DISCUSSION PAPER

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Food security challenges and beyond

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Acronyms and abbreviations

AEDB	Alternative Energy Development Board
CII	Confederation of Indian Industry
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon di-oxide
EBP	Ethanol Blending Programme
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign direct investment
GDP	Gross domestic product
GHG	Greenhouse gas
GHI	Global Hunger Index
GW	Gigawatts
HC	Hydrocarbon
HSD	High-speed diesel
IEA	International Energy Agency
INR	Indian Rupees
LCA	Life cycle analysis
MPP	Minimum purchase price
NGO	Non-governmental organization
NPB	National Policy on Biofuels
OECD	Organisation for Economic Co-operation and Development
OMCs	Oil Marketing Companies
PM	Particulate Matter
PSO	Pakistan State Oil
R&D	Research and development
RED	Renewable Energy Directive
RFS	Renewable Fuel Standard
SAARC	South Asian Association for Regional Cooperation
TBOs	Tree-borne-oils
Tcf	Trillion cubic feet
US	United States

Contents

Executive summary

With its scanty and dwindling reserve of crude, South Asia is particularly vulnerable to oil shocks. All the countries of the region are perennial net oil importers, which not only draws down a large chunk of foreign exchange reserves of these countries, but also makes them highly energy insecure. In this context, most South Asian countries are promoting blending of biofuels with liquid petroleum fuels (ethanol with petrol and biodiesel with petro-diesel) for the transport sector, predominantly with energy security concerns in view, apart from greenhouse gas (GHG) emissions reduction and other rural development considerations. While India and Pakistan are frontrunners in the region in biofuel production and consumption, sparse initiatives are underway in Bangladesh, Nepal and Sri Lanka as well.

While the need for the diversification of energy resources in South Asian countries cannot be overemphasized, the contribution that conventional or first-generation biofuels can make to energy security is physically very limited, and comes at a considerable financial cost, apart from other potentially negative environmental and socio-economic implications. Biofuels cannot sustain without subsidies, fuel mandates, or other government support. In view of the generous subsidies on fossil fuels that are continuing even in the face of rising crude oil prices in some South Asian countries, it may be all the more difficult for biofuels to emerge as a cost-effective alternative to fossil fuels unless adequate subsidies and other policy incentives are provided. However, given that the realization of benefits from the production and usage of biofuel is still contestable and considerable gaps exist in the state of knowledge, such policy support are clearly fraught with risks and may turn out to be counter-productive unless they are informed by the potential negative fallout of biofuels, and appropriate checks and balances are set in place to deal with such implications.

The challenges posed by biofuels in South Asia have only been exacerbated since 2006 with the increasing volatility and frequent spikes in international food prices. This has widely been attributed to increasing biofuel production, among a host of other factors. The region's fight against hunger has not matched its robust economic growth. The proportion of undernourished people in the region has gone up since 1995–1997. Aggressive promotion of first-generation biofuels, therefore, may not be a prudent decision unless adequate policy cushions are put in place against the potential trade-offs. For instance, if a large market is developed for an inedible fuel crop like jatropha, it is bound to impart intense pressure to reduce costs and increase profits by cultivating it on higher-quality arable land to obtain higher yields.

A related issue is whether there is enough available waste land in South Asia to significantly increase first-generation biofuel production, without any fallout on food production. Water availability is no less a concern. Adequate land and water availability analysis has not been conducted in the context of South Asia so as to appropriately gauge the competing claims on land and water and hence infer about future production potential. Although many model-based projections and estimates under various scenarios exist, these are at best very rough and indicative estimates, given that it is extremely challenging to simulate reality unless one gets a true picture of the wastelands and available water resources.

Another important question is whether biofuels can be developed sustainably in South Asia without raising GHG emissions or causing other adverse environmental implications. Going by the findings of life cycle analysis studies that have been carried out internationally as well as in South Asia, the environmental implications of biofuels still remain an open question. Given the complexity of direct and indirect impacts of biofuel expansion on land, water use and biodiversity, defining sustainability in an all-encompassing manner is extremely challenging. This is all the more so for a region as diverse as South Asia. Unless a foolproof sustainable process of production is adopted for large-scale biofuel production, it may turn out to be a bane instead of a boon for South Asia.

Second-generation biofuels are being mooted as the right alternative to address the challenges posed by the promotion of first-generation biofuels. Technically speaking, it may be possible to produce a large proportion of transportation fuels using advanced biofuel technologies, specifically those that can be grown using a small share of the world's land area (e.g., microalgae), or those grown on arable lands without affecting food supply (e.g., agriculture residues). However, a number of barriers limit the near-term commercial application of advanced biofuel technologies. These barriers include low conversion efficiency from biomass to fuel; limits on supply of key enzymes used in conversion; large energy requirements for operation; and dependence in many cases on commercially unproven technologies, among others.

Although in view of the sustainability advantages of advanced biofuels *vis-à-vis* conventional biofuels the former is often regarded as a "cleaner and greener" option, it remains that any energy source produced on a large scale, or without sufficient care, runs the risks of adverse environmental fallout. For instance, the removal of agriculture residues may have impacts on biodiversity, because of changed habitat functions like shelter, fodder source or nesting places. The export of agriculture residues from the field means a loss of organic material, which influences the fertility balance of the soil. The reduced soil coverage may also lead to a change in the humidity regulation of the soil and reduced protection of evaporation and erosion due to wind and precipitation. Furthermore, GHG emissions might occur through soil carbon changes when extracting residues, as well as due to the use of fertilizers and diesel caused by straw removal. Even algal biofuels, just like crops, require land, water, fertilizers, pesticides and inputs that are costly. Hence, advanced biofuels, if produced unsustainably, may not be able to resolve the problems that are currently being encountered with first-generation biofuels.

In the final analysis, biofuels, whether conventional or advanced, should not be regarded as a silver bullet. They should not be the exclusive or even the main focus of climate change and energy policy in South Asian countries. It is much more essential to encourage energy conservation through promotion of energy-use efficiency and other forms of renewable energy like wind, solar and small hydro. All countries in South Asia should place biofuels in the context of a comprehensive energy policy, which includes conservation as well as promotion of other renewable energy alternatives. Biofuel policies should also be guided by broader sustainable development considerations, and the economic, social and environmental implications of biofuel policies should be more carefully assessed.

Chapter 1

Introduction

The rapid depletion of fossil fuels, especially petroleum, over the past century, driven by rapid economic growth, has prompted a search for more sustainable alternatives. The variegated claims made by peak oil theorists[1] indicate that crude oil production has either peaked or is about to reach the acme and would shortly be on the verge of a decline. This essentially implies that the cost of extraction of crude is only going to increase as demand for oil follows an upward trend even as the crude oil gets increasingly scarce. In other words, oil-importing countries, like those in South Asia, would have to increasingly compete with one another to get hold of this non-renewable scarce resource.

Furthermore, the lion's share of crude oil reserves, albeit depleting, is in the hands of only a few countries concentrated predominantly in the Middle East. If one adds to this the increasing volatility in crude oil prices driven, among other factors, by the growth of speculative tendencies in the oil market, the plight of oil-importing countries is only going to increase in the near future. A plethora of renewable alternative options coupled with various initiatives towards energy efficiency and conservation are being promoted worldwide to deal with an impending disaster that could potentially be precipitated by a rapid depletion of fossil fuels. Among the portfolio of renewable alternatives available, biofuels have emerged as a preferred alternative, particularly as a transport fuel in pure form or blended form (with petrol and diesel). The past decade is witness to an increasing interest across the world, including in South Asia, in the promotion of biofuels.

The production and use of biofuels is not a new phenomenon, however. Initial efforts to produce biofuels date back to the early days of the automobile. However, they were quickly replaced as the fuel of choice by cheap petrol, which continued relatively unchallenged until the oil crisis of the 1970s, which induced some countries to explore alternatives to fossil fuels—predominantly for energy security-related concerns.

In 1975, for instance, the Brazilian government launched the PROALCOOL Programme with the aim of gradual replacement of imported petrol with blends of ethanol produced from domestically grown sugarcane in its transport system. In the United States (US), interest in biofuels also began in response to the oil crisis of the 1970s, and legislation to promote the production and use of ethanol as a transport fuel was passed. It was during this period that biofuels came to be regarded as a serious alternative to fossil fuels for the first time. However, once the oil crisis died down during the late 1970s and the early 1980s, interest in biofuels also got eroded gradually (Bandyopadhyay and Das 2012).

Among the portfolio of renewable alternatives, biofuels have emerged as a preferred alternative, particularly as a transport fuel.

The resurgence in interest coupled with renewed investments in biofuels began on the eve of the millennium, especially in Organisation for Economic Co-operation and Development (OECD) countries and in Brazil, when oil prices started to gear above US$25/barrel in 2003 only to eventually reach the historical peak of US$147/barrel in 2008 (Runge and Johnson 2008).

A growing number of developing countries also followed suit and began investing in feedstocks for the production of biofuels. The rationale behind the aggressive promotion of biofuels, particularly in developing countries, may be found in the purported potential of this alternative source of energy to: i) augment energy security by substituting fossil fuels, thereby saving on foreign exchange for developing countries that are perennially dependent on imported crude; b) help in lowering greenhouse gas (GHG) emissions in the context of increasing climate change concerns; and c) contribute towards economic development, especially rural development, and concomitant poverty eradication (Elder *et al*. 2008). Tanzania and several other sub-Saharan nations started developing biofuels in order to replace imports of petroleum and save on foreign exchange reserves (Jumbe *et al*. 2009; Bekunda *et al*. 2009). Some other countries like Malaysia, Indonesia and Argentina are growing biofuels for exports to the attractive subsidized European and American markets (Gerasimchuk *et al*. 2012).

South Asian countries, grappling with limited and dwindling reserves of indigenous crude, have become perennial net oil importers.

South Asian countries, which have been grappling with limited and dwindling reserves of indigenous crude, have turned out to be perennial net oil importers, drawing down a large chunk of their foreign exchange reserves to import crude. Recognizing the dire importance of alternate sources of energy for reducing transport's dependence on petroleum products (petrol and diesel), some South Asian countries have already initiated blending of liquid petroleum fuels with biofuels for the transport sector, while some others are mulling such blending. For instance, while India and Pakistan are frontrunners in the region in biofuel production and consumption, sparse initiatives are underway in other countries like Bangladesh, Nepal and Sri Lanka (Bandyopadhyay and Das 2012).

Biofuels are often regarded as a cleaner and greener alternative to fossil fuels. The design of subsidies and other policy support to the sector in different countries is also generally done by keeping the positive benefits of biofuels in view. For instance, the US in its Energy Independence and Security Act of 2007 and the European Union (EU) in its Renewable Energy Directive of 2009, respectively, underscored energy security (through diversification of energy sources), environmental sustainability (abatement of GHG emissions and air pollution) and regional economic development (particularly in rural areas) as key objectives underlying the subsidies provided for biofuel development (Gerasimchuk *et al*. 2012).

The environmental obstacles or possible side effects, including the potential implications of land-use change and effects on food security, were not accounted for. The picture was not very different in other parts of the world as well. For instance, in Malaysia and Indonesia, substantial land-clearing was carried out to make way for planting oil-palm, a biofuel feedstock. Indonesia also burnt its tropical forest land and cleared it for oil-palm production (Runge and Johnson 2008).

Some recent scholarly studies, including those based on life cycle analysis (LCA), however, have cast serious doubts on the purported positive effects of biofuels. In fact, it has widely been indicated that biofuels could end up causing more environmental and social problems than they actually solve (Elder *et al*. 2008). A number of studies have also found biofuels to be a major cause of worldwide food-price inflation—attributable primarily to the integration of oil and energy markets with the markets for agriculture commodities. These studies have also cautioned that biofuels could exacerbate food insecurity (Naylor *et al*. 2007; Runge and Johnson 2008; FAO 2008, 2009, 2010; IIASA 2009; Abbott *et al*. 2011; Wise 2012), lead to water shortages (Agence France-Presse 2007), aggravate water pollution (Engelhaupt

2007), increase GHG emissions through land-use changes while adding to other indirect environmental costs (Righelato and Spracklen 2007; Searchinger *et al*. 2008; Gallagher 2008; UNEP 2009; Scharlemann and Lawrence 2008), adversely affect biodiversity (Lawrence 2007; UNEP 2009), and so on. Serious doubts have also been raised on the parameter of net energy consumption of biofuels, i.e., whether biofuels consume more energy than they actually produce (Lang 2005).

The biofuel industry is still at its infancy in South Asia, where some countries have started blending biofuels with conventional fuels (petrol and diesel) for the transport sector only recently. The industry cannot sustain without subsidies, fuel mandates, or other government support.[2] However, given that the realization of benefits from the production and usage of biofuels is still contestable and sufficient gaps exist in the state of knowledge, such policy support are clearly fraught with risks and may turn out to be counter-productive unless they are informed by the potential negative fallouts of biofuels, and appropriate checks and balances are set in place to deal with such implications.

Against this backdrop, this paper attempts to provide a holistic account of the pros and cons of the promotion of biofuels in South Asia. With this aim in view, the paper does not restrict its scope only to biofuels' implications for food security in South Asia, but also covers other important issues like energy security and environmental aspects. The structure of the paper is as follows. Chapter 2 begins with a brief outline of the taxonomy of biofuels. Chapter 3 provides an overview of the existing and projected production and consumption scenarios of biofuels across the globe as well as in South Asia. Chapter 4 then goes on to discuss the biofuels initiatives and policies in various countries of the region. Chapter 5 assesses the role of biofuels in enhancing the energy security scenario of South Asian countries, while Chapter 6 explores how far biofuels could be considered as environmentally benign. Chapter 7 delves into the contentious issues around the so-called food-fuel debate and brings out the implications of biofuels for food security in the region. Chapter 8 discusses regional initiatives on biofuels development in South Asia and explores the prospects for future cooperation. Chapter 9 concludes the paper with a set of policy recommendations.

The biofuel industry is still at its infancy in South Asia, where some countries have started blending biofuels with conventional fuels for the transport sector only recently.

Chapter 2

Taxonomy of biofuels

Biofuel is a generic term that refers to fuel derived from biomass, such as plants and organic wastes. The International Energy Agency (IEA) adopts a simplified classification of biofuels based on the maturity of the technology deployed. This taxonomy uses terms such as "conventional" and "advanced" to distinguish between different genres of biofuels (IEA 2011b).

Conventional biofuels, commonly referred to as first-generation biofuels, include sugar- and starch-based ethanol, oil-crop-based biodiesel and straight vegetable oil, and biogas[3] derived through anaerobic digestion. Typical feedstocks used in these processes include sugarcane and sugar beets, starch-bearing grains like corn and wheat, oil crops like rapeseed (canola), soybean and oil palm, and, in some cases, animal fats and used cooking oils. The technology for producing conventional biofuels is well-established and is being deployed for producing biofuels on a commercial scale.

Advanced biofuels, usually referred to as second- or third-generation biofuels, include biofuels based on feedstocks like ligno-cellulosic biomass (e.g., cellulosic ethanol), biomass-to-liquids diesel and bio-synthetic gas. The technologies deployed for producing advanced biofuels are conversion technologies that are still in the research and development (R&D) or demonstration stage. The category also includes novel conversion technologies, such as algae-based biofuels and the conversion of sugar into diesel-type biofuels using biological or chemical catalysts. Table 2.1 describes the characteristics of conventional and advanced biofuels.

Table 2.1 Feedstocks and conversion processes for conventional and advanced biofuels

Biofuels	Feedstock to fuel conversion process	Feedstocks	Crops	
			For ethanol	*For biodiesel and bio-jet*
Conventional biofuels (first generation)	Fermentation Transesterification Hydrogenation	Sugar Starch Vegetable Oils Animal fats Used cooking oils	Wheat Corn Potatoes Beet Sugarcane Cassava	Palm oil Soybean Rapeseed (canola) Sunflower Jatropha circus Camelina Sativa
Advanced biofuels (Second/third generation)	Bio-chemical Thermochemical Hybrid (biorefinery)	Lignin Cellulose Hemi-cellulose	Woody biomass Grasses Agriculture by-products Waste streams Algae Seaweed	

Source: Gerasimchuk et al. (2012).

The most common conventional biofuels that are used largely as a transport fuels are ethanol and biodiesel. Both ethanol and biodiesel are used in internal combustion engines either in pure form or more often as an additive. Some of the key technical advantages and disadvantages of using ethanol and biodiesel in vehicles are briefly summarized in Table 2.2.

Table 2.2 Technical advantages and disadvantages of using ethanol and biodiesel in vehicles

Fuel	Advantages	Disadvantages
Ethanol	High octane rating[a]: The octane number of ethanol is 120, much higher than that of petrol (ranges between 87 and 98) Clean burning characteristics: Reduced emissions of pollutants such as carbon monoxide, unburnt hydrocarbons, and particulate matter, among others; contains no sulphur Reduced emissions of GHGs from combustion	Storage tanks, dispensing equipment require corrosion-resistant materials since use of ethanol has shown corrosion More aldehyde[b] emissions (however, emissions are mostly acetaldehydes with less adverse health effects compared to formaldehydes emitted by petrol engines) Engine life becomes shorter
Biodiesel	Non-toxic Non-inflammable with a high flash point Easy handling and storage as in the case of diesel Naturally oxygenated fuel Substantial reduction in HC, CO, PM and CO_2; free from sulphate	Tends to dilute engine oil, necessitating frequent oil changes

Notes: *a. it is the measure of the ignition quality of gas (petrol). Higher the octane number, the less susceptible is the gas to "knocking" (explosion caused by its premature burning in the combustion chamber) when burnt in a standard (spark-ignition internal combustion) engine.*
b. Any of a class of highly reactive organic chemical compounds obtained by oxidation of primary alcohols, characterized by the common group (—CHO) and used in the manufacture of resins, dyes, and organic acids. Formaldehyde is the simplest and most widely used aldehyde.

Source: *Bourne (2007).*

Chapter 3

Current trends and future projections of biofuels[4]

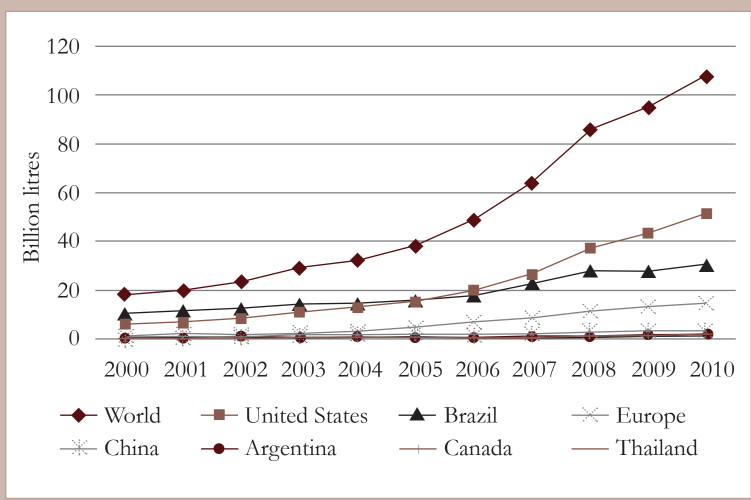
3.1 Biofuel production

Liquid biofuels (ethanol and biodiesel) provide around 3 percent of total road transport fuel globally (on an energy basis) and considerably higher shares are achieved in certain countries (IEA 2011b). Production capacity of biofuels continues to be centred primarily in the US, Brazil and the EU. Production in the US consists mostly of ethanol from corn; in Brazil of ethanol from sugarcane; and in the EU mostly of biodiesel from rapeseed. Other countries producing fuel ethanol include Australia, Canada, China, Colombia, the Dominican Republic, France, Germany, India, Jamaica, Malawi, Poland, South Africa, Spain, Sweden, Thailand and Zambia, among others. Rapid expansion of biodiesel production has occurred in Southeast Asia (Malaysia, Indonesia and Singapore), China, Latin America (Argentina and Brazil) and Southeast Europe (Romania and Serbia).

Global biofuel production grew from 16 billion litres in 2000 to more than 100 billion litres in 2010 (Figure 3.1). The global market for biofuels (ethanol and biodiesel) in 2011 was worth US$83 billion (Gerasimchuk *et al.* 2012). Commercial production of advanced biofuels remained low in 2011, except for a handful of hydro-treated vegetable oil plants in operation. A few large cellulosic ethanol plants were under construction at the year's end, including facilities in Italy and the US. As for South Asia, biofuel production increased from 170 million litres in 2000 to 420 million litres in 2010 (Figure 3.2), India being the predominant contributor to the growth process—though there are sparse initiatives in various other countries in the region (see Chapter 4).

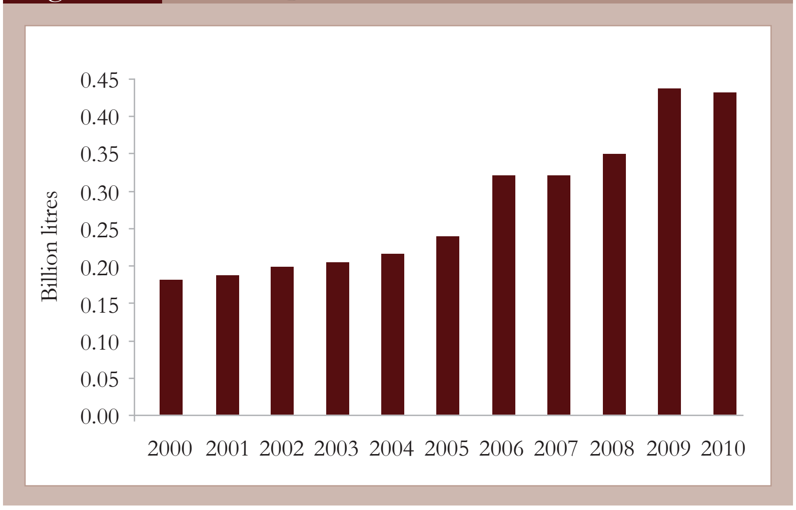
In 2011, the US and Brazil accounted for 63 percent and 24 percent of global ethanol production, respectively, compared with 60 percent and 30 percent in 2010. Although the global production of ethanol was stable during 2000–2010, it went down marginally in 2011, for the first time since 2000, to an estimated 86.1 billion litres (REN21 2012). In Brazil, ethanol production was down by almost 18 percent in 2011 relative to 2010, from about 25.5 billion litres to 21 billion litres. Declining investment in new sugarcane assets and plantations

Figure 3.1 Global biofuel production



Source: Energy Information Administration, Department of Energy, US, www.eia.gov (accessed 28 July 2012).

Figure 3.2 Biofuel production in South Asia



Source: Energy Information Administration, Department of Energy, US, www.eia.gov (accessed 28 July 2012).

since the 2008 financial crisis, combined with poor sugarcane harvests due to unfavourable weather and high world sugar prices, resulted in this significant decrease. This decline led Brazil to announce new policies to stimulate sugar production and to reduce, in September 2011, the amount of anhydrous ethanol required in petrol to 20 percent from 25 percent. Although global production fell in 2011, corn ethanol production in the US reached a new high, exceeding 54 billion litres. This country, which was a net biofuel importer until 2010, saw its exports rise nearly threefold from 1.5 billion litres in 2010 to 4.5 billion litres in 2011. The US continued to gain international market share from Brazil, which was the world's leading ethanol exporter for many years. About one third of US exports of ethanol flowed to Brazil (REN21 2012).

As of January 2012, US corn ethanol manufacturers operated 209 plants with a total annual capacity of over 56 billion litres. This represented an increase of 5.3 billion litres relative to the previous one year (i.e., since January 2011). During the same time, in Brazil, there were 440 plants with a capacity of 37 billion litres. New plants are starting to operate in Brazil, implying that Brazil's capacity is expected to expand further, although the investment has been relatively low over the past three years (REN21 2012).

China was the world's third largest ethanol producer and Asia's largest in 2011, at 2.1 billion litres. It was followed by Canada (1.8 billion litres), France (1.1 billion litres) and Germany (0.8 billion litres). Africa accounted for only a tiny share of world production, but saw a slight increase during 2011 compared to 2010.

In contrast to ethanol, global biodiesel production continued to expand, increasing by almost 16 percent to 21.4 billion litres in 2011, compared with 18.5 billion litres in 2010. In Europe, annual biodiesel production capacity rose slightly in 2011, to 25.1 billion litres, up from 24.9 billion litres in 2010. Around 22 percent of the total capacity was located in Germany and 20 percent of it in Spain. The EU remained the largest regional producer of biodiesel, but its total production declined by 6 percent, and the EU's share of the world total was down from 53 percent in 2010 to 43 percent in 2011.

Biodiesel production capacity is also expanding rapidly in the US, where there were 190 biodiesel plants with a combined annual production capacity of 11 billion litres in 2011. The US saw a record increase in biodiesel production in 2011, to nearly 3.2 billion litres—an increase of 159 percent mainly from soybeans. As a result, the country surpassed the 2010 leaders—Germany, Brazil, Argentina and France—to become the world's top producer of biodiesel. The dramatic increase in biodiesel production in the US was due to a government mandate in mid-2010 that required refiners to blend 3.1 billion litres of biodiesel with petro-diesel in 2011 or face stiff daily fines. Germany dropped from the first to the second place globally, although its production increased by 18 percent, and, with 3.2 billion litres of biodiesel production, it was not far behind the US. It was followed by Argentina (2.8 billion litres), which saw an increase of 34 percent over 2010, and Brazil (2.7 billion litres), which recorded a 12 percent rise. Production in France dropped from 1.9 billion litres in 2010 to 1.6 billion litres in 2011. Biodiesel production capacity in Argentina was estimated to be 3.8 billion litres in 2011, up almost 36 percent over 2010 (2.8 billion litres). Although it produced less than Argentina, Brazil had far more biodiesel production capacity by the end of 2011—6.5 billion litres, with 70 plants in place (REN21 2012).

Interestingly, airlines around the world have shown growing interest and involvement in aviation biofuels as part of their effort to reduce fuel costs and GHG emissions. In 2011, several airlines, including Aeromexico, Finn air, KLM Royal Dutch Airlines, Lufthansa, Thai Airways, United Airlines and Alaska Airlines, began to operate commercial flights using various biofuel blends (REN21 2012).

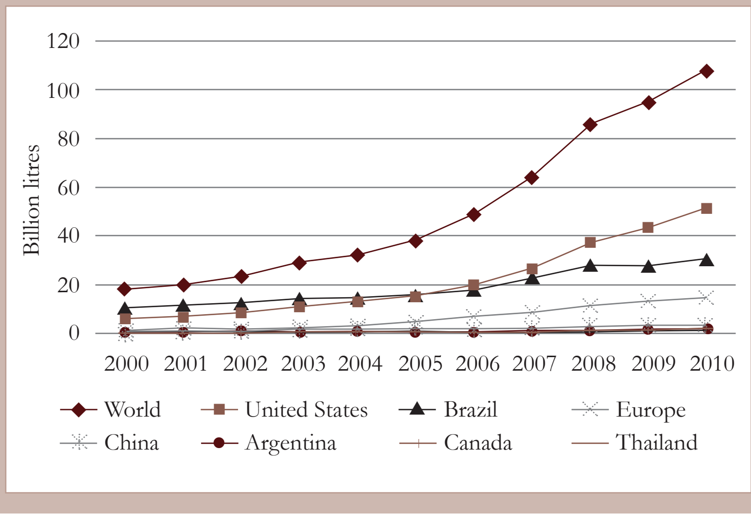
Although commercial production of advanced biofuels remained low in 2011, interest in these fuels is showing an upward trend. In December, the US Navy signed contracts to purchase around 1.7 million litres of advanced biofuels, and it plans to displace 50 percent of its fossil fuel demand with alternative fuels by 2020, amounting to 2.3 billion litres of biofuels annually (REN21 2012).

3.2 Biofuel consumption

Figure 3.3 shows global biofuel consumption whereas Figure 3.4 depicts the biofuel consumption scenario in South Asia. Policies such as production subsidies, tax exemptions, share in total transport fuel obligations, and blending mandates continue to support liquid biofuels for consumption in the transport sector. As of early 2012, biofuel obligations and mandates existed in at least 46 countries (at the national level) and in 26 states and provinces. As of mid-2011, mandates in place around the world called for a biofuels market of at least 220 billion litres by 2022, with expected demand to be driven primarily by Brazil, China, the EU and the US (REN21 2012). As of early 2012, fuel-tax exemptions and production subsidies existed in at least 19 countries.

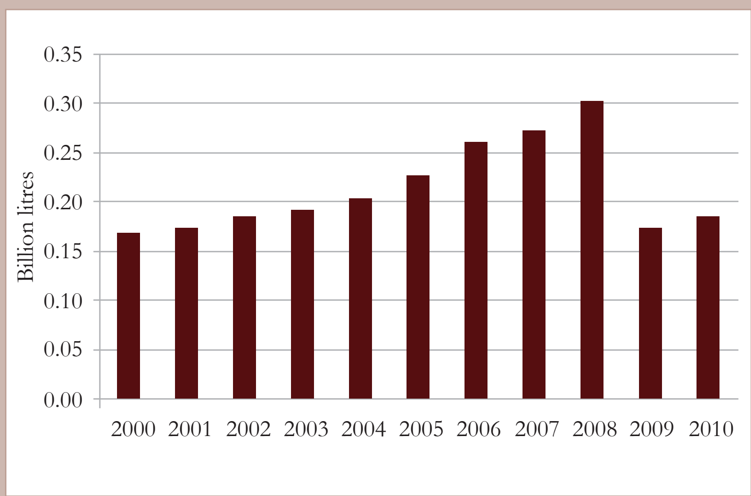
The majority of mandates were in the EU countries, as part of the 10 percent target for renewable energy in transport by 2020, followed by Asia. New mandates enacted during 2011 include Canada's Renewable Fuel Standard for

Figure 3.3 Global biofuel consumption



Source: Energy Information Administration, Department of Energy, US, www.eia.gov (accessed 28 July 2012).

Figure 3.4 Biofuel consumption in South Asia



Source: Energy Information Administration, Department of Energy, US, www.eia.gov (accessed 28 July 2012).

B2 (2 percent biodiesel blend) for both transport diesel and heating oil. While Canada's national E5 (5 percent ethanol blend) mandate remained, four provinces enacted higher individual mandates. In addition, British Columbia increased its biodiesel mandate and Saskatchewan added a new biodiesel mandate. Denmark adopted its first biofuels quota (3.5 percent) in 2011, and Germany began to roll out an E10 blend. Several governments revised policies in 2011. Brazil reduced its mandated ethanol blend level from 24 percent to 18–20 percent, partly in response to poor sugarcane yields in recent years. The government also announced financing for agribusiness to increase sugarcane yields, as well as loans of US$2.6 billion to sugar companies to encourage investment in larger ethanol storage facilities to better meet domestic demand during the two months when sugarcane is not harvested.

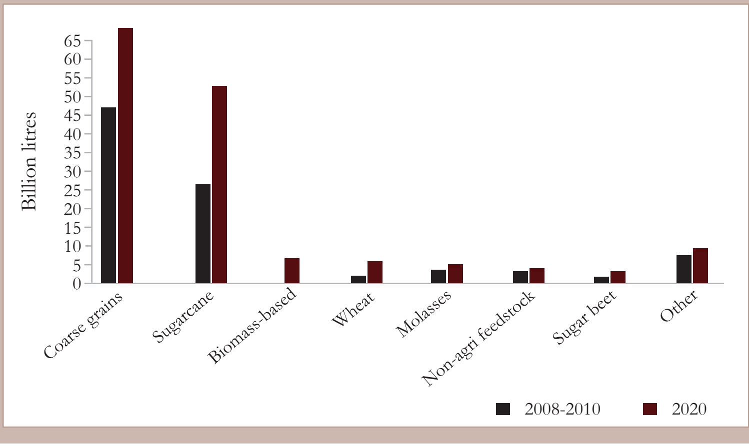
In Europe, Belgium extended its existing B4 and E4 blending mandates; Spain increased its 2011 biofuels mandate from 5.9 percent to 6.2 percent (in terms of energy content), rising to 6.5 percent for 2012–2013; and Bulgaria, Finland, Poland and Italy followed suit. In Australia, New South Wales postponed its biodiesel mandate increase (from B2 to B5) due to a lack of sufficient local

Table 3.1 Production projection of ethanol and biodiesel for 2020 (million litres)

	Region/country	Ethanol	Biodiesel
Aggregate	World	154,961.9	41,917.2
	OECD	84,164.2	22,925.4
	Non-OECD	70,797.7	13,477.2
OECD countries	Australia	492.0	719.0
	Canada	2,358.9	593.9
	Chile	39.7	79.1
	EU-27	16,315.9	17,610.2
	Japan	946.3	-
	Korea	179.5	-
	Mexico	90.2	-
	Turkey	87.9	52.1
	US	63,960.9	4,002.2
Africa	Algeria	18.5	0.01
	Egypt	64.6	0.01
	South Africa	421.4	99.9
Latin America and Caribbean	Argentina	469.8	3231.2
	Brazil	50,392.5	3,139.2
	Uruguay	51.4	84.6
Asia	Bangladesh	303.7	0.01
	China	7,930.5	-
	India	2,204.1	3,292.7
	Iran	135.5	0.01
	Malaysia	73.9	1,330.7
	Pakistan	408.3	180.0
	Saudi Arabia	42.1	0.01

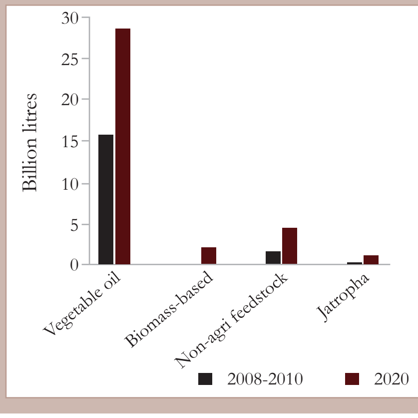
Source: Based on OECD-FAO's Agricultural Outlook 2011–2020 (from OECD.Stat).

Figure 3.5 Ethanol production by feedstocks



Source: Based on OECD-FAO (2011).

Figure 3.6 Biodiesel production by feedstocks



Source: Based on OECD-FAO (2011).

supplies to meet the proposed target. In the US, the national volumetric ethanol excise tax credit, first introduced in the 1980s, expired at the year's end; the US import tariff (approximately US$0.14/litre) was also eliminated at the end of 2011. The US Renewable Fuel Standard, an ethanol blending mandate, remains in place; in addition, a US$510 million initiative was announced to boost next-generation biofuels, and the Defence Department began investing in biofuels for marine and aviation needs. Table 3.1 and Figures 3.5 and 3.6 delineate the future outlook of ethanol and biodiesel. Table 3.1, based on the *Agricultural Outlook 2011–2020* (OECD-FAO 2011), indicates the future production potential of ethanol and biodiesel until 2020, region-wise and country-wise. Figures 3.5 and 3.6 indicate global ethanol and biodiesel production by feedstocks used.

Chapter 4

Biofuel policies in South Asia

With its scanty and dwindling reserve of crude, the South Asian region is particularly vulnerable to oil shocks. All the countries of the region are perennial net oil importers. Such import dependence for crude not only draws down a large chunk of foreign exchange reserves of these countries, but also makes them highly energy insecure. In this context, most of the South Asian countries are promoting blending of biofuels with liquid petroleum fuels (ethanol with petrol and biodiesel with petro-diesel) for the transport sector, predominantly with energy security concerns in view. Another major driving force is the purported potential of biofuels to contributing towards mitigation of GHGs. Besides, the interest in biofuels is also driven by the potential co-benefits in the form of increasing employment opportunities, rural development, and reducing indoor pollution associated with firewood or direct use of biomass in inefficient *chullahs* (oven), thereby improving population health in rural areas, and so on.

Among South Asian countries, India and Pakistan are frontrunners in biofuel production and consumption, but initiatives are underway in several other countries like Bangladesh and Nepal as well. However, all these initiatives are confined to usage of first-generation biofuels, namely ethanol and biodiesel. This also provides a rationale for why the paper focuses on these two liquid biofuels. Annex 1, which is self-explanatory, provides a brief overview of feedstocks used and policy incentives provided in select South Asian countries and some of the key biofuel-producing countries/regions across the globe. This chapter takes a closer look at the biofuel policies and other initiatives undertaken by different South Asian countries (see Annex 2 for a summary).

4.1 India

India is the world's fifth largest primary energy consumer, and fourth largest petroleum consumer after the US, China and Japan. In the financial year 2011–12, petroleum consumption in India was around 148 million tons (approx. 172 billion litres). More than 70 percent of India's energy requirement is met by imports resulting in a huge strain on the exchequer. India's oil import expenditure exceeded US$135 billion in the financial year 2011–12, up 22 percent over the previous year (USDA 2012a).

Biofuel production initiatives in South Asia are confined to usage of first-generation biofuels, namely ethanol and biodiesel.

The transport sector accounts for the largest share of the consumption of petroleum products in India—around 51 percent. Diesel and petrol account for more than 95 percent of the requirement for transportation fuel, and demand is expected to grow at 6–8 percent over the coming years in tandem with the rapidly expanding vehicle ownership (USDA 2012a). Evidently, India's energy security would remain vulnerable until alternative fuels to substitute or supplement petro-based fuels are developed based on indigenously produced renewable feedstocks (Government of India 2008). In this context, biofuels are promoted by the Government of India with the primary objective of improving the country's energy security. The National Policy on Biofuels (NPB) that was drafted by the Ministry of New and Renewable Energy of the Government of India and was approved by the Union Cabinet in September 2008 aims at the mainstreaming of biofuels in the energy and transportation sectors of the country in the coming decades, thereby contributing to energy security and climate change mitigation, while at the same time generating new employment opportunities and leading to environmentally sustainable development. An indicative target of 20 percent blending of biofuels—both for biodiesel and ethanol—by 2017 has been proposed in the NPB, with a provision for periodical review and modification as per the availability of biodiesel and ethanol. Thus, there is an element of flexibility ingrained in the NPB. While the blending levels prescribed for biodiesel are intended to be "recommendatory", the same for ethanol has already been made mandatory.

India's National Policy on Biofuels aims at mainstreaming biofuels in the energy and transportation sectors of the country.

In fact, way back in September 2002, the Ministry of Petroleum and Natural Gas of the Government of India came up with a notification making 5 percent blending of ethanol with petrol by Oil Marketing Companies (OMCs) "mandatory" in nine Indian states and four Union Territories with effect from January 2003 through its ambitious Ethanol Blending Programme (EBP). Meanwhile, a Committee on Development of Biofuels was constituted in July 2002 by the Planning Commission, the final report of which was released in July 2003 (Planning Commission 2003). The Report recommended that India move progressively towards the use of biofuels. As regards ethanol, the Report called for further strengthening of the ongoing EBP.

In India, ethanol is predominantly being produced from sugarcane molasses, a by-product of sugar production. Ethanol production in India, therefore, depends largely on availability of sugar molasses, which in turn depends on production of sugarcane. Since sugarcane production in India is cyclical, ethanol production also keeps fluctuating from one year to another, often failing to meet the optimum supply level required to meet the demand at any given point in time. Lower sugar molasses availability and consequent higher molasses prices also affect the cost of production of ethanol, thereby disrupting its supply under the EBP. This has acted as a key constraint confronting the EBP ever since its inception. In order to augment the availability of ethanol, the sugar industry has been permitted since October 2007 to produce ethanol directly from sugarcane juice. Even then, adequate supply of ethanol for the EBP has continued to remain unattained from time to time for a host of other reasons as well. The January 2003 target of 5 percent blending could be implemented only partially due to unavailability of ethanol, owing to low sugarcane production in the financial years 2003–04 and 2004–05. Resurgence in sugarcane production in 2005–06 and 2006–07 led the government to revive the 5 percent blending norm in November 2006, mandating it for 20 states and four Union Territories, subject to commercial viability.

In October 2007, the Government of India announced a "mandatory" 5 percent blending of ethanol with petrol across the country (except North East, Jammu and Kashmir and island territories). Although the attainment of even this target continued to remain elusive owing to a shortage of sugarcane in 2007–08, in October 2008, the government went ahead in pushing the bar upwards to 10 percent, which obviously was never realized. In fact, the 5 percent blending target has yet to be accomplished successfully. While lack of availability of sugar molasses is a major constraint in this respect, there are other teething problems as well. Failure to set an ethanol pricing formula, and procedural delays by various state governments, among other reasons, are being held responsible for delayed procurement under the EBP even in the years of good sugarcane production. For instance, while sugarcane and sugar production have been good over the past three consecutive years (including 2012–13), even in 2010–11, the OMCs have been unable to procure contracted ethanol supplies from sugar mills and ethanol manufacturers. The contracted supply for 2011–12 is estimated to be just sufficient to meet 2 percent blending of ethanol with petrol under the EBP (USDA 2012a). Presently, only three fifths of total facilities are actually supplying ethanol, severely constraining its supply for the EBP.

In August 2010, the government fixed an *ad hoc* provisional procurement price of Indian Rupees (INR) 27 per litre of ethanol by the OMCs for the EBP. Subsequently, an expert committee was constituted under the Planning Commission to recommend a formula for pricing ethanol, which, in March 2011, came up with its recommendation for fixing the price of ethanol at 20 percent lower than that of petrol. However, consensus has still remained elusive on the pricing policy of ethanol.

Meanwhile, given the upswing in the sugarcane production cycle, molasses stocks are getting exported to Europe for cattle feed, while exports of ethanol from India have also grown significantly in the past three years. Notably, export of biofuel is only permitted after supply meets the domestic requirement and the final decision is taken by the National Biofuel Coordination Committee. The export of feedstock as well as ethanol coupled with the inability to meet the domestic blending target tends to indicate a lack of appropriate policy initiatives in India towards effective implementation of the EBP.

As for biodiesel, the Planning Commission Report released in 2003 recommended the launching of a National Mission on Biodiesel based on non-edible tree-borne-oils (TBOs). Since the domestic requirement of edible oilseeds in India is higher than production, it was not regarded as a viable option for the country. Instead, non-edible oilseeds like jatropha, pongamia, jojoba and karanja came to be regarded as appropriate feedstocks for the production of biodiesel in India. While hundreds of such non-edible oilseeds are available in India, the Planning Commission Report identified jatropha curcas as the feedstock of choice for India. Biodiesel production in India is predominantly focused on using jatropha; however, other non-edible TBOs, such as pongamia, karanja and animal fats like fish oil, are also being used (USAID 2009).

The Planning Commission Report proposed a target of blending 5 percent biodiesel with high-speed diesel (HSD) beginning 2006–07, gradually raising it to 20 percent in 2011–12, i.e., by the end of the 11th Five Year Plan. It was estimated that with a projected demand of 52.33 million tons of HSD (approx. 62.38 billion litres) by 2006–07, meeting the proposed 5 percent blending target will need 2.19 million hectares of land to be brought under jatropha plantation. On the other hand, with a projected HSD demand of 66.9 million tons (approx. 79.75 billion litres) by 2011–12, plantation of jatropha over about 11.2 million hectares of land would be required to meet the 20 percent blending target. The Report estimated that about 13.4 million hectares of land could potentially be made available for jatropha plantation. The National Mission on Biodiesel was proposed in two phases. Phase I was to consist of a Demonstration Project to be implemented by 2006–07. As a follow-up to the Demonstration Project, Phase II, scheduled to begin in 2007, was to consist of a self-sustaining expansion of plantation and other related infrastructure with the support of the government with the aim of producing enough biodiesel to meet the 20 percent blending target in 2011–12.

About 13.4 million hectares of land could potentially be made available for jatropha plantation in India.

For implementation of the Demonstration Phase (2003–2007), the Ministry of Rural Development was appointed as the nodal ministry to plant jatropha in 400,000 hectares of land. This phase also proposed nursery development, establishment of seed procurement and establishment centres, installation of transesterification plants, and blending and marketing of biodiesel. Public and private sectors, state governments and research institutions (Indian and foreign) involved in the programme achieved varying degrees of success in this phase. In October, 2005, the Ministry of Petroleum and Natural Gas announced a biodiesel purchase policy under which the OMCs would purchase biodiesel from 20 procurement centres across the country to blend with HSD as of January 2006. Purchase price was set at INR. 26.50 per litre. However, the cost of biodiesel production turned out to be 20–50 percent higher than the set purchase price. Consequently, there was no sale of biodiesel (USDA 2012a).

Total commercial production of jatropha-based biodiesel in India is small, with estimates varying from 140 million to 300 million litres per year.

While the Phase II or the self-sustaining phase of the National Mission was to bring in about 11.2 million hectares of land under jatropha plantation by 2011–12 in order to meet the 20 percent blending target, only about half a million hectares of land has actually been planted with jatropha, of which two thirds is believed to be new plantations needing two to three years to mature (USDA 2012a). Currently, biodiesel production is small and decentralized, yields are low, and production costs remain high (USAID 2009).

Jatropha plantation is a subject for state governments in India. Public-sector petroleum companies and private-sector firms have entered into memoranda of understanding with state governments to establish and promote jatropha plantation on government wastelands or to contract with small and medium farmers. However, only a few states have been able to actively promote jatropha plantation despite the government's incentives and encouraging policies. Smaller land holdings and ownership issues with government- or community-owned wastelands have further hindered large-scale jatropha plantation, while use of conventional low-yielding jatropha cultivars has exacerbated the supply-side constraint. The progress of the Biodiesel Mission has been impeded by inadequacy in seed collection and extraction infrastructure; buy-back arrangement; and capacity- and confidence-building measures among farmers, among other factors.

Given the inadequacy of jatropha seeds production, most of the biodiesel units are not operational most of the year. There are about 20 large-capacity biodiesel plants in India that produce biodiesel from alternative feedstocks such as edible oil waste (unusable oil fractions), animal fats and inedible oils. Presently, total commercial production and marketing of jatropha-based biodiesel in India is small, with estimates varying from 140 million to 300 million litres per year. Negligible commercial production of biodiesel has impeded efforts and investments by both private- and public-sector companies. Whatever little biodiesel is produced is sold to the unorganized sector (irrigation pumps, mobile towers, kilns, agricultural usage, owners of diesel generators, etc.) and to experimental projects carried out by automobile manufacturers and transport companies. However, there has been no commercial sale of biodiesel across the biodiesel purchase centres set up by the Government of India, as the government biodiesel purchase price of INR 26.5 per litre is still below the estimated biodiesel production cost (INR 35 to 40 per litre) (USDA 2012a). Unavailability of feedstock supply, rising wage rates and inefficient marketing channels are among the major factors that have contributed to higher production costs. In view of reports that most biodiesel companies in India are working at very low capacity and some are idle, the government has reportedly contemplated fixing a higher price of INR 34 per litre for purchase of biodiesel through OMCs. However, this proposal has yet to materialize.

The National Policy on Biofuels proposed to set up a National Biofuel Coordination Committee headed by the prime minister and comprising ministers from concerned ministries as members to provide overall coordination, effective end-to-end implementation and monitoring of biofuel programmes. The Committee has accordingly been set up. The National Policy envisaged putting in place appropriate financial and fiscal measures to support the development and promotion of biofuels and their utilization in different sectors. Except for a concessional excise tax of 16 percent on ethanol, no other central taxes and duties are proposed to be levied on biodiesel and ethanol. Biofuel technologies and projects would be allowed 100 percent foreign equity through an automatic approval route to attract foreign direct investment (FDI), provided the biofuel is for domestic use only, and not for export. Planting of inedible oil-bearing plants would not be open to FDI participation. To avoid competition with food crops, the policy supports increasing biodiesel plantations on community, government-owned and forest wastelands, but not on fertile, irrigated lands.

The policy also details incentives for growers of biofuel crops. Cultivators, farmers, landless labourers, etc. are to be encouraged to undertake plantations that provide the feedstock for biodiesel and ethanol. Such cultivation/plantation is to be supported through a minimum support price for the non-edible oilseeds used to produce biodiesel, with a provision for its periodic revision so as to ensure a fair price to farmers.[5] The corporate sector is also to be enabled to undertake plantations through contract farming by involving farmers, cooperatives and self-help groups, among others. It was proposed that employment provided in plantations of trees and shrubs bearing non-edible oilseeds would be made eligible for coverage under the National Rural Employment Guarantee Programme, now known as Mahatma Gandhi National Rural Employment Guarantee Programme.

The National Policy further proposed that in the determination of biodiesel purchase price, the entire value chain comprising production of oilseeds, extraction of bio-oil, its processing, blending, distribution and marketing would have to be taken into account and that the minimum purchase price (MPP) for biodiesel by the OMCs would be linked to the prevailing retail diesel price. The MPP for ethanol would be based on the actual cost of production and import price of ethanol. The MPP, both for biodiesel and ethanol, would be determined by the Biofuel Steering Committee and decided by the National Biofuel Coordination Committee. In the event of diesel or petrol price falling below the MPP for biodiesel and ethanol, OMCs are proposed to be duly compensated by the government.

The National Policy asked states to set up or designate an agency for development and promotion of biofuels in their jurisdictions to decide on land use for plantation of non-edible oilseed plants and allot government wasteland for raising such plantations. It may be noted here that while as per the Planning Commission estimates, adequate waste and barren land exists in India for bringing under jatropha plantation, in actuality much of this land may be otherwise occupied, making it rather difficult to reallocate it for jatropha plantation. Moreover, companies involved in the biodiesel business may not be interested in producing biodiesel feedstock in barren or waste land, if the productivity is not high enough to make the venture profitable.

Much of the so-called "waste and barren" land in India is already in use.

A major thrust would be given through the National Policy to innovation, and research and development (R&D) and demonstration in the field of biofuels. The Policy also envisaged development of next-generation, more efficient biofuel conversion technologies based on new feedstocks. If necessary, a National Biofuel Fund was also proposed to be set up for providing financial incentives, including subsidies and grants, for new and second-generation feedstocks, advanced technologies and conversion processes, and production units based on new and second-generation feedstocks.

Although the multi-pronged policy prescriptions for development and promotion of biofuels appear positive, the achievement of the targeted blending of 20 percent by 2017 seems a remote possibility, given the existing infrastructure and the institutional set-up and other constraints. Some key constraints are posed by sub-national policies. For instance, the administrative controls that some Indian states have placed on the free movement of biofuels across state borders, and restrictions at the district level, make it very difficult for biofuels to be transported across state and district borders. Another key constraint arises from differential tax structures at the state level (USAID 2009). Considering the slow rate of progress in biofuel production and the fact that several policy issues still need to be resolved, it is unlikely that India's biofuel targets will be achieved as scheduled (USAID 2009).

The Federal Government of Pakistan has set a target of gradual introduction of biodiesel blending with petroleum diesel.

4.2 Pakistan

In Pakistan, the biofuels industry is still at its infancy.[6] At present, the stake of biofuels in the Pakistan's energy mix is negligible (SAARC Energy Centre 2008). Pakistan consumes 8 million tons (approx. 9.5 billion litres) of diesel annually, out of which 4 million tons (approx. 5 billion litres) are imported. If 10 percent of the country's annual diesel consumption is replaced with biodiesel, it would result in an estimated savings of more than US$1 billion per annum (Government of Pakistan 2008a).

Realizing the importance of biodiesel, the Alternative Energy Development Board (AEDB) of the Government of Pakistan outlined the National Biodiesel Programme (Government of Pakistan 2008a) and decided to assist and facilitate the stakeholders involved for this purpose. The AEDB formulated the Policy Recommendations for use of biodiesel as an alternative fuel, which are primarily aimed at reducing the country's fuel import bill. The Economic Coordination Committee of the Federal Cabinet approved the Policy Recommendations in February 2008. Under these Policy Recommendations, the Ministry of Water and Power in collaboration with the AEDB is to act as the apex coordinating and facilitating body for the biofuels programme. The Federal Government has set a target of gradual introduction of biodiesel blending with petro-diesel so as to achieve a minimum share of 5 percent by 2015 and 10 percent by 2025. The OMCs are to purchase biodiesel (B100) from biodiesel manufacturers and sell this biodiesel blended with petro-diesel starting at B5 at their retail sales points. The Ministry of Petroleum and Natural Resources was to develop fuel quality standards for B100 and blends up to B20 with the technical support of the Hydro Carbon Development Institute of Pakistan. The Oil and Gas Regulating Authority will be regulating the pricing mechanism of various blends of biodiesel (B5, B10, etc.), ensuring its competitiveness with petro-diesel (SAARC Energy Centre 2008). Fiscal incentives in the form of exemption of taxes and duties on biodiesel-related equipment, machinery and other specific items were issued through a notification in 2008 (Government of Pakistan 2008b).

As part of the implementation of the National Biodiesel Programme, the AEDB coordinated with relevant stakeholders and formed an advisory committee to steer the National Biodiesel Programme.[7] The AEDB has successfully engaged the state-run Pakistan State Oil (PSO) for furthering the National Biodiesel Programme. The PSO has established an Alternate Energy Department at its head office in Karachi. The PSO has selected non-edible plants/seeds species, such as castor, jojoba and jatropha, for production of biodiesel (Ali *et al.* 2012).

Experimental cultivation of biodiesel feedstock on a scientific basis has also been started. The cultivation has risen from around two acres in 2005 to more than 700 acres in 2010. A number of institutions imported jatropha seeds from a variety of sources and countries for germination. They have been growing such nurseries at various sites in Sindh, Punjab and Balochistan. The PSO, for instance, has established a jatropha nursery and a jatropha model farm on 22 acres of land available at Pipri Marshalling Yard, Karachi. The AEDB has also provided a biodiesel production plant to the PSO for the optimization of biodiesel processing techniques. The PSO has processed and tested different biodiesel blends on its fleet vehicles and generators. Pakistan's first-ever commercial biodiesel production facility has been set up in Karachi by a private company. This biodiesel refinery has a capacity of producing 18,000 tons (approx. 20 million litres) of biodiesel per annum.

As for ethanol, in July 2006, a pilot project was initiated by the AEDB through the PSO and the Hydro Carbon Institute of Pakistan to assess the introduction of blended petrol with 10 percent locally produced fuel ethanol (E10), aimed at meeting the energy shortfall. In a separate move, the Federal Government directed the provincial authorities to initiate sale of blended fuel in their jurisdictions. The plan of E10 blending with petrol was jointly managed by the Ministry of Industries and Production and the Ministry of Petroleum. The Ministry of Petroleum intimated that introduction of E10 fuel in the transport sector was a pilot move, initially for a period of two years. It was proposed that beginning in early 2010, the PSO would start marketing of E10 ethanol-blended petrol in Karachi. The Oil and Gas Regulating Authority has been empowered to fix the price of E10. The Federal Minister for Petroleum and Natural Resources also considered the possibility of ethanol-blended HSD marketing (Ali *et al.* 2012).

Sugar molasses is the main feedstock used in Pakistan for ethanol, as it is currently the most economically viable means for producing ethanol in the country.[8] The sugar industry is the second largest industry in Pakistan, after the textiles industry. Over the past two decades, Pakistan has consistently been ranked as one of the three largest molasses exporters in the world. Until recently, the bulk of the raw molasses was exported, with only minor quantities converted into industrial alcohol for domestic use and export. An even smaller proportion was converted into ethanol for export. However, since the new millennium, there has been consistent investment in ethanol distilling and now there are around 15 distilleries operating in Pakistan with an installed capacity of 400,000 tons (approx. 0.55 billion litres) and producing different grades of ethanol. Pakistan has emerged as a major exporter of ethanol with exports increasing from 100,000 tons (approx. 0.14 billion litres) in 2004 to 225,000 tons (approx. 0.3 billion litres) in 2010. A record high export of 350,000 tons (approx. 0.48 billion litres) was attained in 2008.[9] With the increased production and export of ethanol, molasses export has come down drastically, because the bulk of it has been used for producing ethanol.

Sugar molasses is the main feedstock used in Pakistan for ethanol, as it is currently the most economically viable means for producing ethanol in the country.

Many institutions in the country are engaged in carrying out R&D activities to evaluate the prospects of introducing biofuels in the country. These include the AEDB, Hydro Carbon Institute of Pakistan, M/S Clean Power Ltd., universities and other academic institutions.

4.3 Sri Lanka

Bioenergy has been a primary source of energy for Sri Lanka throughout its history. The country has no known fossil fuel reserves and is, therefore, highly dependent on oil imports. Although around 57 percent of Sri Lanka's energy demand is met by indigenous primary sources (biomass, hydro and, to a lesser extent, solar and wind), there is still a 43 percent dependence on imported primary and secondary resources (crude oil, small quantities of coal used for industrial kilns and refined petroleum products). The share of biomass as a primary energy source has gradually reduced, from 65 percent in 1990 to 47.4 percent in 2007 (even though it has increased in absolute terms), while the share of petroleum has increased considerably, from 22 percent in 1990 to 43 percent in 2007. This is due to increases in transport requirements, and more importantly, the use of petroleum-based fuel for electricity generation. This has placed a heavy burden on the national economy as well as the energy security of the country (PISCES 2010). The transport sector of Sri Lanka is almost entirely dependent on imported petroleum oil.

Though there is no dedicated policy for biofuels as such, the National Energy Policy and Strategies announced in 2006 (Government of Sri Lanka 2006) proposed encouraging the development of biofuels for the transport sector for improvement in energy security. It stated that fuel diversification in the transport sector would be encouraged through rail and road transport systems based on off-peak electricity supply, and underlined the promotion of biofuels as a high-priority R&D need (Government of Sri Lanka 2006). It further stated that every effort would be made to replace petroleum-based fuels with indigenous biomass and biofuels in industrial thermal applications and transport applications by encouraging such fuel-switching initiatives through appropriate incentives, including facilitation of access to green funding, such as through the Kyoto Protocol's Clean Development Mechanism (Government of Sri Lanka 2006).

Sri Lanka has the capacity to produce ethanol from sugar molasses at its sugar factories, although this is currently only done for the alcoholic beverage industry.

Despite the aforesaid policy pronouncements and a roadmap to achieve 20 percent share of biofuels in fuel consumption by 2020,[10] biofuel production in Sri Lanka is yet to take off. There is no specific ministry or agency directly responsible for biofuels, but around eight ministries have direct or indirect relations therein. The Sri Lanka Sustainable Energy Authority, established in 2007, handles the alternative energy sector. It focuses on promoting indigenous energy resources in Sri Lanka, including bioenergy, and increasing fuel diversity through renewable energy development.

Sri Lanka has the capacity to produce ethanol from sugar molasses at its sugar factories, although this is currently only done for the alcoholic beverage industry. Even though coconut oil could serve as feedstock for biodiesel, edible oils would not be under consideration in the country for the production of biofuels in view of the potential food-fuel trade-off. Several small-scale initiations have taken place to explore the possibility of biodiesel production from non-edible oilseeds, such as rubber, neem and jatropha (SAARC Energy Centre 2008).

With its origin in the Central American region, jatropha was most likely introduced to Sri Lanka by the Portuguese some 500 years ago and has since been well naturalized. It can be seen in most parts of the country except in high elevations, but is predominantly found in the lowly and dry zones commonly as a fence post plant. Though people are familiar with the plant and the ease with which it grows, there had been no attempts to grow it on a plantation scale until recently. With renewed interest in jatropha as a biofuel plant, several requests have been made to the government to obtain state land for the large-scale cultivation of this plant (SAARC Energy Centre 2008).

Some of the initiatives to start biofuel production from jatropha include (PISCES 2010):

- A community-based biodiesel processing centre established by Practical Action at the Rasnayakapura Divisional Secretariat area.
- A plot of jatropha plantation established by the Department of Agriculture to observe the yield performance for biodiesel.
- Studies commissioned by several universities and research institutions on the crop itself: plantation, oil expelling, fuel processing, applications, etc.
- Cultivation of jatropha and commercialization of biodiesel as a transport fuel by private-sector organizations.

It is widely believed that using existing cultivated land to develop Sri Lanka's bioenergy sector would be a risk to the country's food security. Biofuels should be aimed to be grown on un- or under-utilized land (PISCES 2010). Lack of information on land use and degraded/waste/marginal lands are major constraints in designing biofuel plantation.

Lack of sound government policy on biofuel production, lack of coordination among responsible government and private-sector organizations, lack of scientific information on suitable management practices, lack of high-yielding cultivars for large-scale plantations, lack of low-cost multiplication practices for planting material production, among other things, also negatively affect the development of the biofuel industry in Sri Lanka (SAARC Energy Centre 2008).

4.4 Nepal

Petroleum is the predominantly used commercial energy (more than 60 percent) in Nepal, with complete import dependence. Renewables constitute a miniscule proportion of the energy mix of the country. Nepal has a huge hydropower potential with a theoretical generation capacity of 83 gigawatts (GW), out of which only 44 GW is techno-economically feasible. However, only around 1 percent of this is currently being harnessed (SAARC Energy Centre 2008).

Biofuels are expected to have certain beneficial effects for both urban and rural Nepal. There is a scope for blending biodiesel and ethanol with fossil fuels especially for urban areas in the transportation sector with a potential reduction in urban air pollution, improvement in energy security with lesser disruptions, reduction in financial losses (lesser subsidy) and more stable fuel price. The rural energy sector could benefit from plant oil-run cook stoves, irrigation pumps, electricity generators, agro-processing mills and tube well pumps.

Being an agricultural country, Nepal has potential for producing ethanol from sugarcane and oil from seeds. Jatropha and sugarcane are two feedstocks that are potentially suitable for biofuel production in Nepal. Sugarcane is being used by sugar factories and the excess molasses from the sugar factories are adequate to produce ethanol for blending with petrol. Jatropha is found to be growing recklessly all over Nepal in the terai (plains) and lower hills.

Nepal has initiated certain national-level initiatives for promotion of biofuels. The ministerial cabinet made a decision to blend 10 percent ethanol with petrol in 2004 and the Nepal Standard (NS 475) was developed for ethanol as a transportation fuel. However, the E10 target has not come into effect due to a difficulty in agreement between the state-owned oil company and sugar mills regarding pricing of ethanol. The oil company itself is facing a financial crisis because of state-regulated low oil prices. Moreover, private entrepreneurs have been discouraged from entering the biofuel business due to a lack of favourable policies pertaining to the sector (SAARC Energy Centre 2008).

The Government of Nepal has been implementing the National Biofuel Programme since 2008–09 by focusing particularly on the promotion of jatropha for the production of biodiesel. A number of plantation practices and engine test runs have been successfully conducted in Nepal. As biofuel has a huge potential for addressing the rural energy requirements in Nepal, jatropha is being introduced rapidly in various rural programmes as well. There are certain mass plantations for jatropha seeds.

The Government of Nepal has been implementing the National Biofuel Programme since 2008–09 by focusing particularly on the promotion of jatropha for the production of biodiesel.

4.5 Bangladesh

Bangladesh is another heavily petroleum import-dependent country. The country imports nearly 1.2 million to 1.4 million tons (approx. 14 billion to 16 billion litres) of crude oil and 2.4 million to 2.6 million tons (approx. 2.8 billion to 3 billion litres) of refined petroleum products, leading to a total petroleum import bill of more than US$3 billion.

The sources of primary energy in Bangladesh are dominated by gas with a 45.5 percent stake, followed by biomass (35 percent). Contribution by petroleum, coal and hydro are 18 percent, 1 percent and 0.5 percent, respectively. As of 2007, the proven and probable gas reserves in Bangladesh stood at 28.62 trillion cubic feet (Tcf), while the recoverable gas reserve was 20.63 Tcf. Compressed natural gas (CNG) has been used in vehicles since 1997 in Bangladesh (SAARC Energy Centre 2008).

To deal with its energy security concerns, Bangladesh is looking for renewable energy, such as solar, wind and biofuels (SAARC Energy Centre 2008). Biofuels are viewed from different perspectives by different quarters in Bangladesh. The Ministry of Energy regards them as an alternative source of energy; non-governmental organizations (NGOs) prefer to emphasize the employment generation and poverty alleviation aspects; while the roads, railways and water development authorities look at biofuels from a prevention of soil erosion angle.

The Ministry of Energy has commenced work on biodiesel. Some of their plans include identification of appropriate species (like jatropha), testing and cultivating biofuel plantations with a community forest concept throughout the country, assisting the establishment of small crashing plants, collection of raw oil, and refining and blending it with diesel. Further, 11 regional centres of the Bangladesh Agricultural Research Institute have been selected, with the government providing necessary funds, to use molasses. As for cultivation, places like road sides, areas adjacent to railway tracks, deforested hilly areas, embankments, coastal islands and chars have been identified (SAARC Energy Centre 2008).

Nonetheless, biofuel production is yet to take off in Bangladesh, even as debates are on regarding appropriate policies and technologies (Safa *et al*. 2010). This is for several reasons. Bangladesh is one of the most densely populated countries in the world in which agriculture contributes a major share of the gross domestic product (GDP) and acts as a major source of employment. Food security is always a major concern and always gets top priority—the country being a net importer of food, edible oil and fuel. Therefore, the land suitable for food crop cultivation cannot be used for plantation of biofuels (SAARC Energy Centre 2008). Even though the climate for oilseeds, such as jatropha or castor oil is favourable, it is difficult to establish large-scale plantations for biofuels due to the high population density of this country. However, small-scale plantations are not likely to be economically viable to farmers. Some government-owned land could be an option to commence. Feasibility studies on biodiesel and identification of the suitability of plants are underway (SAARC Energy Centre 2008).

Although the climate for oilseeds is favourable in Bangladesh, it is difficult to establish large-scale plantations for biofuels due to high population density.

4.6 The Maldives

The Maldives, a country with a large number of small islands, has fisheries, tourism and coconuts as its main sources of income. Like other countries in the region, the Maldives is also a net importer of petroleum. The government is conducting feasibility studies to produce biodiesel from coconut shells. Used cooking oils are another possible feedstock under consideration (SAARC Energy Centre 2008).

Chapter 5

Biofuels' contribution towards enhancing energy security

Energy security implies provision of secure, reliable, adequate and affordable sources of energy to the masses. The concern for energy security nowadays is no longer confined within the periphery of a single nation, but is increasingly considered as a compelling cross-border issue. Although energy security encompasses availability of and accessibility to all sources of energy, irrespective of their carbon content, the increasing concern for climate change in recent times has shifted the focus more towards harnessing cleaner energy sources with low carbon content.

One of the primary motivations that drive governments worldwide to promote biofuels is the potential for enhanced energy security and reducing dependence on imported crude, thereby saving on foreign exchange. Given that petroleum crude-based fuel still comprises 95 percent of the energy used in the transportation sector (Kahn *et al.* 2007), and that three fourths of the world's proven oil reserves are confined in just seven countries, namely Iran, Iraq, Kuwait, Russia, Saudi Arabia, United Arab Emirates and Venezuela (Naylor *et al.* 2007), the concerns over the reliability of future supplies are well founded. The increasing volatility in international crude prices simply exacerbates the problem.

Given the extent of dependence on imported crude of most developing countries, including those in South Asia, even a full-throated development of biofuels is unlikely to provide adequate respite. It could at best reduce the dependence on petroleum-based fuel only marginally. An interesting calculation carried out by Rajagopal and Zilberman (2007) shows that even if 25 percent of the world's current annual production of sugarcane, corn, wheat, sorghum, sugar beet and cassava was used for ethanol production, it would still account for merely 21 percent of petrol demand. Given the high price-inelasticity of petroleum fuel demand coupled with its high income-elasticity, energy demand is only likely to grow rapidly in tandem with rising income in the future, irrespective of high prices. If the current scenario of the scale and extent of production and consumption of biofuels across the globe is anything to go by, biofuels are highly unlikely to keep pace with such rapid growth in energy demand. Furthermore, the production of biofuel is usually feasible and economically sustainable when the oil price continues to persist on the higher side and only when a generous portion of subsidy is dedicated exclusively to its promotion and development.

Given the extent of dependence on imported crude in South Asia, even a full-throated development of biofuels is unlikely to provide adequate respite.

5.1 Biofuels in the context of energy security in South Asia

Some of the key features of South Asia that are relevant in the context of energy security are:

- Burgeoning population and high dependence on imported oil (which varies from around 25 percent for Bhutan to 100 percent for the Maldives).
- High energy poverty, particularly in rural areas due to a very high depen-

dence on traditional non-commercial fuel (i.e., biomass and firewood) consumption for cooking and lighting.
- High income poverty coupled with low Human Development Index that makes the shift to modern commercial energy services all the more challenging (World Bank 2011a; UNDP 2011).

In the light of the aforesaid features, among others, some of the key challenges and the vulnerabilities of South Asia in the context of energy security are as follows:

- Low resilience to international oil-price volatility. As the transport sector is the largest consumer of oil in South Asia and as its oil demand is highly inelastic to price rise in the short to medium run, this sector in the region is most exposed to oil-price volatility.
- Deforestation and environmental degradation due to intensive use of traditional biomass and firewood, and high morbidity and mortality of rural children and women due to unavoidable exposure to indoor smoke on account of using biomass and firewood in inefficient traditional ovens for combustion.
- High energy subsidy, especially on commercial fossil fuels, with the intention of shielding the poor and vulnerable, but largely without the desired benefit percolating to the intended beneficiaries.
- Very limited scope of leapfrogging and altering the existing energy resource base or achieving technological breakthrough due to cost considerations

Emulation of the Brazilian success story may not be feasible for other countries as initial conditions may not be similar.

To add to the region's woes, world energy prices, especially the price of crude oil, have risen dramatically over the past five years. Crude oil prices, which were routinely benchmarked at under US$30 per barrel in past long-term oil-price forecast studies, shot up to US$147 per barrel in mid-2008 and have been constantly hovering around the psychological threshold mark of US$100 per barrel. If this trend persists, it will have a debilitating impact on the economies of South Asia, and will put the scarce foreign exchange reserve base of the region under heavy stress in order to meet the ballooning oil import bill. Some countries, like the Maldives and Sri Lanka, would be particularly hard-hit, since they have very limited reliable energy alternatives to fall back upon in the event of an oil shock.

For major oil-importing nations like those in the South Asia region, an important reason behind the promotion of domestic biofuels and providing policy support, including subsidies, for that purpose is to save on foreign exchange needed to pay the burgeoning oil import bill. Brazil stands out as a huge success story in this respect. Brazil had put in place its PROALCOOL programme as a response to the 1970s' oil price shock. The Programme succeeded in reducing Brazil's dependence on imported crude substantially by focusing on the substitution of crude with ethanol generated from domestically produced cheap sugarcane. However, emulation of the Brazilian success story may not be feasible for other countries as initial conditions may not be similar. Besides, economics of fuel prices also plays a significant role in this context. For instance, substitution of imported oil products with domestically produced biofuels would be possible only when biofuels are effectively cheaper than petro-fuels (with or without subsidies). The actual price relationship varies for different types of biofuels and changes over time, with Brazil's sugarcane-based ethanol being on an average the cheapest biofuel option available.

Some South Asian countries are already grappling with removing subsidies and pruning control on petroleum-based transport fuels. It might be all the more difficult to promote biofuels as they would not be competitive unless the subsidy is eliminated. For instance, the Indian government is having a tough time in increasing diesel prices, due to the fear

Table 5.1 Net energy imports (% of energy use)

Country	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
Bangladesh	15.53	19.63	18.53	19.97	19.35	19.14	18.25	18.99	16.37	16.46	16.28
India	8.49	13.10	20.25	19.65	19.91	19.26	21.05	21.32	22.33	23.92	24.58
Nepal	4.97	8.53	11.96	12.38	10.03	10.48	9.77	10.64	10.69	10.72	10.88
Pakistan	20.13	23.31	26.08	24.27	23.52	19.50	19.94	19.22	22.15	23.71	23.56
Sri Lanka	24.02	32.39	42.98	43.32	44.58	46.38	45.84	45.34	43.25	45.20	43.23
South Asia	10.19	14.67	21.08	20.42	20.50	19.55	21.01	21.17	22.20	23.72	24.21

Source: World Development Indicators Online (accessed 26 July 2012).

of political backlash, although the potential cascading impact on the economy may not be significant (Soni *et al.* 2012). Moreover, substitution of petro-fuels with domestically produced biofuels is possible only when adequate biofuels are produced domestically. Otherwise, such substitution may call for import of biofuels, thereby eating up at least a part of the foreign exchange saved, if not the whole. Furthermore, if a country is already importing food and diverts food supplies to biofuel production, then it simply turns out to be a case of replacing oil imports with more food imports. This could only be advantageous to the extent that the world food markets are more stable than the world petroleum markets (FAO 2008b). Hence, improving the energy security scenario will be particularly difficult for those countries in South Asia that are both net food importers (e.g., Bangladesh, Nepal) and net energy importers (Table 5.1).

Biofuels' contribution to substituting petroleum-based transport fuels to reduce South Asian countries' dependence on imported crude could at best be marginal. Thus, promoting conventional biofuels to achieve energy self-reliance may not be a well-conceived idea. At best, what could be achieved is a diversification of energy sources. There are, however, potential costs to the environment and household food security, which should be taken on board before large-scale promotion of biofuels is pursued. Considering from the cost and viability point of view, development of biofuels may not be an appealing idea in South Asia unless the subsidies and price control that are existing on petroleum-based fuels are removed in a progressive manner.

Unless the subsidy on fossil fuel is eliminated, it is difficult to promote biofuels as they would not be competitive.

Chapter 6

Biofuels' environmental implications

Biofuels can influence the environment in multiple ways and are associated with various environmental impacts along the production-consumption chain (Figure 6.1). The plant (that provides feedstock for biofuel) takes up CO_2 during its growth, which is again released when the biofuel is burnt, e.g., in a vehicle. The plant uptake of CO_2 and fuel burning neutralize each other. However, the process of planting, harvesting, transport and transformation leads to GHG emissions in the life-cycle of producing biofuels. These need to be compared with the life-cycle emissions of conventional fuels to establish the GHG reduction due to usage of biofuels (known as life cycle analysis or well-to-wheel analysis). In other words, the life cycle analysis (LCA) for biofuels takes into account emissions not only from the end use combustion of biofuels in vehicle engines, but from the energy used in the entire value chain that includes cultivation, processing and transportation of biofuels.

Emissions related to crop production include:

- Emissions due to energy usage in crop cultivation and harvesting;
- Emissions (nitrous oxide, i.e., N_2O) due to fertilizer usage, including potentially upstream emissions associated with chemical fertilizer production;
- Emissions related to land-use change leading to changes in carbon stocks in carbon pools (e.g., energy crops are planted in areas formerly covered by forests).

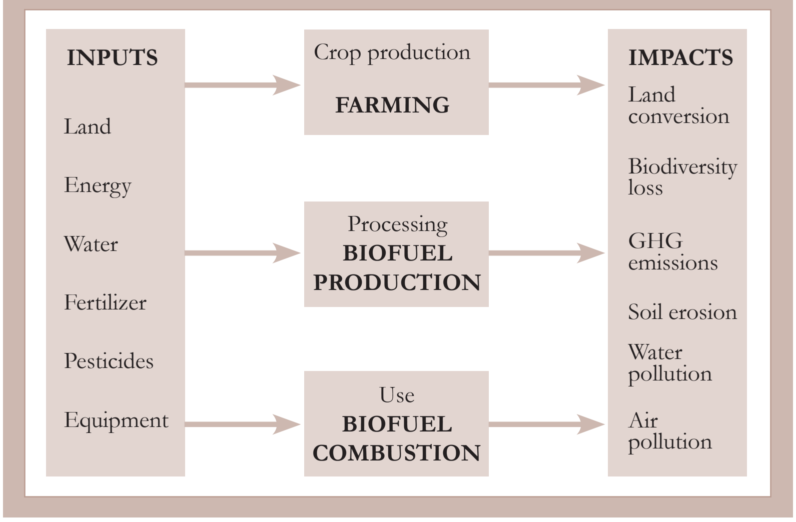
Biofuel production-related emissions include:

- Energy used in the biofuel refinery (electricity and fossil fuel);
- Methane emissions resulting from waste-water treatment facilities in the refinery.

Transport emissions include emissions associated with the transport of agriculture inputs to the biofuel refinery and the transport of (blended) biofuel to the gas station. LCA studies of the biofuel systems often show significant variations with respect to the net energy ratio[11] and GHG emissions reduction due to different assumptions on critical variables that have a decisive impact on the energy and GHG emissions, such as yields and conversion technologies, fertilizer application rates, evaluation, number of en-

The life cycle analysis for biofuels takes into account emissions from the energy used in the entire value chain.

Figure 6.1 Production/consumption chain of biofuels



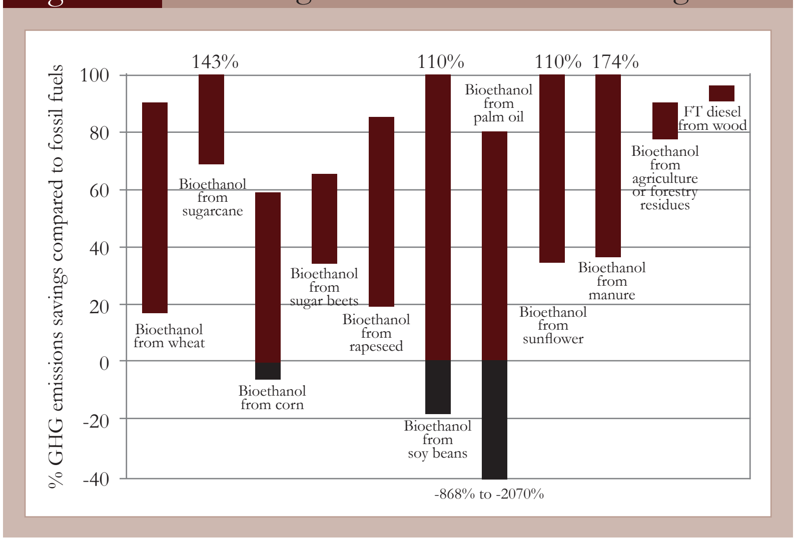
Source: UNEP (2009).

ergy inputs included in the calculations, the approach used for inputs-outputs attribution between the product and co-products, and the distance between the biofuel refinery and the feedstock location. (Alexander 2009; Elder *et al.* 2008; Prueksakorn and Gheewala 2008; Varadharajan *et al.* 2008; Whitaker and Garvin 2009; Whitaker and Garvin 2010). The yield is further dependent on land quality, water availability, fertilizer application and weather (Elder *et al.* 2008).

The GHG emissions reduction potential for the same crop planted on a given piece of land in a given country could vary from one year to another.

Thus, the GHG emissions reduction potential for the same crop planted on a given piece of land in a given country could vary from one year to another depending on the weather situation. Usually, there are considerable variations in the results, as well as in the design of the studies. Studies may differ in results depending on what is included in the "life cycle" (usually referred to as boundary conditions) and whether they consider by-products and assumptions about production methods. It also deserves to be mentioned that the life-cycle-wide impacts of biofuels are usually examined in a comparative manner, in order to single out which alternative—among fossil or bio-based options—has relatively lesser environmental burden. Often, the alternatives have different strengths and weaknesses.

Figure 6.2 Percentage of GHG emissions savings



Source: UNEP (2009).

Figure 6.2 shows a summary of indicative percentage variations in the GHG emissions saving from biofuels *vis-à-vis* fossil fuels, found in various LCA studies. It may be noted that the figure does indicate a net positive impact of biofuels in terms of reducing GHG emissions compared to fossil fuels.

Fuel-wise, the highest GHG savings are recorded for sugarcane (70 percent to more than 100 percent), whereas corn could save up to 60 percent but may also cause 5 percent more GHG emissions. The highest variations are observed for biodiesel from palm oil and soya. High savings of the former depend on high yields, while those of the latter depend on credits of by-products. Negative GHG savings, i.e., increased emissions, may result, in particular, when production takes place on converted natural land and the associated mobilization of carbon stocks is accounted for. High GHG savings are recorded for biogas derived from manure and ethanol derived from agriculture and forest residues, as well as for biodiesel produced from wood.

More recently, the IEA has brought out a succinct review of 60 LCA studies on GHG emissions from biofuels *vis-à-vis* the replaced fossil fuels (Figure 6.3). The study demonstrates that, depending on the details of the process and the way the feedstock is produced (including the amount of fertilizers used), the net balance of life cycle GHG emissions can vary significantly even for the same fuels. Interestingly, the review has made a clear demarcation of conventional and advanced biofuels while examining their impact on GHG emissions reduction.

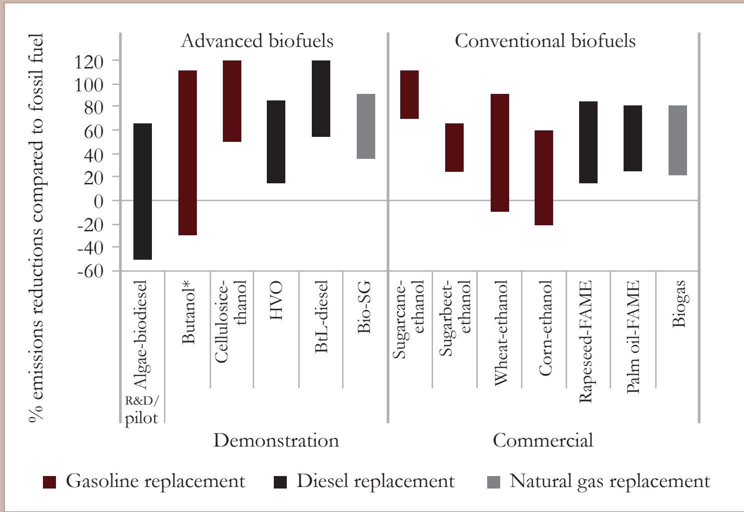
As Figure 6.3 indicates, ethanol from sugarcane seems to have a much higher potential for GHG emissions reduction than other conventional biofuels, a finding similar to UNEP (2009). Although some advanced biofuels, such as ethanol or biodiesel from ligno-cellulosic feedstocks, seem to have considerable potential for GHG emissions reduction, the estimates for these processes are theoretical or based on pilot plants rather than those operating on a commercial scale. Hence, the uncertainties surrounding the estimates also tend to be higher.

It also deserves to be mentioned at this juncture that the LCA studies reviewed by the IEA (2011b) do not cover the impacts from indirect land-use change. Indirect impacts of biofuel production, like the destruction of natural habitats (e.g., rainforests or savannahs) to expand agriculture land, may have larger environmental fallouts compared to the direct effects. In fact, most of the LCA studies leave out the impacts of the increased biofuel feedstock cultivation on land-use change, such as rainforest destruction or conversion of bogs and peat lands to arable cropping. Therefore, these studies tend to underestimate the negative effects of biofuels on GHG emissions significantly. In the worst cases, the GHG emissions from biofuels production may be higher than those from an equal amount of fossil fuels (Delucchi 2006; Farrell *et al.* 2006).

Indirect land-use change resulting from expansion of biofuel production is a significant source of GHG emissions. For example, if fertile land hitherto used for food crops (such as corn, soybeans, palm nuts, canola) is diverted into production of biofuels, this could lead, within the same jurisdiction or elsewhere in the world, to clearing of wild lands to meet the displaced demand for crops. Such indirect land-use changes resulting from the production of biofuels could result in extra GHG emissions, on the one hand, and deforestation and biodiversity loss, on the other (Tilman *et al.* 2009). A recent study concludes that if land-use changes are taken into account, biofuels may result in as much as 50 percent higher GHG emissions when compared to fossil fuels (Searchinger *et al.* 2008). In a letter to the Intergovernmental Panel on Climate Change in 2007, Pimentel *et al.* (2007) pointed out that biofuels will be unsustainable even if they are produced in small areas, as it usually means taking away fertile land from agriculture use, leading to deforestation and land-use change related to GHG emissions. A consensus is emerging that increased GHG emissions from rainforest destruction will be significantly more than the GHG emissions that will be saved by replacing rainforests with biofuel crops (Fargione *et al.* 2008). It has also been estimated that the peat lands in Southeast Asia store about 42,000 Mt of carbon which could potentially be released into the atmosphere if they are converted to palm oil production (Hooijer *et al.* 2006). Some recent studies on GHG emissions resulting from direct change of land use have also estimated significant additional emissions in the cases of clearing forests for bio-feedstock plantations in Malaysia and Indonesia as such land conversion may disrupt any future potential for storing carbon in biomass and soil (Lopez and Laan 2008; Dillon *et al.* 2008). Therefore, prevention of the conversion of rainforests and peat lands to biofuel production is an important priority.

Against this backdrop, a number of studies have highlighted the danger of large-scale biofuel mandates. For instance, it was estimated that the additional usage of conventional biofuels required to

Figure 6.3 Percentage GHG emissions reductions



*Notes: *Emissions savings of more than 100 percent are possible through use of co-products. Bio-SG = bio-synthetic gas; BtL = biomass-to-liquids; FAME = fatty acid methyl esters; HVO = hydro treated vegetable oil.*

Source: IEA (2011b).

Indirect land-use change resulting from expansion of biofuel production is a significant source of GHG emissions.

meet the blending mandates in the 27 EU member states by 2020 would result in indirect land-use change across an area between 4.7 million hectares (about the size of the Netherlands) and 7.9 million hectares (about the size of Ireland). Taking into account such significant impacts on land use, the same study estimates that, counter to GHG emissions reduction targets, such policies will lead to an increase in GHG emissions in the range from 31.3 to 64.6 Mt of CO_2 equivalents (Bowyer and Kreschmer 2011).

Biofuels also have other potential impacts on biodiversity, and air and water quality. These effects have not been studied as extensively by LCA analysis as the energy balance and GHG emissions. Biodiversity will be threatened by large-scale production of monoculture biofuel crops, especially if it involves extensive destruction of rainforests (Bergsma *et al.* 2006). Therefore, there may be complex trade-offs between biodiversity and GHG emissions reduction. Water quality may also be negatively affected by large-scale production of biofuels, due to greater fertilizer use in feedstock production and effluents from processing industries. Current LCA studies have been criticized for not clearly considering policies or economic effects; basically, they assume a narrowly defined set of activities replacing existing practices (Delucchi 2003). It is likely that the impacts of different life-cycle stages may be affected by various government policies or economic conditions. These may vary over time, across countries, or even within countries.

There may be complex trade-offs between biodiversity and GHG emissions reduction.

What is required are comprehensive LCA studies that cover broad time scales; different transportation modes, fuels and feedstocks; lifecycle of vehicles using the fuel; condition of the infrastructure under which each kind of fuel will be used; and effects of other policies, such as pricing policy, that may produce effects not directly related to the fuel. Also, LCA studies preclude impacts such as deforestation of tropical rainforests and land-use changes, and assign imputed costs to possible environmental problems such as biodiversity loss.

Although the aforementioned LCA studies throw some light on the GHG emissions or net energy consumption associated with biofuels, most of these studies may not be applicable in the context of Asia, especially South Asia, as they are either based on data from non-Asian countries where production processes are different, or are based on assumed values under ideal conditions. Thus, the findings are only indicative in nature and may not adequately reflect the actual scenario of production, processing and transportation of biofuels in South Asia. Since the net energy consumption and environmental fallouts of biofuels depend on a plethora of factors, such as agriculture production practices, refining technologies and feedstock sources, the actual performance of biofuels, for instance in South Asian countries, could actually be better or worse and would clearly be contingent upon the nature and extent of usage of energy and other inputs.

In this context, some recent LCA studies carried out in the South Asian context on jatropha (Jatropha Curcas L)[12] deserve a special mention. These studies have largely been carried out in India. A study carried out by the Confederation of Indian Industry (CII) (CII 2010) came out with a framework for estimation of energy and carbon balance of various categories of biofuels (ethanol and biodiesel) in the Indian context. The study analysed the inputs and data received from various industries, R&D labs, and academic institutions involved in production and research of biofuels, besides referring to published data available in the public domain. It focused on four key parameters: net energy balance, net carbon balance, net energy ratio and percentage reduction in carbon emissions.[13] Based on the analyses carried out in the report, biodiesel from jatropha oil has been observed as having favourable characteristics in terms of energy and carbon balance compared to other biofuels. This is due to the significant energy contribution from the co-products obtained during biodiesel production, namely seed husk, seed cake and glycerol, which contribute almost 48 percent of the total energy generated during the end-use stage. On the other hand, sweet sorghum-based ethanol has been observed to have the best conversion efficiency in terms of converting input energy to output energy. The CII report estimated the GHG emissions reduction value of 30 percent for biodiesel in comparison to petroleum diesel, which is considerably lower than earlier studies (e.g., Whitaker and Garvin 2009; Whitaker and Garvin 2010; Xiaoyu *et al*. 2009; Gheewala and Prueksakorn 2006; Achten *et al*. 1997) that reported GHG emission reductions ranging from 50 percent to 93 percent from jatropha-based biodiesel.

Another study carried out in the Indian context, Achten (2010), evaluated a small-scale low-input-based jatropha system grown on degraded land, which is unsuitable for cultivation of food crops. Although the results show a reduction in non-renewable energy requirement (82 percent) and global warming potential (55 percent) in comparison to the reference system, the acidification and eutrophication[14] have been observed to increase by 49 percent and 430 percent respectively. Land-use change, however, gets triggered by shifting from degraded land to jatropha plantation.

A more recent study on LCA for biodiesel (Kumar *et al*. 2012), carried out to assess energy balance—GHG emissions for the production of 1 ton of jatropha biodiesel (approx. 1.1 kilolitre)—observed that the GHG emissions reduction with respect to petroleum diesel for generating 1 Giga Joule energy varied from 40 percent to 107 percent, and net energy ratio values ranged from 1.4 to 8 depending upon the methodology used for energy and emissions distribution between product and co-products and also on whether irrigation facility has been used or not. The authors underscored that the amounts of process energy consumption and GHG emissions in the individual stages of the LCA were a strong function of co-product handling and irrigation. In other words, the net savings in energy consumption and GHG emissions were clearly contingent upon the process adopted.

In the light of the uncertainty and contestable impact of biofuel expansion on the environment, many governments, particularly in OECD countries, have tried to design targeted biofuel sustainability policies. However, these approaches have their own share of problems and challenges. The schemes that have addressed the increasing concerns over negative environmental fallouts of biofuel expansion include, among others, the provisions of the EU Renewable Energy Directive (RED), the criteria of the Roundtable on Sustainable Biofuels, the International Sustainability & Carbon Certification, the United Kingdom Renewable Transport Fuel Obligation, and the US Renewable Fuel Standard (RFS). These schemes or criteria are primarily aimed at assessing the environmental impacts of individual biofuels and placing restrictions on the use of biofuels that do not comply with the norms or stipulations underlying them.

The existing biofuel sustainability schemes or criteria do not consider indirect land-use changes.

However, these criteria or schemes are largely based on assessing minimum savings in GHG emissions and impacts on direct land use, although initiatives are being undertaken for both the US-RFS and the EU-RED to encompass the impacts of indirect land-use changes as well. But this would require cross-border monitoring and an internationally acceptable methodology, which is yet to be developed. Therefore, assessment of biofuels' origin turns out to be very difficult (Scarlat and Dallemand 2011; Gerasimchuk *et al*. 2012).

Recently, the EU-RED has come under a lot of criticisms for its approach in defining the sustainability criteria (Lin 2010). A recent carefully crafted LCA study carried out to examine the claim

The development of biofuels could exert additional pressure on the water systems.

of GHG emissions savings from biofuels in the EU-RED indicates that the savings of GHG emissions from biofuel lie far below what is claimed (Pehnelt and Vietz 2012). The EU-RED requires that in order to be classified as "sustainable" and eligible for the mandatory blending scheme within the EU, the GHG emissions associated with the production and use of biofuels should be at least 35 percent lower than those associated with the production and use of conventional fuels. The study by Pehnelt and Vietz that examined the uncertainty of GHG emissions savings from biofuels clearly brought out that the emissions savings from rapeseed biodiesel, which is the main category of biodiesel produced in the EU, do not reach the 35 percent threshold as stipulated by the EU-RED. The authors have also underscored that given the striking difference in their findings and the lack of transparency in the EU's calculations, it appeared to them that "EU seems to prefer 'politically' achieved typical and default values regarding rapeseed biodiesel over scientifically proven ones".

Some biofuel feedstocks—for instance, sugarcane—require significant quantities of water, particularly in hot and changing climates. This means that in countries already experiencing water stress, such as those in South Asia, the development of biofuels will exert additional pressure on the water systems, with feedback into global food markets. Large-scale biofuel production consumes water and impacts water quality in a variety of ways. These impacts include: i) use of water to grow and process feedstock into fuels; ii) release of agrochemicals into surface and ground water; and iii) change in local watershed hydrology caused by biofuel crops. Ambitious plans to scale up biofuel production will only increase water demands (USAID 2009).

South Asia is already well-known to be the most disaster-prone region in the world, and is also among the most vulnerable regions to the effects of climate change. Geography coupled with high levels of poverty and population density has rendered South Asia particularly vulnerable to the impacts of climate change (World Bank 2009). The region's geographic expanse covers a variety of climate zones and ecosystems ranging from lush tropical forests to arid deserts and high-altitude forests and lakes. Given such diversity, climate risks in the region also vary widely from one part to another (see Annex 3 for country-wise vulnerability to various climate change impacts) (World Bank 2009). In such a scenario, if large-scale production of biofuels results in aggravation of the pressure on land use, water and biodiversity, the problems could only get compounded.

The fallout of biofuel production worldwide has a lot of uncertainty elements. Unless a foolproof sustainable process of production is adopted for large-scale biofuel production, it may actually turn out to be a bane instead of a boon for South Asia. However, adoption of such a foolproof, sustainable process is highly challenging even in the context of developed countries, leave aside developing countries. Given the complexity of direct and indirect impacts of biofuel expansion on land, water use and biodiversity, defining sustainability in a region as diverse as South Asia, with its demographic, socio-economic, human development and governance challenges, is extremely difficult.

Chapter 7

Biofuels and the food-fuel debate

Even if one assumes that biofuels do have certain beneficial impacts, it will be difficult to justify their promotion if such policies trigger diversion of land and food crops to biofuels, thereby contributing towards a rise in food prices (Msangi *et al.* 2006; Food and Agricultural Policy Research Institute 2005; Rajagopal and Zilberman 2007)—the so-called food-fuel trade-off. The debate over the impact of subsidized biofuel production on food prices picked up during 2006–2008 when, in spite of a record worldwide crop yield, global prices of traded food commodities, such as staple cereals and sugars, reached record highs (World Bank 2011b). The International Monetary Fund's (IMF) index of internationally traded food commodity prices increased 130 percent from January 2002 to June 2008 and 56 percent from January 2007 to June 2008. Prior to that, food commodity prices had been relatively stable after reaching lows in 2000 and 2001, following the Asian financial crisis.

The increase in food prices was led by grains, whose prices began rising in 2005 despite a record global crop production in the 2004–2005 crop year.[15] Between January 2005 and June 2008, corn prices almost tripled, wheat prices increased 127 percent and rice prices increased 170 percent. The increase in grain prices was followed by increases in the prices of fats and oils in mid-2006, which too followed a record harvest of oilseeds in 2004–2005. Other foods prices (sugar, citrus, banana, shrimp and meat) increased 48 percent between January 2005 and June 2008 (Mitchell 2008).

Notably, these hikes in food prices corresponded with the introduction of biofuel consumption mandates in the US, Europe and some other countries and the rapid increases in global biofuel production (Jung *et al.* 2010). For instance, nearly one fourth of the total corn produced in the US was used for biofuel production during 2007–2008 as against 11.9 percent five years earlier (Chand 2008). In addition to cereals, oilseed crops like rapeseed, soybean and sunflower were also being diverted to biofuel production. The EU used nearly 4.7 million tons (approx. 5.3 billion litres) of rapeseed oil for biodiesel production that constituted around 64 percent of its total output of rapeseed oil in 2007–2008. In terms of area, nearly 47.8 million hectares of arable land was set aside for growing biofuel feedstocks in 2006–2007, which constituted nearly 3.4 percent of the total arable land available for cultivation in the world (Trostle 2008).

Food-price hikes have corresponded with the introduction of biofuel consumption mandates in some countries and the rapid increases in global biofuel production.

From the very beginning, the debate on biofuels' possible role in food-price spikes has been strikingly emotive, with many organizations adopting hard-line, polar-opposite positions, and the media, intergovernmental organizations, NGOs and politicians all being drawn in (Charles 2011). A lot of furore got generated when the study undertaken by Dr. Donald Mitchell—Lead Economist at the World Bank's Development Prospects Group—identified biofuels as the most important driver of food-price volatility, responsible for 75 percent of the observed price increases (Mitchell 2008).

Estimates of the contribution of biofuel production to food-price increases are difficult, if not impossible, to compare.

Much debate and analyses followed, with studies scrutinizing Mitchell's methodology and findings. For instance, it was pointed out that the weak US dollar and the direct and indirect effects of high petroleum prices had not been sufficiently taken into account in Mitchell's methodology (Charles 2011). Nonetheless, evidence that biofuels were contributing to rising food prices was also emerging from a number of research institutions and leading intergovernmental organizations like the World Bank, the OECD and the IMF. However, the estimates on the percentage of the food-price rises between 2006 and 2008, which could be attributed to the expansion of biofuels, varied widely (Table 7.1).

The wide range of variations in the estimates, as depicted in Table 7.1, reflects the considerable uncertainty among experts on the actual role biofuels played in the food-price rise *vis-à-vis* a range of other factors. A key problem emanates from the technical difficulty of estimating the relative weights to be attributable to different, interlinked factors that affect world food prices, such as declining dollar, rising energy prices, increasing agriculture costs of production, growing foreign exchange holdings by major food-importing countries, and policies adopted by some food-exporting countries to mitigate their own food-price inflation (Mitchell 2008); and increasing financial speculation (Wise and Murphy 2012), among other factors.

Moreover, estimates of the contribution of biofuel production to food-price increases are difficult, if not impossible, to compare. Estimates can differ widely due to different time periods considered, different prices (export, import, wholesale, retail) considered, and differences in the food products covered, among others. For instance, differences in the estimates of the impact of biofuels on the price index of all food commodities depend

Table 7.1 Contribution of biofuel expansion to food-price rises during 2006–2008

Study	Percentage assigned to biofuels' contribution	Food prices analysed	Methodology
Mitchell (2008)	70–75% rise in food commodities prices	Corn, wheat, rice, oilseeds and index of food commodity prices since 2002	*Ad hoc* approach, as it does not use structural models to calculate the driving factors
Lipsky (2008)	70% of the increase in corn prices and 40%of the increase in soybean prices	Corn, soybean	Unspecified (based on IMF estimates)
Rosegrant (2008)	25–30%	Corn, wheat, sugar, oils and cassava	Partial equilibrium model (IMPACT Model) analysing the interactions among agriculture commodity supplies
Baier, Clements, Griffiths and Ihrig (2009)	12%	Corn, sugar, barley and soybean	Estimated direct effects using simple supply and demand equations; then added indirect effects to the equations
CBO (2009)	28%–47%	Corn	Analysed corn prices between April 2007 and April 2008 in attributing price increases to increased ethanol production
Collins (2008)	60%	Corn	Mathematical simulation

Source: Authors' compilation.

largely on how broadly the food basket is defined and what is assumed about the interaction between prices of corn and vegetable oils (directly influenced by demand for biofuels) with prices of other crops such as rice through substitution on the supply or demand side. Moreover, the analyses depend on the currency in which prices are expressed, and whether the price increases are inflation adjusted (real) or not (nominal). Further, different methodologies will likely yield different results (Mitchell 2008).

Notwithstanding the differences in estimates, there emerged a clear international consensus that the policies to encourage biofuel expansion, particularly in the US and the EU, were a major contributor to rising food prices. Jean Ziegler, the United Nations Special Rapporteur on the Right to Food, went to the extent of calling the increasing practice of turning crops into biofuels "a crime against humanity", which left millions of poor people hungry. In 2008, Joachim von Braun, Director General of the International Food Policy Research Institute, had called on governments to revoke "biofuel subsidies and excessive blending quotas", recommending that biofuel production should be frozen at current levels and a moratorium enacted on the use of grains and oilseeds for biofuels in order to free up commodities for use as food (Charles 2011).

Though food prices decreased in 2009, they began to rise again in 2010–2011. Once again, biofuels, particularly corn-based ethanol, were singled out as a key contributing factor (Abbott *et al.* 2011; Wise and Murphy 2012). The resurgence of price rise in 2010–2011 only deepened the view that the policies and principles guiding agricultural development and food security were deeply flawed. In fact, a paradigm shift is under way, caused by the deepening integration of agriculture, energy and financial markets in a resource-constrained world, which is made more vulnerable by climate change (Wise and Murphy 2012). The transmission of energy prices to agriculture markets has traditionally been viewed in terms of energy inputs to agriculture (e.g., fertilizer, mechanization and transportation). Now the relationship is determined by the "parity price" between crops and fossil fuels (also referred to as the "break-even price")— defined as the price at which revenues from crop-based biofuel are sufficient to cover production costs (Naylor *et al.* 2007).

In 2011, a group of key international organizations released a report entitled Price Volatility in Food and Agricultural Markets (FAO *et al.* 2011) that stressed that government-imposed consumption mandates for biofuels aggravate the price inelasticity of demand that contributes to volatility in agriculture prices. The report recommended that G20 governments should "remove provisions of current national policies that subsidize (or mandate) biofuels production or consumption". However, in recognition of the political economy challenges of such a step, the recommendation also provided for a "second best option". It recommended that when global markets are under pressure and food supplies are endangered, the countries should replace the rigid biofuel production or consumption targets with more flexible arrangements. The reference point in this respect is Brazil, which uses flexible biofuel support policies to reconcile its interests in both remaining the world's largest exporter of sugar and increasing the share of ethanol from sugarcane in the domestic transport fuel mix (Gerasimchuk *et al.* 2012).

The representatives of the biofuel industry have largely taken a hard-line stance in refuting the food-fuel link.

Quite expectedly, representatives of the biofuel industry have largely taken a hard-line stance in refuting the food-fuel link, blaming food price increases on the interplay of various factors not linked to biofuels. It is argued, for instance, that the 2008 price peaks were driven by speculation, as investors shifted from share markets to commodity markets, and that retail companies in the US had failed to pass on savings after prices had begun to fall. The stakes are obviously quite high for the biofuel industry, since it has invested significant amounts of money in developing the infrastructure and technologies for biofuels, which would suffer if government subsidies and mandates were reduced or stopped—the likely result of establishing a causal link between biofuel production and increasing prices for staple food products. This tension largely explains the lack of constructive dialogue between the biofuel industry and other stakeholders for assessing the scope of the problem (Charles 2011).

What is clear is that the debate will continue to intensify as governments increase biofuel blending mandates and as biofuel production levels rise. It may be recalled here that the IEA forecasts that biofuel support and production will grow significantly in the next 15 years. An increasing global population, continued commodity market speculation, and weather-related production short-falls will also continue to contribute towards volatile global food markets and put pressure on an already-strained agriculture sector (Charles 2011).

A high percentage of the population being net food buyers makes South Asian countries highly vulnerable to food-price rise.

There is now widespread agreement that international agriculture prices will remain significantly higher than pre-crisis levels for at least the next decade, with many warning that demand will outstrip supply by 2050 unless concerted action is taken to address the underlying problems with the food systems (Wise and Murphy 2012). Though extensive literature has been written on the food-fuel trade-off, the debate is far from over. Given that biofuel production and volatile food markets are likely to continue to co-exist, developing a better understanding of how biofuels affect food markets is of critical importance to undertake an appropriate policy stance.

7.1 Food-fuel trade-off and South Asia

Although the biofuel programmes of South Asian countries were not in any way responsible for the food-price rise of 2006–2008, like many other countries across the globe, the countries of the region also had to bear the brunt. In South Asia, which has the largest concentration of poor people in the world, increase in food prices is particularly damaging. Rising food commodity prices tend to negatively affect lower-income consumers more than higher-income consumers. First, lower-income consumers spend a larger share of their income on food. For instance, for the average household in South Asia, food takes up close to half of total spending, compared to only 17 percent in the US. Moreover, staple food commodities such as corn, wheat, rice and soybeans generally account for a larger share of food expenditures in low-income families (Trostle 2008) and the food-price inflation of 2006–2008 was especially stark for cereals.

In South Asia, while almost all the urban poor are net food buyers, around 70–80 percent of rural households are also net buyers of the main grain staples like rice and/or wheat (World Bank 2010). This high percentage makes South Asian populations vulnerable to food-price rise. For each 1 percent increase in primary staple food prices, poor people are estimated to reduce consumption by 0.75 percentage points (Regmi 2001). With reduced food consumption due to higher prices, there could be a drastic increase in the incidence of hunger. Empirical research further shows that in most developing countries, women bear a disproportionate share of the burden of food-price hikes (FAO 2008).

Furthermore, consumers in low-income, food-deficit countries—like most countries of South Asia—are vulnerable because they must rely on imported supplies, usually purchased at higher world prices (Trostle 2008). During the food-price hikes of 2006–2008, South Asian countries suffered severe terms-of-trade shocks of 1 percent of GDP.[16] Food-price inflation varied significantly among the countries of the region during this crisis. In 2007–2008, it ranged from relatively moderate in India (about 7 percent) to high in Nepal and Bangladesh (about 15 percent) to very high in Pakistan (around 20 percent), Sri Lanka and Afghanistan (more than 30 percent). Besides the inter-country variations, there were significant variations among commodities and, in many countries, among regions (World Bank 2010a).

The food-fuel conflict has led to a search for feedstocks that can be grown on unused marginal lands or wastelands, i.e., areas that cannot be used for growing food crops, and thus may not pose a threat to food security. Many South Asian countries are, therefore, considering jatropha as an alternative feedstock, since it can be grown on wastelands and does not require much water. However, while jatropha may not need significant amounts of water to survive, it does need more water and fertilizers to increase the yield of seeds and oil (Elder *et al*. 2008). Moreover, jatropha will do better on higher-quality land, so there are concerns that it may be difficult to limit jatropha to wastelands alone unless there is an appropriate regulatory framework in place.

The logic of focusing on a crop that cannot be used for food, solely as a way to avoid the food-fuel conflict, is not entirely convincing. If a large market is developed for an inedible fuel crop like jatropha, there will be intense pressure to reduce costs and increase profits by cultivating it on higher-quality arable land to obtain higher yields. In such a scenario, it is unlikely that it would be possible to limit its cultivation to "waste lands" or "marginal lands" and its cultivation may spread to better-quality land and displace food crops (Elder *et al*. 2008).

It is also uncertain as to what extent the so-called marginal lands or wastelands are actually remaining unused in South Asian countries like India and Bangladesh, which suffer from intense population pressure. Ground realities may reveal that the land, which is appearing as marginal land or wasteland in government records, is actually being used for subsistence crops or livestock grazing by poor people without secure tenure. Shifting the land to commercial uses like jatropha plantations may further disenfranchise the landless poor (Elder *et al*. 2008). Thus, the issue of classification of wasteland becomes relevant in this context.

In India, for instance, various competing wasteland classifications currently exist—each using different assessment criteria. These classification systems in India are rooted in the colonial land settlement process. The term "wasteland" was applied under both the *zamindari* and *ryotwari* settlement systems—the two dominant land tenure systems of the colonial period (Gidwani 2008). It was broadly applied to various land types that are underperforming in terms of their revenue-generating (i.e., tax collection) potential (Gidwani 2008). A key function of the land classification schemes, in general, was to improve the productive capacity of lands and minimize efficiency loss (Gidwani 2008; Gilmartin 2003).

It is uncertain as to what extent the so-called marginal lands or wastelands are actually remaining unused in South Asian countries.

Land classification thus hinged solely on the economic significance of a plot of land, thus minimizing any ecological, cultural or livelihood benefits it might also bestow on local communities and ecosystems (Baka 2011). Despite the existence of wasteland classifications, corporate, government, civil society and village stakeholders interviewed by Baka (2011) uniformly agreed that there was no such thing as "wasteland". Corporate and government stakeholders believed there was only "wasted land", i.e., the land that could be put to a more productive (i.e., economic) use. Civil society and village stakeholders, on their part, felt all lands were currently in use and served an important purpose in the village.

While sporadic one-time assessments have been conducted to examine the economic significance of wastelands to rural livelihoods in India, such analyses are currently not included in wasteland assessment procedures (Baka 2011). Without addressing this particular dimension in wasteland classification, *In Tamil Nadu, India, biodiesel companies have slowly been amassing plantations of privately owned "wastelands".*

however, the efficacy of wasteland development schemes, such as biofuels, is questionable (Baka 2011).

However, additional clarity in wasteland assessment may not necessarily improve the welfare impacts of wasteland development. On the contrary, such clarity could end up hastening the land grab that is occurring in rural India (Baka 2011). For instance, it is revealed by field studies that in the South Indian state of Tamil Nadu, being motivated by the official policy to restrict feedstock cultivation to waste and marginal lands, biodiesel companies have slowly been amassing plantations of privately owned "wastelands"—the Indian government's term for marginal lands—by purchasing lands from farmers at low rates and/or re-registering farmer's lands without their knowledge or consent. It is further found that after short-lived attempts at raising biofuel plantations and likely after receiving government subsidies for seedling procurement and land preparation, the companies are in the process of selling lands into real estate for at least double the purchase price (Baka 2011).

Thus, instead of minimizing threats to food security and enhancing rural welfare, growing biofuels on marginal and wastelands are allegedly doing the exact opposite by dispossessing farmers of their land. Notably, such biofuels-induced land grabs have been found to occur in Africa as well (Cotula *et al.*, 2009; Sulle and Nelson 2009; World Bank 2010b), the difference being that the land grabs taking place in India involve smaller tracts of land and are more subtle and obscure (Baka 2011). Similar stories may emerge from other South Asian countries as well when they go for large-scale promotion of biofuels, unless appropriate mechanisms are put in place to deal with any such eventualities.

Chapter 8

Regional initiatives for promotion of biofuels in South Asia

South Asia imports most of its oil from the Middle East, a region plagued by security concerns and geopolitical risk. As per an IEA estimate in 2004, the loss of GDP averages nearly 1 percent in Asia on account of a US$10 per barrel increase in oil prices. Hence, diversifying the sourcing of fuels is considered as a foremost step in mitigating these risks and the associated vulnerabilities that arise out of this over-dependence.

Some of the major options and strategies to mitigate the energy security risk factors that have been explored, debated and discussed in the past at various regional forums and meetings under South Asian Association for Regional Cooperation (SAARC) include development of strategic oil reserves; reducing dependence on the Middle East for oil imports by diversifying and establishing institutional and strategic relationship for joint procurement of oil from other sources; sharing of information and know-how on alternate sources of fuel for the transport sector (like CNG and biofuel) and on energy demand management measures (like efficiency and conservation); sharing development of know-how on improved coal combustion technologies and on development of renewable energy technologies (like wind and solar); and regional gas and electricity trading and establishment of a regional grid for gas and electricity.

In the context of the promotion of biofuels in South Asia, the initiatives that have been undertaken under a project known as ProBIOS deserves a special mention. The project "ProBIOS: Promotion of Biofuels for Sustainable Development in South and South-east Asia"[17] aimed at facilitating government officials and other stakeholders through strategic capacity building and appropriate technology partnerships with the EU. The project was implemented by Winrock International India, and assisted by a consortium of consultants led by the two EU partner organizations, namely the Energy Research Centre for Netherlands, and the Research Centre for Energy, Environment and Technology, Spain, under the "Operations and Practical Dialogue" component of the Asia Pro Eco Programme of the European Commission.

The ProBIOS project aimed at facilitating government officials and other stakeholders through strategic capacity building and appropriate technology partnerships with the EU.

The project, during its inception, recognized that the barriers to the use of biofuels were substantial. This was because there was no long-term policy to promote biofuels, no financing mechanism was in place, the level of awareness about biofuel technologies in the transportation sector was low, and the best technologies were not always available to Indian companies. In view of the aforesaid barriers, the project aimed at raising awareness and developing adequate capacity in India and neighboring countries to increase the use of biofuels in order to improve local environmental conditions and promote sustainable investment. The project was eventually intended to improve the environmental quality in the Asian region with its eventual positive impact on the global climate. It was also intended to create long-term sustainable investment and trade between EU countries and South (and South-east) Asian countries. The project first undertook a thorough review of issues related to biofuels in India and surrounding countries, as well as in Europe in order to enable learning from experience. The second stage focused on knowledge exchange and capacity building through several working conferences and workshops in South and Southeast Asia and in the EU, and through a study tour for South and Southeast Asian biofuel stakeholders and policy makers in the EU.

As far as SAARC-level initiatives are concerned, a passing mention of biofuels could be noted as a part of the portfolio of renewable energy alternatives that are available for moving towards a low-carbon green trajectory and in the context of energy diversification. The Delhi Declaration (of 4 April 2007) pertaining to the 14th SAARC Summit recognized the need for strengthening renewable energy development, such as in hydropower, biofuels, solar and wind. The Colombo Declaration (of 3 August 2008) pertaining to the 15th SAARC Summit noted that increased access to energy is critical for fulfilling the legitimate expectations of growth and development in South Asia. It observed that the escalation of oil prices threatens both the energy security and economic growth of South Asia. In this context, SAARC governments recognized the need to expeditiously develop and conserve conventional sources of energy and to build up renewable alternative energy resources, including indigenous hydro, solar, wind and bio.

Regional cooperation initiatives on biofuels in South Asia have hardly moved into action from mere statements.

In recognition of the growing importance of biofuels in the region, the SAARC Energy Centre (SEC) under its Technology Transfer programme organized a one-week SAARC Regional Training Workshop on Biofuels, in cooperation with the Sri Lanka Sustainable Energy Authority on 22–26 September 2008 at Dambulla, Sri Lanka (SAARC Energy Centre 2008). The workshop was intended to provide the latest in-depth knowledge on the technology, status and prospects of biofuels to professionals of the SAARC region. It was attended by official nominees of five of SAARC's member states (Bangladesh, Bhutan, Nepal, Pakistan and Sri Lanka), among other participants.

The primary objectives of the workshop were to:

- Impart training to the participants selected from member states to acquire knowledge on present global and regional status and future prospects of biofuels.
- Provide the know-how on the latest trends and technologies to produce and use biofuels from available resources.
- Provide a platform for sharing experience with each other.
- Help member states to reduce their import dependence on oil.
- Promote regional cooperation in biofuels.

In a nut shell, as it stands now, regional cooperation initiatives on biofuels in South Asia have hardly moved into action from mere statements. In fact, that seems to be the case with overall regional cooperation in South Asia also. In the 16th SAARC Summit (held in Thimphu in April 2010), India called on SAARC countries to challenge themselves by acknowledging that the glass of regional cooperation, regional development and regional integration is half empty. India pointed out that although SAARC countries have created institutions for regional cooperation, they have not yet empowered them adequately to enable them to be more pro-active. The challenge, therefore, is to translate institutions into activities, conventions into programmes, and official statements into popular sentiments. Declarations at summit- and official-level meetings do not amount to regional cooperation or integration. It is time for SAARC to act.

However, as far as biofuels are concerned, in view of the fact that biofuel initiatives are still at a nascent stage even at the national level in the region, it may indeed be a bit too premature to "act" on regional cooperation on biofuels in South Asia. Above all, given that the food and energy security implications as well as the environmental benignity and rural development prospects of biofuels still remain open questions, any regional initiatives for promotion of biofuels need to be well thought-out.

Chapter 9

Conclusion

South Asia is particularly vulnerable to oil shocks. All the countries of the region are perennial net oil importers, which not only draws down a large chunk of foreign exchange reserves of these countries, but also makes them highly energy insecure. In this context, most South Asian countries are promoting blending of biofuels with liquid petroleum fuels (ethanol with petrol and biodiesel with petro-diesel) for the transport sector, predominantly with energy security concerns in view, apart from GHG emissions reduction and other rural development considerations. While India and Pakistan are frontrunners in the region in biofuel production and consumption, sparse initiatives are underway in Bangladesh, Nepal and Sri Lanka.

While the need for the diversification of energy resources in South Asian countries cannot be overemphasized, the contribution that conventional or first-generation biofuels can make to energy security is physically very limited, and comes at a considerable financial cost, apart from other potentially negative environmental and socio-economic implications. Biofuels cannot sustain without subsidies, fuel mandates, or other government support. In view of the generous subsidies on fossil fuels that are continuing even in the face of rising crude oil prices in some South Asian countries like India, it may be all the more difficult for biofuels to emerge as a cost-effective alternative to fossil fuels unless adequate subsidies and other policy incentives are provided. However, given that the realization of benefits from the production and usage of biofuel is still contestable and sufficient gaps exist in the state of knowledge, such policy supports are clearly fraught with risks and may turn out to be counter-productive unless they are informed by the potential negative fallout of biofuels, and appropriate checks and balances are set in place to deal with such implications.

The challenges posed by biofuels in South Asia have only been exacerbated since 2006 with the increasing volatility and frequent spikes in international food prices. This has widely been attributed to increasing biofuel production, among a host of other factors. Especially, the mandate-setting by the US for corn-based ethanol production, and the EU for vegetable oil-based biodiesel production, in order to combat oil price volatility, have been widely held responsible. It is claimed that such policy initiatives led to a rising demand for feedstocks and created an upward pressure on prices of food crops and agriculture commodities. This unhealthy intertwining of the markets for oil and agriculture commodities coupled with extreme weather events and increasing speculative tendencies in the agriculture commodity markets have only made the situation worse.

The challenges posed by biofuels in South Asia have only been exacerbated since 2006 with the increasing volatility and frequent spikes in international food prices.

The International Food Policy Research Institute came out with a new Global Hunger Index (GHI) in 2011 (Von Grebmer *et al.* 2011), which shows a dismal performance of South Asia as a region. The region has lowered its GHI score by a mere one point despite robust econom-

An important question is whether biofuels can be developed sustainably in South Asia without raising GHG emissions or causing other adverse environmental implications.

ic growth. Moreover, the proportion of undernourished people in the region has gone up since 1995–1997. In the light of this unstable scenario, which can hardly be expected to show any sign of respite in the near future, aggressive promotion of first-generation biofuels may not be a prudent decision unless adequate policy cushions are put in place against the potential trade-offs. For instance, barring the use of food crops for biofuel production may not be a foolproof mechanism to combat the food-fuel trade-off. If a large market is developed for an inedible fuel crop like jatropha, it is bound to impart intense pressure to reduce costs and increase profits by cultivating it on higher-quality arable land to obtain higher yields. In such a scenario, it is unlikely that it would be possible to limit its cultivation to "wastelands" or "marginal lands" alone, and its cultivation may spread to better-quality land by displacing food crops, unless an appropriate regulatory framework and institutional mechanism are put in place to deal effectively with any such eventualities.

Another related issue is whether there is enough available waste land in South Asia to significantly increase first-generation biofuel production, without any fallout on food production. Water availability is no less a concern. Adequate land and water availability analysis has not been conducted in the context of South Asia so as to appropriately gauge the competing claims on land and water and hence infer about future production potential. Although many model-based projections and estimates under various scenarios—as carried out, for instance, by the IEA and the FAO—exist, these are at best very rough and indicative estimates, given that it is extremely challenging to simulate reality unless one gets a true picture of the wastelands and available water resources.

Another important question is whether biofuels can be developed sustainably in South Asia without raising GHG emissions or causing other adverse environmental implications, which are some of the key reasons cited for the promotion of biofuels. Going by the findings of LCA studies that have been carried out internationally as well as in South Asia, the environmental implications of biofuels still remain an open question. In the light of the uncertainty and contestable impact of biofuels' expansion on the environment, many governments, particularly in OECD countries, have tried to design targeted biofuel sustainability policies.

However, these approaches have their own share of problems and challenges. For instance, these criteria or schemes are often based on assessing minimum savings in GHG emissions and impacts on direct land use, leaving aside the impacts of indirect land-use changes. Given the complexity of direct and indirect impacts of biofuel expansion on land, water use and biodiversity, defining sustainability in an all-encompassing manner is extremely challenging—more so for a region as diverse as South Asia, with its demographic, socio-economic, human development and governance challenges. However, unless a foolproof sustainable process of production is adopted for large-scale biofuel production, it may actually turn out to be a bane instead of a boon for South Asia.

Second-generation biofuels are being mooted as the right alternative to address the challenges posed by the promotion of first-generation biofuels. Technically speaking, it may be possible to produce a large proportion of transportation fuels using advanced biofuel technologies, specifically those that can be grown using a small share of the world's land area (e.g., microalgae), or those grown on arable lands without affecting food supply (e.g., agriculture residues). However, a number of barriers limit the near-term commercial application of advanced biofuel technologies. These barriers include low conversion efficiency from biomass to fuel; limits on supply of key enzymes used in conversion; large energy requirements for operation; and dependence in many cases on commercially unproven technologies, among others. Hence, despite huge future potential, large-scale deployment of advanced biofuel technologies is unlikely in the near future unless and until further R&D leads to the lowering of these barriers (Cheng and Timilsina 2010).

Although in view of the sustainability advantages of advanced biofuels *vis-à-vis* conventional biofuels the former is often regarded as a "cleaner and greener" option, it remains that any energy source produced on a large scale, or without sufficient care, runs the risks of adverse environmental fallout. For instance, the removal of agriculture residues may have impacts on biodiversity, because of changed habitat functions like shelter, fodder source or nesting places. The export of agriculture residues from the field means a loss of organic material, which influences the fertility balance of the soil. The reduced soil coverage may also lead to a change in the humidity regulation of the soil and reduced protection of evaporation and erosion due to wind and precipitation (WWF 2012). Furthermore, GHG emissions might occur through soil carbon changes when extracting residues, as well as due to the use of fertilizers and diesel caused by straw removal. Even algal biofuels, just like crops, require land, water, fertilizers, pesticides and inputs that are costly. It would, therefore, be crucial to realize that, on a lifecycle basis, some advanced biofuels can generate higher levels of GHG emissions and have more negative impacts on land and water use—as well as biodiversity and local livelihoods—than some conventional biofuels (Gerasimchuk *et al.* 2012). Hence, advanced biofuels, if produced unsustainably, may not be able to resolve the problems that are currently being encountered with first-generation biofuels.

In the final analysis, biofuels, whether conventional or advanced, should not be regarded as a silver bullet. They should not be the exclusive or even the main focus of climate change and energy policy in South Asian countries. It is much more essential to encourage energy conservation through promotion of energy-use efficiency and other forms of renewable energy like wind, solar and small hydro. All countries in South Asia should place biofuels in the context of a comprehensive energy policy, which includes conservation as well as promotion of other renewable energy alternatives. Biofuels policies should also be guided by broader sustainable development considerations, and the economic, social and environmental implications of biofuel policies should be assessed more carefully.

Advanced biofuels, if produced unsustainably, may not be able to resolve the problems that are currently being encountered with first-generation biofuels.

Endnotes

1 In 1956, the geologist M. King Hubbert predicted that United States (US) oil production would peak in the early 1970s (Hubbert 1953). Around 1995, several analysts began applying Hubbert's method to world oil production, and most of them estimated that the peak year for world oil will be between 2004 and 2008. These analyses were reported in some of the most widely circulated sources: Nature, Science, and Scientific American (Deffeys 2008). The historic crude price spike to US$147 a barrel in 2008 is often considered as a testimony to the truth in peak oil theory.

2 According to recent estimates made by the International Energy Agency (IEA) in its *World Energy Outlook 2011*, biofuel subsidies on a global scale, which include the support provided through consumption mandates, amount to around US$22 billion as of 2010 (IEA 2011a).

3 This paper does not cover biogas and focuses only on ethanol and biodiesel.

4 This section draws heavily on REN21 (2012).

5 Different levels of minimum support price for oilseeds have already been declared by certain states.

6 "Biodiesel Development in Afghanistan and Pakistan", available at: www.khalilshah.com/projects/growthconsulting/documents/Biodiesel_Development_in_Afghanistan%20and_Pakistan.pdf

7 www.aedb.org/bioprogram.htm (accessed 4 August 2012).

8 However, the Ministry of Food, Agriculture and Livestock has also been directed to explore other sources of raw material for bio-ethanol production such as corn, wheat, rice, potatoes and sorghum.

9 www.unicol.com.pk/ (accessed 3 August 2012).

10 www.hindu.com/2006/12/14/stories/2006121401510400.htm

11 Net energy ratio is the ratio of energy output obtained from the end use of the biofuel to energy input used for the production of the biofuel.

12 The oil from jatropha could be easily extracted and converted to biodiesel using transesterification.

13 The report defined these parameters as below:
Net energy balance: The energy supplied by the biofuel and associated co-products at the end use minus the energy required during various manufacturing stages of the biofuel.
Net carbon balance: The net quantity of GHG emitted/avoided to the atmosphere during the various stages of manufacture, distribution and end use of the fuel.
Net energy ratio: The ratio of energy output obtained from the end use of the biofuel to energy input used for the production of the biofuel.
Percentage carbon emission reduction: The net quantity of GHG emissions avoided compared to the use of the petro fuel substituted by the biofuel.

14 Acidification potential is based on the contributions of SO_2, NOx, HCl, NH_3 and HF to the potential acid deposition, i.e., on their potential to form H+ ions.

Eutrophication potential is defined as the potential to cause over-fertilization of water and soil, which can result in increased growth of biomass (sourced from onlinelibrary.wiley.com, accessed 9 August 2012).

15 Crop years begin with harvest and continue until the next harvest.

16 http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/0,,contentMDK:21712205~menuPK:2246552~pagePK:2865106~piPK:2865128~theSitePK:223547,00.html (accessed 5 August 2012).

17 www.ecn.nl/units/ps/themes/renewable-energy/projects/probios/ (accessed 12 August 2012).

Annexes

Annex 1: Biofuel feedstocks and policy incentives in select countries

Country	Currently used feedstocks for		Types of policy incentives and support for biofuel production and consumption					
	Ethanol	Biodiesel	Price support	Direct budgetary spending and credit support, e.g., for biofuel refineries, R&D	Tax relief (breaks, exemptions, reduced rates, etc.)	Provision of government-owned assets at below market value, particularly land and water	Blending targets and mandates	
							Current mandate/ target	Future mandate/ target
Argentina	Sugarcane molasses, sugarcane juice, corn	Soybean oil	Price of ethanol set by government	n.a.	Preferential tax for biodiesel	n.a.	E5, B7	n.a.
Australia	Wheat, corn, barley, sorghum, waste wheat starch, molasses	Tallow, used cooking oil, canola oil, soybean oil, palm oil	n.a.	Biofuels Capital Grants Programme; Sugar Industry Innovation Fund; Greenhouse Gas Abatement Programme; R&D grants	Domestic production grant (up to 2011); Energy grants (Cleaner Fuels Scheme (2011–2015); Ethanol Distribution Programme	n.a.	New South Wales: E4, B2	New South Wales: E6 (2011), B5 (2012); Queensland: E5 (on hold until autumn 2011)

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Country	Currently used feedstocks for		Types of policy incentives and support for biofuel production and consumption					
	Ethanol	Biodiesel	Price support	Direct budgetary spending and credit support, e.g., for biofuel refineries, R&D	Tax relief (breaks, exemptions, reduced rates, etc.)	Provision of government-owned assets at below market value, particularly land and water	Blending targets and mandates: Current mandate/target	Blending targets and mandates: Future mandate/target
Brazil	Sugarcane, cassava	Soybean	n.a.	Significant in the past under the PROALCOOL programme; at present, there are auctions where the National Petroleum Agency buys given quantities of biodiesel to ensure supply targets	Excise and state duty exemptions, tax exemptions at sub-national level	Significant in the past under the PROALCOOL programme	E20-25, B5	n.a.
Canada	Corn, wheat, wood waste, wheat straw	Canola oil, rendered animal fats (tallow), yellow grease, rapeseed oil	n.a.	Capital grants, feasibility studies, R&D	Fuel tax exemptions (including by sub-national jurisdictions), accelerated depreciation allowance	n.a.	E5 (up to E8.5 in 4 provinces, B2 (nationwide) (2012), B2-B3 (in 3 provinces)	B2 (nationwide) (2012)

China	Corn, wheat, cassava	Waste vegetable oil	n.a.	Low-interest loans, direct subsidies to compensate for losses	VAT on biofuels; consumption tax exemption	n.a.	E10 (9 provinces)	n.a.
Columbia	Sugarcane	Palm oil	Government regulates minimum price for producers	n.a.	Tax exemption to new palm oil in 2004–2012	n.a.	E10, B10	B20 (2015); 60% of vehicles must be flex fuel by 2012
EU	Wheat, sugar beet	Rapeseed oil, soybean oil	n.a.	R&D spending	Exemptions for fuel excise tax	Single Payment Scheme: payments per hectare of land used in the production of bio feedstocks	5.75% biofuels*	10% renewable energy in transport**
India	Sugarcane molasses, sugarcane juice	Jatropha, pongamia, karanja, animal fats like fish oil	Minimum support price for oil seed growers; fixed price for ethanol and biodiesel	National Biofuel Fund under consideration; subsidized loans to sugar mills	Exemption from central excise tax (4%) for biodiesel, concessional excise duty (16%) on ethanol	n.a.	E5	E20, B20 (2017)
Indonesia	Molasses, cassava	Crude palm oil	n.a.	Research grants; seedling cultivation subsidies; state oil company losses; infrastructure subsidies	VAT exemption	Land concessions for wood and palm	E3, B2.5	E5, B5 (2015); E15, B20 (2025)

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Country	Currently used feedstocks for		Types of policy incentives and support for biofuel production and consumption					
	Ethanol	Biodiesel	Price support	Direct budgetary spending and credit support, e.g., for biofuel refineries, R&D	Tax relief (breaks, exemptions, reduced rates, etc.)	Provision of government-owned assets at below market value, particularly land and water	Blending targets and mandates	
							Current mandate/ target	Future mandate/ target
Malaysia	None	Crude palm oil	n.a.	Soft loans to biodiesel plants; grants for R&D from Malaysian Palm Oil Board	Investment Tax Allowance	Support for land development	B5	n.a.
Thailand	Molasses, cassava	Crude palm oil, waste cooking oil, jatropha	n.a.	Subsidy from the state oil fund, support for R&D, subsidies for refiners (13.5 baht/litre for E85) (2010)	Ethanol producers excise tax exemption	n.a.	B2 compulsory from 2011, B4 compulsory for 3 months to coincide with harvest, and to be adapted to match supply	9 MMl/d ethanol (2017)
Switzerland	Wood-cellulose	Rapeseed oil, animal fats, used cooking oil, various virgin plant oils	n.a.	Area payments to oilseed production, support to processing, *ad hoc* support to R&D (2008)	Reduced rate for imported biofuel under Mineral Oil Tax Law (2008)	n.a.	None	None

United States	Corn	Soybean	n.a.	R&D grants; cellulosic grants; bioenergy research centres; small scale bio-refineries; cellulosic biofuel processes; loan guarantees	Volumetric tax credits, particularly the Volumetric Ethanol Excise Tax Credit (expired at the end of 2011); reductions in state motor fuel taxes; small producer tax credits (expired at the end of 2011); domestic production tax deduction for cellulose-based biofuels	Relaxation of emissions regulations	48 billion litres, of which 0.02 billion cellulosic ethanol	136 billion litres, of which 60 billion cellulosic ethanol (2022)

*Note: B = biodiesel (B2 = 2% biodiesel blend); E = ethanol (E2 = 2% ethanol blend); Ml/d = million litres per day. *Currently, each member state has set up different targets and mandates. **Lignocellulosic-biofuels, as well as biofuels-made waste and residues, count twice and renewable electricity 2.5 times towards the target.*

Source: ABARE (2007); Gerasimchuk et al. (2012); Steenblik et al. (2008); USAID (2009); USDA (2012b); USDA (2011a); USDA (2011b); and IEA.

Annex 2: Biofuel feedstocks and policies in select South Asian countries

Country	Feedstocks in use/under consideration for		Blending targets and mandates		Select policy initiatives and incentives in place/under consideration
	Ethanol	Biodiesel	Current mandate/target	Future mandate/target	
Bangladesh	Sugarcane molasses	Jatropha	–	–	Work on biodiesel by the Ministry of Energy commenced; feasibility studies on biodiesel underway; initiatives taken for identification of appropriate species as biofuel feedstocks; testing and cultivating biofuel plantations with a community forest concept throughout the country being considered; places like road sides, areas adjacent to railway tracks, de-forested hilly areas, embankments, coastal islands and chars identified for cultivation of fuel crops.
India	Sugarcane molasses, sugarcane juice	Jatropha, pongamia, karanja, animal fats like fish oil	E5	E20 (2017); B20 (2017)	National Policy on Biofuels in place; National Biofuel Coordination Committee in function; National Biofuel Fund under consideration for providing financial incentives; National Mission on Biodiesel being implemented; biodiesel plantations being promoted on community, government-owned and forest wastelands, but not on fertile, irrigated lands; minimum support price for oilseed growers; fixed price for ethanol and biodiesel; subsidized loans to sugar mills; exemption from central excise tax (4 percent) for biodiesel, concessional excise duty of 16 percent on ethanol; major thrust on research, development and demonstration on biofuels, including second-generation biofuels, under the Biofuels Policy.

Nepal	Sugarcane molasses	Jatropha	–	–	National Biofuel Programme in place; particular focus on promotion of jatropha for the production of biodiesel; a number of plantation practices and engine test runs conducted; Nepal Standard (NS 475) developed for ethanol as a transportation fuel; decision by the ministerial cabinet on E10 blending in 2004 (not implemented yet).
Pakistan	Sugarcane molasses	Jatropha, castor, jojoba	–	B5 (2015); B10 (2025)	National Biodiesel Programme in place; experimental cultivation of biodiesel feedstocks on a scientific basis underway; R&D activities underway to evaluate the prospects of introducing biofuels; fiscal incentives in the form of exemption of taxes and duties on biodiesel-related equipment, machinery and other specific items; pricing of various blends of biodiesel to be regulated for ensuring their competitiveness with petro-diesel; fuel quality standards for B100 and blends up to B20 to be developed; pilot initiatives on E10 undertaken by the government.
Sri Lanka	Sugarcane molasses	Jatropha, rubber, neem	–	–	Proposal on encouraging development of biofuels for the transport sector in the National Energy Policy and Strategies 2006 (though no dedicated policy for biofuels as such); roadmap proposed to achieve 20 percent share of biofuels in fuel consumption by 2020; government initiatives underway for jatropha cultivation for biodiesel production.

Source: Authors' compilation.

Annex 3: Climate change impacts and vulnerability index for South Asian countries

Ecosystems	Threats	Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka
Coastal (mangroves, mudflats, estuaries)	Inundation, salination, storms, species loss		■		■	■			
Coral reefs	Bleaching, acidification, loss of ecological and protective services, reduction in species diversity				■	■			■
Inland wetlands	Desiccation, drainage and diversion, degradation and service loss	■		■	■			■	■
Forests	Loss of forest cover and species, altered composition and structure, enhanced evapotranspiration			■	■		■		■
Mountain (subtemperate, temperate)	Altitudinal shifts in vegetation disrupting species types			■			■		
Mountain (subalpine, alpine)	Loss of vegetation cover	■		■	■		■	■	
Glaciers	Loss of coverage	■		■	■		■	■	
Desert	Expansion	■			■			■	
Rangelands and grasslands	Regime shift, degradation due to overgrazing and increased incidence of fire	■			■			■	
Freshwater (rivers, lakes)	Desiccation, increased salinity at coast, degradation due to increased demand	■	■		■	■	■	■	
Species diversity (floral and faunal)	Loss of diversity and habitat, changes in species composition and food web		■		■		■		■

Source: World Bank (2009).

References

ABARE. 2007. "Outlook for biofuels in Australia: The challenges ahead." *Australian Commodities*, March Quarter 07.1, Australian Bureau of Agricultural and Resource Economics. Available at: http://adl.brs.gov.au/data/warehouse/pe_abare99001733/ac07_mar.pdf

Abbott, Philip C., Christopher Hurt and Wallace E. Tyner. 2011. "What's driving food prices in 2011?" Farm Foundation Issue Report, NFP.

Achten, W., B. Muys, E. Mathijs, V. P. Singh and L. Verchot. 1997. "Life cycle assessment of biodiesel of biodiesel from Jatropha curcas L. energy balance: Impact on global warming, biofuels and industrial products from Jatropha curcas." Proceedings from the Symposium "Jatropha 97", 23–27 February, pp. 123–31.

Achten, Wouter. 2010. "Sustainability evaluation of biodiesel from *Jatropha curcas* L.: A life cycle oriented study." PhD Dissertation, Katholieke Universiteit Leuven, Groep Wetenschap & Technologie, Arenberg Doctoraatsschool, België.

Agence France-Presse. 2007. "Water for biofuels or food?", August 17.

Alexander, N.E. 2009. "Development of the Jatropha cultivation and biodiesel production: Case study of Karnataka State, India." PhD Thesis, Imperial College, London.

Ali, Tariq, Jikun Huang and Jun Yang. 2012. "An overview of biofuels sector of Pakistan: Status and policies." *International Journal of Economics and Research* 3(1): 69–76.

Baier, S., M. Clements, C. Griffiths and J. Ihrig. 2009. *Biofuels impact on crop and food prices: Using an interactive spreadsheet*. Board of Governors of the Federal Reserve System, International Finance Discussion Papers, No. 967.

Baka, Jennifer. 2011. "Biofuels and wasteland grabbing: How India's biofuel policy is facilitating land grabs in Tamil Nadu, India." Paper presented at the International Conference on Global Land Grabbing, 6–8 April 2011, organized by the Land Deals Politics Initiative (LDPI) in collaboration with the Journal of Peasant Studies and hosted by the Future Agricultures Consortium at the Institute of Development Studies, University of Sussex.

Bandyopadhyay, Kaushik R. and Kasturi Das. 2012. "Biofuels and food security in South Asia." *Trade Insight* 8 (1): 20–22. Kathmandu: South Asia Watch on Trade, Economics and Environment (SAWTEE).

Bekunda, M., C. Palm, C. de Fraiture *et al*. 2009. "Biofuels in developing countries." In Howarth, R.W. and S. Bringezu (eds.). *Biofuels: Environmental consequences and interactions with changing land use*. Retrieved from http://cip. cornell.edu/biofuels/

Bergsma, G., B. Kampman, H. Croezen and M. Sevenster. 2006. "Biofuels and their global influence on land availability for agriculture and nature: A first evaluation and a proposal for further fact finding." *Solutions for environment, economy and technology*. Delft: CE.

Bourne, Joel K. 2007. "Biofuels: Boon or boondoggle?" *National Geographic*, October, National Geographic Society, Florida, USA.

Bowyer, C. and B. Kretschmer. 2011. *Anticipated indirect land use change associated with expanded use of biofuels and bioliquids in the EU – An analysis of the National Renewable Energy Action Plans*. Institute for European Environmental Policy.

CBO. 2009. *The impact of ethanol use on food prices and greenhouse-gas emissions*. US Congressional Budget Office. Retrieved from http://www.cbo.gov/ftpdocs/100xx/doc10057/04-08-Ethanol.pdf

Chand, R. 2008. "The global food crisis: Causes, severity and outlook." *Economic and Political Weekly* 43(26): 115–23.

Charles, Chris. 2011. "Global food prices and increased biofuel production: An overview of the food vs. fuel debate." Geneva: GSI, IISD.

CII. 2010. "Estimation of energy and carbon balance of biofuels in India." Confederation of Indian Industry.

Collins, Keith. 2008. *The role of biofuels and other factors in increasing farm and food prices: A review of recent developments with a focus on feed grain markets and market prospects*. Kraft Foods Global, Inc.

Cotula, Lorenzo, Sonja Vermeulen, Rebeca Leonard and James Keeley. 2009. *Land grab or development opportunity? Agricultural investment and international land deals in Africa*. London/Rome: FAO, IIED and IFAD.

Deffeys, Kenneth E. 2008. *Hubbert's peak: The impending oil shortage*. Princeton, NJ: Princeton University Press.

Delucchi, Mark A. 2006. "Lifecycle analyses of biofuels." Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-06-08.

Delucchi, M. A. 2003. "Issues in lifecycle analysis." Paper presented at Integrated Energy Policy Report Committee Workshop on Transportation Fuels Production, Importation and Infrastructure, 11 July 2003, at Sacramento.

Dillon, H. S., T. Laan and H. S. Dillon. 2008. *Biofuels—At what cost? Government support for ethanol and biodiesel in Indonesia*. Geneva: IISD, GSI.

Elder, Mark, SVRK Prabhakar, Jane Romero and Naoko Matsumoto. 2008. "Prospects and challenges of biofuels in Asia: Policy implications." In *Climate change policies in the Asia-Pacific: Re-uniting climate change and sustainable development*, Chapter 5, pp. 105–31. Hayama: IGES.

Engelhaupt, E. 2007. "Biofuelling water problems." *Environmental Science and Technology*, 15 October.

FAO. 2008. *The state of food insecurity in the world: High food prices and food security—Threats and opportunities*. Rome: Food and Agriculture Organization of the United Nations.

FAO. 2008a. *The state of food and agriculture 2008: Biofuels—prospects, risks and opportunities*. Rome: Food and Agriculture Organization of the United Nations.

FAO. 2008b. *The state of food and agriculture in Asia and the Pacific region*. Rome: Food and Agriculture Organization of the United Nations.

FAO. 2009. *The state of agricultural commodity markets 2009*. Rome: Food and Agriculture Organization of the United Nations.

FAO. 2010. *Bioenergy and food security: The BEFS analytical framework*. Rome: Food and Agriculture Organization of the United Nations.

FAO, IFAD, IMF, OECD, UNCTAD, WFP, the World Bank, the WTO, IFPRI and the UN HLTF. 2011. *Price volatility in food and agricultural markets: Policy responses*. Policy report including contributions by FAO, IFAD, IMF, OECD, UNCTAD, WFP, the World Bank, the WTO, IFPRI and the UN HLTF.

Fargione, J., J. Hill, D. Tilman, S. Polasky and P. Hawthorne. 2008. "Land clearing and the biofuel carbon debt." *Science* 319 (5867): 1235–38.

Farrell, A. E., R. J. Plevin, A. D. Jones, M. O'Hare and D. M. Kammen. 2006. "Ethanol can contribute to energy and environmental goals." *Science* 311: 506–08.

Food and Agricultural Policy Research Institute. 2005. *Implications of increased ethanol production for US agriculture*. Missouri: Food and Agricultural Policy Research Institute.

Gallagher, Ed. 2008. *The Gallagher review of the indirect effects of biofuels production*. The Renewable Fuels Agency.

Gerasimchuk, Ivetta, Richard Bridle, Christopher Beaton and Chris Charles. 2012. "State of play on biofuel subsidies: Are policies ready to shift?" Geneva: GSI, IISD.

Gheewala, H.S. and K. Prueksakorn. 2006. "Energy and greenhouse gas implications of biodiesel from Jatropha curcas L." Paper presented at the Second Joint International Conference on Sustainable Energy and Environment (SEE 2006), 21–23 November, Bangkok, Thailand.

Gidwani, Vinay. 2008. *Capital, interrupted: Agrarian development and the politics of work in India*. Minneapolis, MN: University of Minnesota Press.

Gilmartin, David. 2003. "Water and waste: Nature, productivity and colonialism in the Indus basin." In A. Baviskar (ed.), *Contest grounds: Essays on nature, culture and power*. Delhi: Oxford Unviersity Press.

Government of India. 2008. *National Policy on Biofuels*. Ministry of New & Renewable Energy, Government of India.

Government of Pakistan. 2008a. *National Biodiesel Programme*. Alternative Energy Development Board, Government of Pakistan. Available at: http://www.research.org.pk/Databank/NATIONAL%20BIODIESEL%20PROGRAMME.pdf (accessed 4 August 2012).

Government of Pakistan. 2008b. Ministry of Finance, Revenue and Economic Affairs, Revenue Division, Notification (Customs) No. SRO 474 (I)/2008, Government of Pakistan, Islamabad, 21 May.

Government of Sri Lanka. 2006. *National Energy Policy and Strategies of Sri Lanka*. Ministry of Power and Energy, Government of Sri Lanka.

Hubbert, M. K. 1953. "Entrapment of petroleum under hydrodynamic conditions." *American Association of Petroleum Geologists Bulletin* 37**:** 1954–2026.

IEA. 2011a. *World energy outlook 2011*. Paris: International Energy Agency.

IEA. 2011b. *Technology roadmap: Biofuels for transport*. Paris: International Energy Agency.

IIASA. 2009. "Biofuels and food security: Implications of an accelerated biofuels production." Summary of the OFID study prepared by IIASA, Vienna, Austria.

Jumbe, C., F. Msisska and M. Madjera. 2009. "Biofuel development in sub-Saharan Africa: Are the policies conducive?" *Energy Policy* 37: 4980–6.

Jung, A., P. Dörrenberg, A. Rauch and M. Thöne. 2010. *Biofuels—At what cost? Government support for ethanol and biodiesel in the European Union–2010 Update*. Geneva: GSI, IISD.

Kahn Ribeiro, S., S. Kobayashi, M. Beuthe *et al*. 2007. "Transport and its infrastructure." In Metz, B., O.R. Davidson, P.R. Bosch, R. Dave and L.A. Meyer (eds.). *Climate change 2007: Mitigation*. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, USA: Cambridge University Press.

Kumar, Sunil, Jasvinder Singh, S.M. Nanoti and M.O. Garg. 2012. "A comprehensive life cycle assessment (LCA) of Jatropha biodiesel production in India." *Bioresource Technology* 110: 723–9.

Lang, S. 2005. "Cornell's ecologist's study finds that producing ethanol and biodiesel from corn and other crops is not worth the energy." *Cornell University News Service*, 5 July.

Laurance, W.F. 2007. "Switch to corn promotes Amazon deforestation." *Science* 318(5857): 1721.

Lin, J. 2010. "The sustainability of biofuels: Limits of the meta-standard approach." Working Paper 011, The Governance of Clean Development Working Paper Series, School of International Development, University of East Anglia, UK.

Lipsky, J. 2008. "Commodity prices and global inflation." Remarks by John Lipsky, First Deputy Managing Director, International Monetary Fund, at the Council on Foreign Relations, New York City, 8 May 2008.

Lopez, G. P. and T. Laan. 2008. *Biofuels—At what cost? Government support for biodiesel in Malaysia*. Geneva: GSI, IISD.

Lübbeke, Imke. 2012. "Smart use of residues: Exploring the factors affecting the sustainable extraction rate of agricultural residues for advanced biofuels." WWF.

Mitchell, Donald. 2008. "A note on rising food prices." Policy Research Working Paper 4682, The World Bank.

Msangi, S., T. Sulser, M. Rosegrant, R. Valmonte-Santos and C. Ringler. 2006. *Global scenarios for biofuels: Impacts and implications*. Rome: International Food Policy Research Institute.

Naylor, R., A. Liska, M. Burke, Walter P. Falcon and Joanne C. Gaskell. 2007. "The ripple effect: Biofuels, food security, and the environment." *Environment* 49(9): 30–43.

OECD-FAO. 2011. *OECD-FAO agricultural outlook 2011-2020*. Paris and Rome: OECD and FAO.

Pehnelt, Gernot and Christoph Vietze. 2012. "Uncertainties about the GHG emissions saving of rapeseed biodiesel." *Jena Economic Research Papers 2012,* 039. Jena, Germany: Friedrich Schiller University and the Max Planck Institute of Economics.

Pimentel, D., T. Patzek, F. Siegert, M. Giampietro and H. Haberl. 2007. "Concerns over notes on biofuels in IPCC AR4 mitigation report and SPM." Geneva, 30 October.

PISCES. 2010. "Bioenergy in Sri Lanka: Resources, applications and initiatives." Policy Innovation Systems for Clean Energy Security Working Paper.

Planning Commission. 2003. "Report of the Committee on Development of Biofuel." Planning Commission, Government of India.

Prueksakorn, K. and H.S. Gheewala. 2008. "Full chain energy analysis of biodiesel from Jatropha curca L. in Thailand." *Environmental Science and Technology* 42(9): 3388–93.

Rajagopal, D. and D. Zilberman. 2007. "Review of environmental, economic and policy aspects of biofuels." Policy Research Working Paper, The World Bank.

Regmi, A., M.S. Deepak, J.L. Seale Jr. and J. Bernstein. 2001. "Cross-country analysis of food consumption patterns." In A. Regmi (ed.). *Agriculture and Trade Report*, Vol. 1. Washington, D.C.: United States Department of Agriculture.

REN21. 2012. "Renewables 2012: Global status report." Renewable Energy Policy Network for the 21st Century (REN21).

Righaleto, R. and D.V. Spracklen. 2007. "Carbon mitigation by biofuels or by saving and restoring forests." *Science*, 17 August.

Rosegrant, M.W. 2008. *Biofuels and grain prices: Impacts and policy responses*. Washington, D.C.: International Food Policy Research Institute.

Runge, C. Ford and Robbin S. Johnson. 2008. *The browning of biofuels: Environment and food security at risk*. Washington, D.C.: Woodrow Wilson International Center for Scholars.

Safa, Mohammad, Steve Harrison and John Herbohn. 2010. "Biofuel and agricultural economy of developing countries: Present and future strategy for small-scale farming." Available at: http://www.gozdis.si/ssfett2010/pdf/C7_2_Safa.pdf

SAARC Energy Centre. 2008. Proceedings of SAARC Regional Training Workshop on Biofuels. Organized by the SAARC Energy Centre, Islamabad and Sri Lanka Sustainable Energy Authority, in Kandalama, Sri Lanka, on 22–26 September.

Scarlat, N. and J. Dallemand. 2011. "Recent developments of biofuels/bioenergy sustainability certification: A global overview." *Energy policy* 39: 1630–46.

Scharlemann, J. and W.F. Laurance. 2008. "How green are biofuels?" *Science* 319: 52–53.

Searchinger, T., R. Heimlich, R.A. Houghton *et al*. 2008. "Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land use change." *Science Online*, 7 February.

Soni, Anmol, Anomitro Chatterjee, Kaushik R. Bandyopadhyay, Kerryn Lang and Damon Vis Dunbar. 2012. "A citizen's guide to energy subsidy in India." TERI and IISD. Available at: www.iisd.org/gsi/introductions-non-experts/citizens-guide-energy-subsidies-india

Steenblik, Ronald, Christopher Beaton and Juan Simón. 2008. *Biofuels—At what cost? Government support for ethanol and biodiesel in Switzerland: 2008 update*. Geneva: GSI, IISD.

Sulle, Emmanuel and Fred Nelson. 2009. *Biofuels, land access and rural livelihoods in Tanzania*. London: IIED.

Tilman, D., R. Socolow, J. Foley *et al*. 2009. "Beneficial biofuels—The food, energy, and environment trilemma." *Science* 325 (5938): 270–71.

Timilsina, Govinda R. and Jay J. Cheng. 2010. "Advanced biofuel technologies." World Bank Policy Research Working Paper 5411, September 2010.

Trostle, Ronald. 2008. "Global agricultural supply and demand: Factors contributing to the recent increase in food commodity prices." A report from the Economic Research Service, United States Department of Agriculture.

UNDP. 2011. *Human development report*. New York: United Nations Development Programme.

UNEP. 2009. *Towards sustainable production and use of resources: Assessing biofuels*. United Nations Environment Programme.

USAID. 2009. *Biofuels in Asia: An analysis of sustainability options*. Washington, D.C.: United States Agency for International Development.

USDA. 2011a. *Colombia: Biofuels annual-2011*. GAIN Report, Global Agricultural Information Network, USDA Foreign Agricultural Service.

USDA. 2011b. *Canada: Biofuels annual-2011*. GAIN Report Number: CA11036, Global Agricultural Information Network, USDA Foreign Agricultural Service.

USDA. 2012a. *India: Biofuels annual-2012*. GAIN Report Number: IN2081, Global Agricultural Information Network, USDA Foreign Agricultural Service.

USDA. 2012b. *Argentina: Biofuels annual-2012*. GAIN Report, Global Agricultural Information Network, USDA Foreign Agricultural Service.

Varadharajan, A., W.S. Venkateswaran and R. Banerjee. 2008. "Energy analysis of biodiesel from Jatropha." World Renewable Energy Congress (Energy WRECX).

Von Grebmer, K., M. Torero, T. Olofinbiyi, H. Fritschel, D. Wiesmann and Y. Yohannes. 2011. *2011 Global Hunger Index: The challenge of hunger—Taming price spikes and excessive food price volatility.* Bonn, Washington, D.C. and Dublin: Welthungerhilfe, International Food Policy Research Institute (IFPRI) and Concern Worldwide.

Whitaker, M. and H. Garvin. 2009. "Life cycle assessment of the use of Jatropha biodiesel in Indian locomotives." Technical Report, NREL/TP-6A2-44428.

Whitaker, M. and H. Garvin. 2010. "Life cycle assessment comparing the use of Jatropha biodiesel in the Indian road and rail sectors." Technical Report NREL/TP-6A2-47462-May-2010.

Wise, Timothy A. and Sophia Murphy. 2012. *Resolving the food crisis: Assessing global policy reforms since 2007*. Global Development and Environment Institute and Institute for Agriculture and Trade Policy.

World Bank. 2009. *South Asia: Shared views on development and climate change*. Washington, D.C.: South Asia Region Sustainable Development Department, The World Bank.

World Bank. 2010a. *Food price increases in South Asia: National responses and regional dimensions*. The World Bank, South Asia Region, Sustainable Development Department, Agriculture and Rural Development Unit.

World Bank. 2010b. *Rising global interest in farmland: Can it yield sustainable and equitable benefits?* Washington, D.C.: The World Bank.

World Bank. 2011a. World Development Indicators online.

World Bank. 2011b. *State and trends of carbon market 2011*. Washington, D.C.: The World Bank.

Xiaoyu Yan, R. Oliver and David A.K. Inderwildi. 2009. "Biofuels and synthetic fuels in the US and China: A review of well-to-wheel energy use and greenhouse gas emissions with the impact of land-use change." *Energy Environmental Science*, 12 November 2009, doi: 10.1039/b915801d.

South Asia Watch on Trade, Economics and Environment (SAWTEE) is a regional network that operates through its secretariat in Kathmandu and member institutions from five South Asian countries, namely Bangladesh, India, Nepal, Pakistan and Sri Lanka. The overall objective of SAWTEE is to build the capacity of concerned stakeholders in South Asia in the context of liberalization and globalization.

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