schemes. This ensures minimum feedstock supplies for biofuels processing while also engaging smallholders in part of the production process (Evans 2010).

Analyses of biofuels production costs under different feedstocks and institutional arrangements have been conducted for Mozambique and Tanzania. These assessments can be separated into two parts: feedstock production and biofuels processing. Feedstock cost estimates are typically conducted by national agricultural ministries as part of their research and extension systems. For example, Tanzania has detailed farm budget surveys, which itemize the cost and physical quantity of different farm inputs, such as seeds, fertilizer and labour for land clearing, weeding and harvesting. These surveys were compiled for different crops grown by smallholders using traditional and advanced technologies. Similar surveys have been conducted for large scale sugarcane estates. With this information it is possible to estimate the production technologies (i.e., input requirements and costs) for alternative feedstock.

Estimating biofuels processing costs involves an accounting exercise tailored to the local context and biofuels investment. Econergy (2008) and Felix et al. (2010) conducted such studies for Mozambique and Tanzania, respectively. Technology capacity assessments initially determined the two countries' ability to adopt different processing technologies. For example, a lack of skilled engineers, biochemists and technicians in Tanzania meant that it could not adopt the most advanced technologies, even though these are more cost efficient than other options. Once the appropriate processing technology was identified it was necessary to cost the required inputs, such as labour and feedstock. Table 3 presents the final estimated ethanol production costs for Tanzania using cassava and sugarcane feedstock grown on either large scale estates or via smallholder outgrower schemes.

Table 3: Ethanol production costs in Tanzania

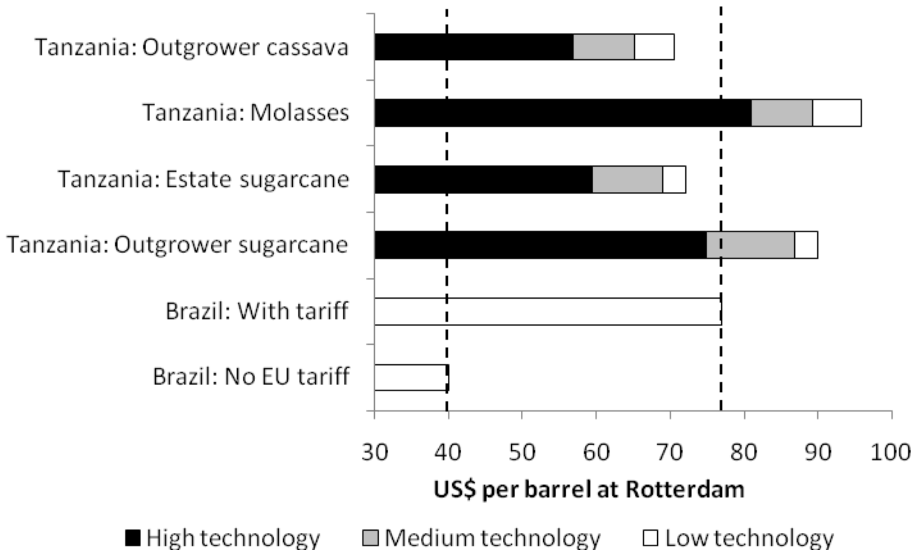
	Sugarcane		Cassava	
	Current technology		Outgrower schemes	
	Large scale estates	Outgrower schemes	Current technology	Advanced technology
Production inputs per 100,000 litres				
Biofuels production (litres)	100,000	100,000	100,000	100,000
Feedstock inputs (mt)	1,441	1,441	546	546
Feedstock yield (litres/mt)	69.4	69.4	183.3	183.3
Land yield (mt/ha)	84.0	42.8	10.0	20.0
Land employed (ha)	17.2	33.7	54.6	27.3
Farm workers employed (people)	7.2	75.8	117.7	18.2
Processing workers employed (people)	0.6	0.8	0.3	0.3
Average production cost per 100 litres (US$)	43.4	56.7	46.9	42.4
Labour and land	8.4	10.6	15.5	13.4
Capital	10.2	9.6	8.4	6.4
Fuels, fertilizers and electricity	8.7	6.8	8.6	11.0
Trade and transport services	9.5	18.1	10.0	7.3
Other inputs	6.6	11.6	4.4	4.3
Feedstock share of total production cost (%)	61.0	64.3	48.3	42.8

Note: Reported technology options are for feedstock production and not biofuels processing facilities.

Source: Own calculations using data from Arndt et al. (2010b).

Since the same biofuels processing technology is used in the table for both small and large scale ethanol production, there is no difference in the amount of sugarcane feedstock required to produce biofuels (see columns 1 and 2). However, smallholders require much more land because their yields are half those of large scale estates (i.e., 43 versus 84 tons per hectare). Sugarcane outgrower schemes also employ ten times more workers than estates per litre of biofuels produced. Overall, it is feedstock that accounts for the largest share of production costs. Since smallholders are less efficient at producing feedstock, and due to the large distances between their farms and processers (which raises transport costs), the total production cost under outgrower schemes is substantially higher than that of estates in Tanzania (i.e., US$0.57 versus US$0.43 per litre). The key role of farm productivity is evident in the two outgrower cassava scenarios, which compare current and more advanced feedstock technologies (see columns 3 and 4). The cost of producing biofuels declines significantly under more advanced farming practices (i.e., from US$0.47 to US$0.42 per litre).

Figure 1: Comparison of Tanzanian and Brazilian ethanol prices (2009)



Notes: Tanzanian ethanol prices include sales of coproducts. Reported technology options are for biofuels processing facilities and not feedstock production.

Source: Own calculations using data from Felix et al. (2010).

Figure 1 compares the final production costs from Tanzania with those in other countries, under different biofuels processing technologies.[2] It shows that only certain biofuels investments in Tanzania could export ethanol competitively vis-à-vis other major ethanol producing countries like Brazil. Indeed, under the 'medium' processing technology, which was deemed appropriate for Tanzania, only cassava grown via outgrower schemes and sugarcane grown on large estates can be exported to Europe at a competitive price. Moreover, Tanzania's competitiveness depends crucially on its exemption from European Union (EU) import tariffs (i.e., under the 'everything-but-arms' trade agreement). Mozambique was also found to be competitive in EU markets, since it is able to supply ethanol from sugarcane estates at US$0.30–US$0.38 per litre (Econergy 2008).

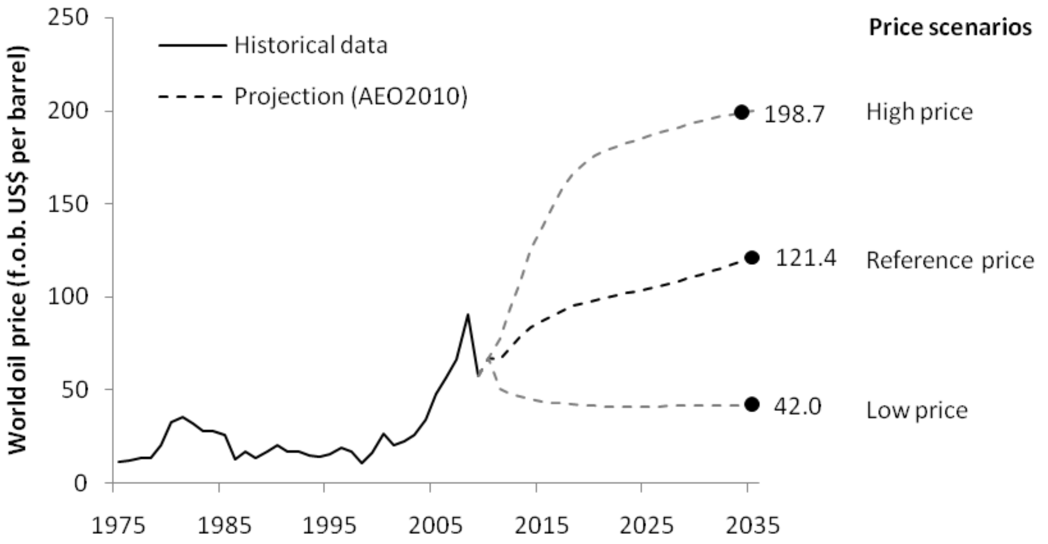
Having information on biofuels production costs and international competeiveness is crucial for national biofuels task forces as they evaluate foreign investors' biofuels proposals. Conducting cost accounting exercises for different biofuels production options is thus afforded the highest priority in our analytical framework, and should be a central component of any national biofuels assessment.

3.2 Profitability and world price volatility

Even if domestic biofuels producers are competitive against other countries, it is does not necessarily follow that they will be profitable relative to fossil fuels. For example, ethanol produced in Mozambique and Tanzania and sold domestically can compete against imported fossil fuels only when the crude oil price at their borders is greater than US$60 and US$66 per barrel, respectively (Econergy 2008; Felix et al. 2010). Oil prices surged to historical highs in mid-2008. With the financial crisis, prices fell back

2 The price estimates for Tanzania and Brazil shown in Figure 1 are drawn from Felix et al. (2010).

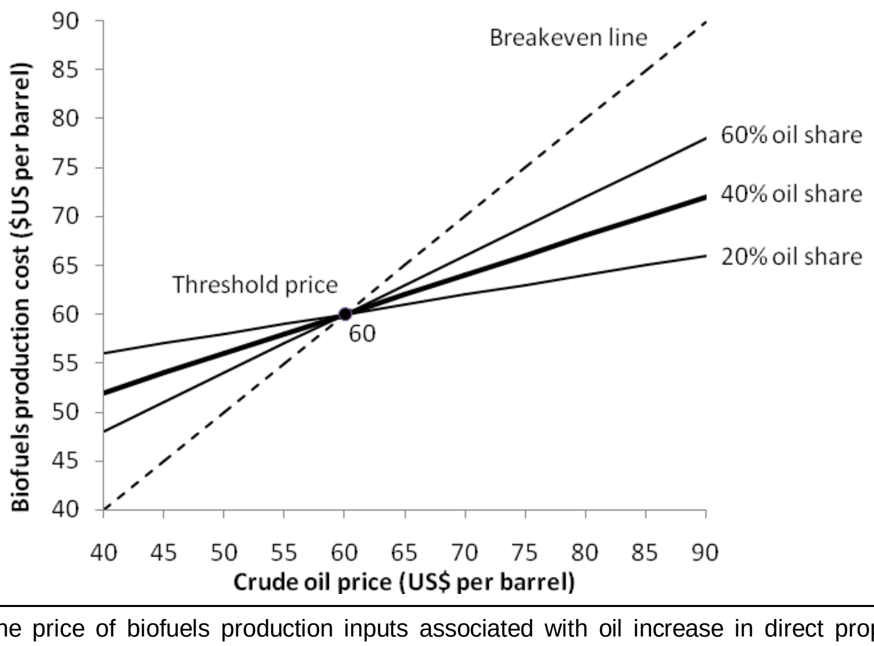
Figure 2: Historical and projected world crude oil prices



Notes: Historical data is average annual free-on-board crude oil import cost to the United States. Projected data is the weighted average crude oil import price delivered to United States refiners.

Source: USEIA (2010a, 2010b).

Figure 3: Ethanol production costs in Mozambique under different oil prices and cost shares



Note: The price of biofuels production inputs associated with oil increase in direct proportion to oil prices.

Source: Own calculations using ethanol production costs from Mozambique (Econergy 2008; Arndt 2010a).

throughout the second half of 2008 and into 2009. Despite the slow recovery from recession in the developed world, oil prices have remained above, usually well above, the break even thresholds for Mozambique and Tanzania. World oil prices are currently above US$75 per barrel and futures prices rise continuously to about US$90 per barrel in 2018. Nevertheless, it is possible that long run prices might not remain above the cost competitive level. Figure 2 shows historical and projected oil prices from the United States Energy Information Agency's 2010 Energy Outlook (USEIA 2010a, 2010b). If the 'low price' projection is realized, then it is unlikely that either country can produce biofuels profitably in the future. However, under both the 'reference price' and 'high price' scenarios, biofuels are highly competitive against fossil fuels.

Identifying oil price thresholds beyond which biofuels become profitable is an important part of any preliminary evaluation of proposed biofuels investments. To identify these thresholds it is important to account for the relationship between biofuels production costs and world oil prices. For example, Table 3 shows that transport is a major component of production costs in Tanzania. Since transport prices depend on gasoline prices, we would expect them to increase under high oil price scenarios, thus driving up biofuels prices alongside oil prices. This is shown in Figure 3, which reports ethanol production costs in Mozambique under different world oil prices, assuming different oil shares in total production costs.

The solid lines in the figure show biofuels production costs while the dotted line shows the break even point (i.e., where oil and biofuels prices are equal). The US$60 per barrel profitability threshold for Mozambican ethanol producers is marked in the figure. About 30–40 per cent of production costs in Mozambique are due to oil inputs (e.g., transport and fertilizer). Since only part of biofuels costs are linked to fossil fuels, these costs increase at a slower rate than oil prices.[3] Thus, biofuels should remain profitable at all oil prices above the threshold, although profit rates will be smaller if oil is a large share of total production costs (see '60 per cent oil share' share). Conversely, if world market fluctuations push oil prices below threshold levels, then profitability erodes slower when oil is a large share of total costs.

In summary, identifying threshold oil prices and the share of oil in production costs is another key consideration when evaluating the suitability of biofuels as a long term investment, and the vulnerability of biofuels profitability to fluctuations in world oil prices. The first two considerations in our analytical framework, dealing with farm/firm-level competiveness and profitability, are thus essential components of any evaluation exercise. If a particular biofuels investment proposal fails on either criterion, then no subsequent analysis is necessary. However, even if long run oil prices are expected to remain above the threshold point, short term fluctuations could still make biofuels temporarily unprofitable.

3.3 Taxes, public investments and fiscal constraints

Because of risks (such as the world price risks mentioned above) and the strategic importance of fuels, foreign investors may petition governments to provide financial support to new biofuels industries. In Mozambique, for example, investors have asked the government to build new infrastructure, including port facilities and roads to connect feedstock producers and biofuels processors. In Mozambique and Tanzania,

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3 The figure assumes that the cost of oil-related inputs into biofuels production expand in proportion to oil prices, while the other non-oil-related input costs remain unchanged. This stylized relationship does not account for price changes for other inputs, such as labour wages, during periods of high and low oil prices, which would affect the cost of non-oil-related inputs (see Arndt et al. 2008).

investors have asked for lower taxes on biofuels vis-à-vis imported fossil fuels in order to encourage domestic sales and offset the cost of initial capital outlays. Finally, as mentioned above, biofuels producers may also request subsidies during downswings in world oil prices in order to ensure profitability.

Governments of low income countries that are dependent on imported fuels, such as Tanzania and Mozambique, have real reasons to consider these petitions. Fuels and derived products (such as plastics and chemicals) can account for up to 20 per cent of total imports. Offsetting world oil price increases with subsidies can be hugely expensive for the public purse and worsen the macroeconomic adjustment necessary to generate the foreign exchange to finance oil imports (see, for example, Arndt et al. 2008). At the same time, allowing prices to pass through to domestic markets can have serious social consequences. Massive riots erupted in Maputo (the principal city of Mozambique) in early 2008 following the imposition of higher public transport tariffs (which stemmed from higher prices for fuel).

Nevertheless, support to biofuels does not come without costs. Maintaining fiscal balance means that expenditures and tax reductions to support biofuels must be offset by reduced spending and higher taxes elsewhere in the economy. This fiscal constraint is obviously most binding when the investments and tax incentives requested by biofuels producers are large enough to hinder the development of other sectors. In such cases, it is essential that opportunity costs of public support be considered when evaluating proposed biofuels investments.

The Mozambique and Tanzania studies did not consider the opportunity costs of providing tax incentives to biofuels producers. However, the preferential treatment of biofuels has been a contentious part of negotiations with foreign investors and between finance ministries and national biofuels task forces. This is because taxes comprise a large part of retail gasoline and diesel prices. For example, taxes made up half of gasoline retail prices and a third of diesel prices in Mozambique during 2004 (IMF 2005a). Nationally, petroleum taxes generated 10.7 and 15.8 per cent of total government tax revenues in Mozambique and Tanzania, respectively (see Table 4). Reducing taxes on biofuels relative to those on imported petroleum and diesel could, therefore, have significant fiscal implications. For example, replacing 10 per cent of imported fossil fuels with tax-free biofuels, which is the current technological limit for blending ethanol, would reduce tax revenues by 1.1 and 1.6 per cent in Mozambique and Tanzania, respectively. To make up this shortfall, these countries would, for example, need to increase direct taxes by 5 and 6 per cent, respectively, or reduce spending on agriculture by 13 and 19 per cent, respectively. Large adjustments such as these would have economywide implications, such as for non-biofuels enterprises or for agricultural growth in rural areas.

Rather than allowing biofuels to go completely untaxed, it may be preferable to provide producer supports or incentives that vary with world oil price levels. As shown in Figure 3, biofuels profitability expands when oil prices are high and declines (or even reverses) when prices are low. Therefore, subsidies during downswings could be financed by taxes during upswings. The point at which subsidies become taxes depends on the threshold price. Moreover, tax and subsidy rates could also vary with oil prices. The size of tax/subsidies would depend on the link between oil prices and profits, which in turn depends on the share of oil in total production costs. A variable incentive scheme

Table 4: Tax revenues and public spending in Mozambique and Tanzania (2004)

	Millions of US$		Share of total (%)	
	Mozambique	Tanzania	Mozambique	Tanzania
Total tax revenues	668	1,512	100.0	100.0
Petroleum taxes	71	239	10.7	15.8
Import duties	98	148	14.6	9.8
Direct taxes	152	411	22.7	27.2
Other taxes (e.g., VAT)	348	713	52.0	47.2
Total priority spending	820	1,276	100.0	100.0
Agriculture	56	126	6.9	9.9
Education	268	510	32.7	40.0
Health	147	266	17.9	20.9
Infrastructure	177	260	21.6	20.3
Other areas or sectors	171	114	20.8	8.9

Source: IMF (2005a, 2005b).

for biofuels producers should therefore build on the firm/farm-level analysis described in previous sections.

Another advantage of variable tax/subsidies schemes is that they could be tailored to favour particular production technologies, such as small scale outgrower schemes, which might otherwise remain unprofitable but whose social benefits may be desirable. However, estimating the social benefits of alternative production scenarios requires the more complex analysis described below.

3.4 Growth linkages, employment and resource constraints

Expanding biofuels production can have implications beyond the biofuels feedstock and downstream processing sectors. This is because biofuels production may generate 'growth linkages' (i.e., spillover effects) to the rest of the economy. For example, as mentioned earlier, producing biofuels requires intermediate inputs, such as transport services to get biofuels to consumers or export markets. In this case, expanding biofuels generates additional demand for locally produced services, which may create jobs and income opportunities for workers and households linked to the biofuels supply chain. Moreover, these new incomes will eventually be spent on consumer goods and services, which again generate additional demand for non-biofuels products. In this way, biofuels could trigger a cycle of intersectoral growth linkages known as a 'multiplier' process.

Both the Mozambique and Tanzania studies used computable general equilibrium (CGE) models to estimate the economic growth effects of expanding biofuels production (see Arndt et al. 2010a, 2010b). This type of economywide model captures the sectoral linkage effects of expanding biofuels production by drawing directly on the production cost and input information described in earlier sections. The two studies found that biofuels investments should significantly increase the pace of economic growth over the coming decade. For example, Table 5 shows that the simulated biofuels investments increased the annual growth rate of gross domestic product (GDP) in Mozambique and Tanzania by between 0.2 and 0.4 percentage points depending on the adopted feedstock and farming arrangement. Growth rate effects are larger in Mozambique relative to the size of simulated investments because Mozambique is a much smaller economy than Tanzania (see Table 1). Apart from sectoral growth linkages, faster economic growth is also a result of expanding the two countries' productive capacity (i.e., attracting new foreign direct investment and bringing new agricultural lands under cultivation).

While there are economywide gains from expanding biofuels production, there are also constraints that may reduce production and incomes elsewhere in the economy. For example, biofuels production requires factor inputs, such as land and labour, which may be in limited supply in some countries. So allocating land to biofuels feedstock may reduce the land available for other crops. Indeed, potential competition over crop land has received considerable attention in the biofuels debate, mainly because of concerns over the possible displacement of food crop production. However, even if uncultivated, arable land is available to produce biofuels, there may still be a displacement of labour from non-biofuels sectors, as workers are drawn into feedstock estates/plantations or as smallholder farmers reallocate their time towards producing feedstock crops. Both land and labour supply constraints mean that, as biofuels production expands, it may cause production in non-biofuels sectors to fall, thus offsetting at least some of the economywide gains mentioned above.

Economywide resource constraints were considered in Mozambique and Tanzania (see Arndt et al. 2010a, 2010b). Both studies assumed that half of biofuels feedstock production will occur on previously uncultivated lands, given these countries' large amounts of unused arable lands. The remaining lands are expected to come from areas

Table 5: Growth effects and resource constraints in Mozambique and Tanzania

	Mozambique		Tanzania	
	Jatropha outgrower schemes	Sugarcane large scale estates	Sugarcane large scale estates	Sugarcane outgrower schemes
Biofuels produced (mil. litres)	198	210	1000	1000
Change in annual GDP growth rate (percentage point)	0.23	0.32	0.35	0.25
Change in cultivated crop land (1000ha)	275	140	86	168
Biofuels feedstock	550	280	172	337
Food crops	-183	-73	65	23
Traditional export crops	-92	-67	-150	-191
Change in employment (1000s)	0	0	0	0
Biofuels jobs	326	130	73	759
Other agricultural sectors	165	59	-76	-95
Other non-agricultural sectors	-491	-189	3	-664
Exchange rate appreciation (%)	9.5	6.3	6.1	7.0
Change in cereals price index (%)	3.3	1.7	-2.4	-2.4

Source: Adapted from Arndt et al. (2010a, 2010b).

currently being used to grow other crops. For example, Table 5 shows that half of the 550,000 hectares of land used to produce biodiesel from jatropha in Mozambique is supplied by an increase in the total amount of cultivated crop land. The remaining lands come from either displacing food crops (i.e., 183,000 hectares) or traditional export crops (i.e., 92,000 hectares). Similarly, producing 198 million litres of biodiesel per year using jatropha and smallholder outgrower schemes creates jobs for 130,000 workers. However, with labour already in short supply, especially during harvest season, these biofuels workers must leave other jobs, causing production in these sectors to decline. Resource constraints were found to be most severe for smallholder outgrower schemes, given their higher labour-intensity and lower farm productivity. Indeed, the very low crop yields of sugarcane farmers in Mozambique explain the larger labour displacement here than in Tanzania.

The CGE modelling approach adopted by our two case studies is a fairly complex method of estimating economywide growth effects. A simpler approach is to integrate the production cost information compiled in earlier sections into an input-output table or social accounting matrix. This can then be used to conduct multiplier analysis (see Breisinger et al. 2009). However, a major limitation of multiplier analysis is that it assumes there are no resource constraints. In a multiplier model, any additional land and labour needed to produce biofuels can be supplied without affecting the resources available in other sectors. Multiplier models therefore tend to overstate the benefits and underestimate the tradeoffs of producing biofuels. These tradeoffs may be particularly important when evaluating large biofuels investments and when land use change and food security are major policy concerns. In such cases CGE modelling is the preferred method of analysis.

3.5 Exports, exchange rates and external balances

Another advantage of CGE models is that they provide a consistent accounting framework for jointly evaluating macro- and microeconomic outcomes. This is important because there are macroeconomic linkages through which biofuels may affect economic growth. For example, biofuels can relieve foreign exchange constraints, which often limit developing countries' ability to import the investment goods needed to expand production in other sectors. Biofuels may also have implications for a country's balance of payments and foreign exchange rate. For example, if biofuels exports expand rapidly (or fossil fuel imports decline) then this can induce an appreciation of the real exchange rate (i.e., by increasing the demand for local currency or reducing demand for foreign currency). This appreciation lowers the competitiveness of other non-biofuels exporters (i.e., by making their goods more expensive for foreigners). Expanding biofuels production therefore has implications for other sectors in the economy, not just via heightened resource competition, but also through its long run effect on a country's external balance and exchange rate.

The importance of considering external balances was shown in Table 5, where the real exchange rates of both Mozambique and Tanzania appreciated significantly under expanded biofuels production. This appreciation caused the production of non-biofuels exports in the CGE model to decline significantly, as evidenced by the fall in the amount of land allocated to traditional export crops. This reduced the amount of displaced food crop land in Mozambique, thereby alleviating some food security concerns. In fact, in Tanzania, where large amounts of land are currently allocated to traditional export crops, the reduction in non-biofuels exports following the real appreciation actually leads to more lands allocated to food crops and a small increase in domestic food production. Thus, in Tanzania the primary concern of the national biofuels task force should be less about long run food security, and more about the fiscal implications and adjustment costs associated with shifting out of traditional export crops and into a new biofuels industry. So if, for example, the public sector costs of replacing existing export crops with a new biofuels industry exceed its economic benefits, then the biofuels proposal should be declined. However, a proposal with negative net benefits may still be desirable if it provides a way of raising rural incomes and reducing poverty.

3.6 Incomes, poverty and food security

Our analytical framework also considers the impact of biofuels investments on household incomes and poverty. Households may benefit directly from biofuels production if they are involved in the biofuels production process, either as feedstock farmers or as employees in processing facilities. In such cases, workers who leave jobs in other sectors to take up employment in the biofuels sector will be better off if they are paid higher wages. However, the indirect benefits of biofuels production may prove as, if not more, important as direct benefits. For example, workers outside of the biofuels sector may benefit from higher average wages caused by increased demand for labour in the biofuels sectors. Similarly, as mentioned above, faster economic growth may generate new income and employment opportunities for workers throughout the economy. Finally, the appreciated exchange rate may reduce the price of imported goods, thus benefiting consumers with more import-intensive consumption patterns. Each of these impact channels should increase income for certain sections of the population.

However, not all households will benefit from expanding biofuels production. In the previous section, we identified farmers growing traditional export crops as being particularly vulnerable to shifts in the real exchange rate. These workers will find their incomes declining alongside their export competiveness and they will eventually have to search for employment in other sectors, possibly in the new biofuels sectors. However, while medium run growth and employment are expected to improve, in the short run there may be lags in the process of switching jobs from one industry to another, especially if new job opportunities are in a different geographic location. During this adjustment period, we would expect at least temporary reductions in some households' incomes and food security. Therefore, the net impact of biofuels production on household incomes and poverty will depend on the type of labour demanded by biofuels producers (i.e., skilled or unskilled), the wages that are paid to biofuels workers relative to existing wages, the effect on consumer prices and households' consumption patterns.

The Mozambique and Tanzania studies both conducted microsimulation analysis using nationally representative surveys of household incomes and expenditures. The predicted changes in consumption and prices from the CGE model were passed down to the survey, where standard poverty measures were calculated. Table 6 reports the change in the poverty 'headcount rate', which is the share of population living below the official poverty line. In both countries it was found that the net effect of biofuels expansion was a reduction in the national poverty rate. Moreover, poor households in both rural and urban areas benefited from faster economic growth, higher wages and lower consumer prices. Poverty declines the most, especially in rural areas, when feedstock is produced using outgrower schemes rather than on plantations – even after controlling for the type of feedstock used. However, the choice of feedstock significantly influences the welfare gains for lower income households. For example, it was found the jatropha or cassava benefited rural households in the bottom income quintile due to their lower skilled and higher labour intensities. By contrast, even when sugarcane-based ethanol was produced using outgrower schemes it was higher income households that benefited the most.

Measuring the impact of biofuels production on household incomes and poverty is particularly complex. 'Partial equilibrium' studies, which only measure direct impacts, will not capture the full economic implications of biofuels for household welfare. They exclude changes in average wages and consumer prices, both of which determine incomes for households that are not employed in the biofuels sectors. These indirect effects may be substantial for large biofuels investments, such as those being proposed for Mozambique. In such cases it is essential that economywide methods, such as CGE modelling, are used to evaluate welfare effects. For smaller investments it is possible that partial equilibrium sector level studies may suffice, such as those that calculate the number of new jobs and the wages in the biofuels sector, or the crop prices and farm revenues that will be earned by participating farmers or workers.

3.7 Environmental implications

Much of the research community working on the environmental implications of biofuels – especially in relation to the renewable fuel policies of the EU and US – are concerned about the land use changes that might be induced by the expansion of biofuels feedstock crops, and what that implies for the greenhouse gas (GHG) emissions. Land use change may be catalyzed by both the direct and indirect (market response mediated) land use effects of biofuels expansion. The key regions of concern are the corn and soybean growing regions of the US, the vast crop livestock agricultural complex of Brazil, and the sensitive areas of South East Asia which grow palm oil (mostly at the expense of forested area). The most recent estimates of net GHG emissions from biofuels derived from corn when land use change is accounted for are about 84–91 per cent of emissions from gasoline (Tyner et al. 2010).

While the agricultural growth potential of Central and Southern Africa is substantial, these regions do not figure strongly into net GHG emissions calculations, due to the small level of biofuels feedstock production currently taking place there. The European Commission commissioned a comprehensive study (Edwards et al. 2010) to look at the GHG emissions arising from the simulated biofuels impacts of various global models, which showed rather small impacts coming from Africa, relative to that from Asia and the Americas, as was also shown in a more recent study for the European Commission (Al-Riffai et al. 2010).

Nevertheless, net emissions are potentially important for countries such as Mozambique and Tanzania. Investors interested in establishing biofuels production in Mozambique, for example, are often vertically integrated fuel suppliers in the EU who are looking to guarantee their ability to meet the EU's fuel content mandates (Al-Riffai et al. 2010). As these mandates are in place largely due to environmental considerations, it is important to consider the net GHG impacts of biofuels production. As emphasized by Tyner et al. (2010), calculating the net impact of biofuels expansion is very complex both at the country and global level. For low income African countries, biofuels might serve as a catalyst for transformation of production technologies and methods, which currently rely heavily upon highly extensive land use patterns and low yielding slash-and-burn technologies. In short, the net impacts of expanded biofuels production on land use change induced GHG emissions in Africa are not at all clear and depend heavily on both the production technologies employed and a combination of indeterminate direct and indirect impacts – which have to be evaluated with respect to a counterfactual scenario with zero or very marginal levels of biofuels production.

Looking beyond land use change, there is some literature that assesses the implications of biofuels expansion on agricultural water use consumption (De Fraiture 2008; Varghese 2007). The results, while dependent upon the particular biofuels scenario chosen, show a relatively low level of impact on the global agricultural water use consumption, due to the fact that the largest biofuels producers rely mostly on rainfed feedstock production, such as for sugarcane in Brazil or palm oil production in South East Asia. The constraints to further irrigated area expansion might be more binding at a local regional level, such as the North China Plain or the groundwater dependent regions of South Asia, although some of these areas might actually experience *less* water stress if they were to switch out of crops like rice towards other grains that are likely to receive a boost in price due to increase feedstock usage for biofuels in OECD countries (Rosegrant et al. 2008). Given that current and projected agricultural areas in most of Africa will continue to be rainfed, we also feel that the implications of these biofuels scenarios on agricultural water use will be small relative to other socioeconomic impacts.

Overall, the interactions between growth, transformation and the environment in low income countries, especially in Africa, is a key topic for future research with agricultural transformation and biofuels occupying an important share of that agenda.

4 Summary and conclusions

In this paper, we outlined an analytical framework that can guide researchers and the national task forces of low income countries as they assess the broader implications of establishing domestic biofuels industries. The framework provides a set of prioritized considerations and evaluation methods. Using this framework, we discussed the comparative socioeconomic effects of biofuels expansion on both Mozambique and Tanzania, and have drawn contrasts between these countries – both in terms of the underlying causality of simulated economywide impacts, as well as in the policy approaches that have been undertaken by the governments of these countries towards biofuels. In both cases, we have shown that there is the potential for biofuels expansion to provide additional growth to the national economies of these countries, and to 'crowd in' needed investments that can bring benefits to the agricultural sector as well as downstream processors. However, in each case, there are important tradeoffs to be considered when contemplating the policies to best serve the development priorities and future food and energy needs of these countries.

Some of these tradeoffs stem from the opportunity costs that are implicit in diverting public resources towards investments in the biofuels sector (and its supporting infrastructure), rather than towards other potential ventures. Modelling results illustrate the tradeoff that exists between the competitiveness of exportable cash crops on international markets, as the macroeconomic effects of biofuels expansion take hold in the simulated scenarios. The competition for labour resources in Mozambique and the implications it has for food production, for example, contrasts with the effects seen in Tanzania, which has a larger and more robust export crop sector and actually sees a rise in food production as labour is released by switching from more intensive cash crops towards biofuels feedstock crops. Both countries, however, need to consider what kind of tax incentives should be placed upon biofuel-related production activities, both in terms of how they compare to the support being given to other export-oriented sectors, as well as the overall budgetary implications for the national economy.

Based on the two case studies, we view biofuels expansion primarily as an opportunity for poorer countries to spur growth and reduce poverty. However, we highlight that there are distributional consequences that place more of a burden on certain socioeconomic groups as the simulated growth in biofuels production takes place within each country. By and large, urban households are more vulnerable to the effects of food price increases than rural smallholders, so there should be some consideration given to the social protection of these households, even though the political economy of national poverty programs tend to give more weight to rural poverty alleviation. More research is required to understand the net impact of biofuels expansion in poor countries on environmental outcomes such as GHG emissions. Because biofuels production is potentially large relative to the existing staple and cash crop activities contained within the agricultural sector and overall economies of these countries, great care must be taken to consider the direct and indirect impacts of biofuels expansion as well as the trajectory of emissions in an appropriately specified counterfactual scenario.

References

Al-Rifai, P., Dimaranan, B., and Laborde, D. (2010). 'Global Trade and Environmental Impact of the EU Biofuels Mandate'. Final Report for EC – DG TRADE. Available at: http://trade.ec.europa.eu/doclib/docs/2010/march/tradoc_145954.pdf

Arndt, C., Benfica, R., Maximiano, N., Nucifora, A. and Thurlow, J. (2008). 'Higher Fuel and Food Prices: Impacts and Responses for Mozambique'. *Agricultural Economics*, 39: 497–511.

Arndt, C., Benfica, R., Tarp, F, Thurlow, J. and Uaiene, R. (2010a). 'Biofuels, Growth and Poverty: A Computable General Equilibrium Analysis for Mozambique'. *Environment and Development Economics*, 15 (1): 81–105.

Arndt, C., Pauw, K. and Thurlow, J. (2010b). 'Biofuels and Economic Development: A Computable General Equilibrium Analysis for Tanzania'. Discussion Paper 966. Washington, DC: International Food Policy Research Institute.

Breisinger, C., Thomas, M. and Thurlow, J. (2009). 'Social Accounting Matrices and Multiplier Analysis: An Introduction with Exercises'. Food Security in Practice Technical Guide 5. Washington, DC: International Food Policy Research Institute.

Cleaver, J., Schram, R. and Wanga, G. (2010). 'Bioenergy in Tanzania: The Country Context'. In I. Maltsoglou and Y. Khwaja (eds), *Bioenergy and Food Security: The BEFS Analysis for Tanzania*. Rome: Food and Agriculture Organization of the United Nations.

De Fraiture, C., Giordano. M. and Liao, L. S. (2008). Biofuels and Implications for Agricultural Water Use: Blue Impacts of Green Energy. *Water Policy*, 10 (Suppl. 1): 67–81.

Econergy (2008). 'Mozambique Biofuels Assessment'. Report prepared for Mozambique's Ministries of Agriculture and Energy.

Edwards, C., Mulligan, D. and Marelli, L. (2010). 'Indirect Land Use Change from Increased Biofuels Demand: Comparison of Models and Results for Marginal Biofuels Production from Different Feedstocks'. JRC Scientific and Technical Reports. Ispra: European Commission Joint Research Centre, Institute for Energy.

Evans, M. (2010). 'Key Requirements for Successful Biofuel Sector Development in Mozambique: A Summary Assessment'. Final Report written in support of the 'Biofuels and the Poor' project (www.biofuelsandthepoor.com).

FAO (2008). *The State of Food and Agriculture. Biofuels: Prospects, Risks and Opportunities*. Rome: Food and Agriculture Organization of the United Nations.

Felix, E., Cardona, C. A. and Quintero, J. A. (2010). 'Technical and Economic Viability of Biofuel Production Chains'. In I. Maltsoglou and Y. Khwaja (eds), *Bioenergy and Food Security: The BEFS Analysis for Tanzania*. Rome: Food and Agriculture Organization of the United Nations.

International Monetary Fund (IMF) (2005a). 'Republic of Mozambique: Selected Issues and Statistical Appendix'. Country Report 05/311. Washington, DC: IMF.

—— (2005b). 'Tanzania: Selected Issues and Statistical Appendix'. Country Report 04/284. Washington, DC: IMF.

Rosegrant, M., Zhu, T., Msangi, S. and Sulser, T. (2008). 'Global Scenarios for Biofuels: Impacts and Implications'. *Review of Agricultural Economics*, 30 (3): 495–505.

Tyner, W. E., Taheripour, F., Zhuang, Q., Birur, D. and Baldos, U. (2010). *Land* Use Change and Consequent CO_2 Emissions Due to Us Corn Ethanol Production: A Comprehensive Analysis'. Final Report. West Lafayette, IN: Purdue University.

USEIA (2010a). 'Petroleum Navigator'. Washington, DC: US Energy Information Administration. Available at: www.eia.gov/dnav/pet/pet_pri_wco_k_w.htm

—— (2010b).'Annual Energy Outlook 2010 with Projections to 2035'. Washington, DC: US Energy Information Administration. Available at: www.eia.doe.gov/oiaf/aeo

Varghese, S. (2007). *Biofuels and Global Water Challenges*. Minneapolis, MN: Institute for Agricultural Trade and Policy.

World Bank (2010). 'World Development Indicators Online'. Washington, DC: World Bank.