| Chapter 5 |

Prospects and Challenges of Biofuels in Asia: Policy Implications

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1. Introduction

Biofuels have attracted worldwide interest for their potential as a substitute for fossil fuels. Fossil fuels have been rapidly depleted by global industrial development over the past century, prompting an urgent search for alternatives. According to a global oil company, at the current rate of extraction and utilization, global oil reserves will last only 40.5 years (Beyond Petroleum 2007). In the past few years many countries have adopted ambitious biofuel promotion policies. Governments are attracted to biofuels because of their potential contributions to (i) energy security; (ii) economic development and poverty reduction; and (iii) the environment, especially lower greenhouse gas (GHG) emissions, and air pollution. Biofuels might help Annex I countries of the United Nations Framework Convention on Climate Change (UNFCCC), such as Japan, to reduce their GHG emissions to comply with the Kyoto Protocol. Developing countries are mainly interested in reducing dependence on imported fuel (saving foreign exchange) and promoting economic development and poverty reduction, especially in rural areas. All countries hope that biofuels will provide a win-win-win strategy that can simultaneously promote energy security, economic development, and environmental protection.

The rush to promote biofuels, however, could be counterproductive if they are not sustainably produced.[1] There are widespread concerns that biofuels could end up causing more environmental or social problems than they solve. Recent studies widely circulated in the media have warned that biofuels might hurt food security (Graham-Harrison 2005), induce water shortages (Agence France-Presse 2007), worsen water pollution (Engelhaupt 2007), increase GHG emissions (Searchinger et al. 2008), and negatively affect biodiversity (Pearce 2005). It is also not clear if biofuel production consumes more energy (Lang 2005) than is produced, or if production and use of biofuels increases GHG emissions instead of reducing them. In short, biofuels are a clear example of a response to climate change that runs the risk of conflicting with sustainable development goals.

Currently, biofuels require subsidies, tariffs, fuel mandates, or other government support for economic viability. Thus, governments and consumers, or both, are paying a significant premium to gain the expected benefits from biofuels. The extent to which the expected benefits of costly biofuel promotion policies are being obtained is not clear, and if the expected benefits do not materialise, then it makes little sense to devote significant resources to them. For example, it would be tragic if money spent to promote biofuels ultimately financed rainforest destruction or worsened the living conditions of the poor. Conversely, if the benefits turn out to be greater than expected, it may be worth paying even more to attain them.

Initially, biofuel promotion policies in many countries focused on the potential for energy security, economic development, and short term economic benefits. Often, environmental obstacles or possible side effects, including the potential implications of land use change and effects on food security, were not adequately taken into account.

To date, little research has specifically addressed biofuels in the Asian context. This chapter reviews and analyses the current state of research on biofuel potential, especially in Asia, and develops policy recommendations based on this analysis. Section 2 discusses the relative advantages and disadvantages of different forms of biofuels compared to fossil fuels according to several environmental and economic criteria. Section 3 reviews and analyses current trends in biofuel production, consumption, and trade in selected Asian countries. Section 4 reviews and analyses current biofuel policies and section 5 concludes with policy recommendations.

2. Biofuel's potential: Promise or peril?

Box 5.1. What are biofuels?

Biofuel is a generic term referring to fuel derived from biomass such as plants and organic waste.

First generation biofuels are made from agricultural feedstocks, vegetable oils, and animal fats using conventional technology. The most common biofuels in commercial use are:

- Bioethanol – is blended with gasoline or petrol and produced by fermenting sugars or starches. Feedstocks include sugarcane, corn, wheat, and sugar beets.
- Biodiesel – is blended with petroleum diesel and produced from vegetable oil or animal fats. Feedstocks include oil from palm, jatropha, coconut, and soybeans.

Second generation biofuels are made from non-food feedstocks, including plant and wood waste (commonly called cellulosic biofuels), micro-algae, or other technologies that are currently advanced or experimental in nature.

The ability of biofuels (box 5.1) to contribute to GHG emissions reduction and other environmental goals, poverty reduction, rural development, and energy security, is a matter of considerable debate. Biofuels are more costly than fossil fuels, and it is important to address the question of whether the costs are worth the benefits, or whether the benefits will actually be realised. There are also concerns about food-fuel conflicts, resource availability and energy input required. This section addresses key issues raised in the debate from the perspective of the Asian region and focuses on first generation biofuels.

2.1. Environmental impacts

Biofuels can influence the environment in multiple ways and determining the net impact of biofuels on the environment is still challenging. Life Cycle Assessment (LCA)[2] studies have evaluated the GHG reduction potential of biofuels and whether they yield more energy than they take to produce (tables 5.1 and 5.2). There is considerable variation in the results, as well as in the design of the studies (International Energy Agency 2004). Studies differ in terms of boundary conditions (e.g. what is included in the "life cycle"), whether they consider by-products, and assumptions about production methods.

Overall, LCA studies suggest that first generation biofuels have significant theoretical potential to reduce GHG emissions (table 5.1) and have higher net energy value than fossil fuels (table 5.2). Ethanol from sugarcane in Brazil and biodiesel from jatropha seem to have the most potential to reduce GHG emissions. LCA studies suggest that sugar based biofuels are superior to starch based ones (e.g. from corn) in terms of avoided GHG emissions (Blottnitz and Curran 2007).

Table 5.1. Comparison of feedstocks in terms of GHG emission reductions

Fuel	Country	CO_2 (% reduction)	Source
Corn ethanol	US	2 (for E10) to 23 (for E85)	(Wang 2005)
Corn ethanol	US	-30	(Pimentel 2001) as quoted by International Energy Agency (2004)
Cassava	Thailand	63	(Nguyen et al. 2007)
Sugarcane	Brazil	80	(International Energy Agency 2004)
Oil palm	Malaysia	60	(Zutphen 2007)
Jatropha	India	80	(Hooda and Rawat 2006)
Coconut	Philippines	60	(Pascual and Tan 2004)

The Institute for Energy and Environmental Research in Germany concluded that all cultivated biofuels are positive in terms of their environmental benefits vis-à-vis their fossil fuel counterparts (Quirin et al. 2004). They further concluded that (i) ethyl tertiary-butyl ether (ETBE)[3] is advantageous compared to bioethanol; (ii) bioethanol from sugarcane is the most favourable form of bioethanol; (iii) biodiesel from rapeseed is more favourable than pure rapeseed oil;[4] and (iv) the comparison between bioethanol and biodiesel depends on the raw material used. Another review of the environmental benefits of biofuels in Brazil, the European Union (EU) and the USA by the International Energy Agency (IEA) reported a significant reduction in GHG emissions from biofuels (International Energy Agency 2004). The review categorically stated that there are net GHG reductions from both bioethanol and biodiesel.

Table 5.2. Comparison of feedstocks in terms of Net Energy Value (NEV)[5]

Feedstock	Country	NEV (MJ/L)	Source
Corn	US	5.89	(Shapouri et al. 2002)
Corn	US	-6.17	(Pimentel 2003)
Cassava	China	15.14	(Hu et al. 2004)
Cassava	Thailand	22.38	(Nguyen et al. 2007)
Sugarcane	Brazil	41.34	(Macedo et al. 2004)
Oil palm	Malaysia	37.45	(Zutphen 2007)
Jatropha	Thailand	3.82	(Prueksakorn and Gheewala 2006)
Jatropha	India	5.26	(Tobin 2005)
Coconut	Philippines	31.72	(Tan et al. 2004)

One controversial study reported that biofuels have negative environmental benefits and energy balances (Pimentel 2002). In response, the US National Biodiesel Board identified several weaknesses in the Pimentel study, including insufficient background information, outdated energy input data for biofuel production, incorrectly considering farm labour as equivalent to fossil energy, ignoring the by-products of ethanol production, and inaccurate consideration of corn production practices (National Biodiesel Board 2005). While reporting positive GHG reductions, another study reported greater environmental impacts from biofuels than fossil fuels due to land use change, such as the conversion of tropical forests to farm land, which may lead to the release of large quantities of carbon dioxide (CO_2) and cause increased air and water pollution and biodiversity loss (Zah et al. 2007).

Significant variation in LCA results for biofuels is expected as the GHG reduction potential will be determined by a wide range of factors, including production methods, distance between the biofuel refinery and the feedstock location, and yield. Yield, in turn, is dependent on factors such as land quality, water availability, fertiliser application, and weather. For example, the GHG reduction potential for the same crop planted on a given piece of land in a given country could vary from year to year depending on the weather.

Many LCA studies may not be applicable to Asia because they are either based on data from countries outside Asia where production processes are different, or are based on assumed values under ideal conditions. Since environmental and energy performance of biofuels depends on various factors, such as agricultural production practices, refining technologies and feedstock sources, the actual performance of biofuels in various Asian areas could be better or worse than indicated by existing studies.

On one hand, GHG emissions from biofuels could be lower in some parts of Asia, since many developing countries employ less energy and other inputs in crop production. The average fertiliser use for maize in North America and Western Europe is 257 kg/ha and 276 kg/ha, respectively, while it is only 117 kg/ha in Asia. Even this average figure could be misleading as countries such as Japan use much more fertiliser per capita than developing countries in the region (Food and Agricultural Organization 2006). To compare farm energy use, fossil fuels (gasoline and diesel) constitute 75% of total agricultural energy use in the USA (Brown and Neal 2005), while in Asian developing countries most farm energy still comes from animal and human power, followed by electricity and diesel (Makhijani 1990).

On the other hand, GHG emissions from biofuels in Asia could also be higher, since energy use in production may be less efficient. For example, India uses significantly more energy to produce a tonne (t) of corn compared to the USA; India uses 4,653 MJ/t of energy for corn (Ali 2006), while the USA uses 4,168 (Pimentel 2003) or 2,068 MJ/t (Shapouri et al. 2002). Also, GHG emissions from animal power have not been determined, and infrastructure for transporting biofuel feedstocks could be more efficient in countries outside Asia. Thus, there is an urgent need to conduct lifecycle studies within an Asian context.

One important factor left out of most LCA studies is the impact of increased biofuel feedstock cultivation on land use change, especially rainforest destruction and conversion of bogs and peat lands to arable cropping. Therefore, existing LCA studies may significantly underestimate the negative effects of biofuels on GHG emissions. One recent study that focuses on the effects of land use change concludes that if land use changes are accounted for, biofuels result in as much as 50% higher GHG emissions when compared to fossil fuels (Searchinger et al. 2008). In a letter to the Intergovernmental Panel on Climate Change (IPCC), 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 lands from agricultural use, leading to deforestation and land use change related to GHG emissions (Pimentel et al. 2007). There is an emerging consensus 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 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). Therefore, prevention of the conversion of rainforests and peat lands to biofuel production is an important priority.

Biofuels may 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 tradeoffs between biodiversity and GHG emissions reduction. Water quality may also be negatively affected by the large scale production of biofuels, due to greater fertiliser use in feedstock production and effluents from processing industries.

Current LCA studies have been criticised 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. Comprehensive LCA studies are required that cover broad timescales; different transportation modes, vehicle drive train types, 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 should include impacts such as deforestation of tropical rainforests and land use changes, and assign imputed costs to possible environmental problems such as biodiversity loss.

2.2. Food-fuel conflicts and resource availability

Even assuming that biofuels can help to significantly reduce GHG emissions, it will be difficult to justify them if their promotion significantly contributes to skyrocketing food prices – the food-fuel conflict. Diversion of land and food crops to biofuels could result in escalating food prices (Msangi et al. 2006; Food and Agricultural Policy Research Institute 2005; Rajagopal and Zilberman 2007), especially in conjunction with several other factors contributing to rising food prices such as increasing population and bad weather. The food-fuel conflict appears to be already occurring, partly due to the conversion of agricultural land from food crops to biofuel crops.[6] Currently rising prices for corn, cassava, and sugar are indicative of what may transpire as many countries try to meet increasing fuel demands through biofuels. In the USA, corn prices have risen by 42% since 2002, reaching a peak of $139/t in 2006 (United States Department of Agriculture 2007). In Brazil, the world's largest producer of sugar and ethanol from sugarcane, sugar prices have risen 303% from $125/t in 2004 to $506/t in 2006 (Center for Advanced Studies on Applied Economics 2007). These changes have been primarily attributed to the conversion of corn and other food products to biofuel production with 50% of sugarcane going into ethanol production (Schmitz et al. 2003). The International Food Policy Research Institute (IFPRI) forecasts a further increase in prices of corn by 26% and oilseeds by 18% due to the planned global expansion of biofuels (Braun 2007). Under a drastic biofuel expansion scenario, prices of corn and oilseeds could rise as much as 72% and 44%, respectively. A similar increase in global palm oil prices has been forecasted (Bhardwaj 2007). For each 1% 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, conflicting with the sustainable development principles intended to alleviate global poverty and hunger.

The food-fuel conflict has led to a search for feedstocks that can be grown on unused marginal lands or wastelands, areas that cannot be used for growing food crops, and thus may not pose a threat to food security. Many Asian countries are therefore considering jatropha as an alternative feedstock, since it can grow 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 fertilisers to increase the yield of seeds and oil. Moreover, jatropha will do better on higher quality land, so there are concerns that it may be difficult to limit jatropha to wastelands. But jatropha's current low productivity will limit incentives to plant it on higher quality land without subsidies or other policy support. It is also uncertain to what extent available “marginal lands” or “wastelands” are actually unused in many Asian countries, which suffer from intense population pressure. These areas may be 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.

Finally, in the context of first generation biofuels, 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, it is unlikely that it would be possible to limit its cultivation to “wastelands,” and its cultivation may spread to better quality land and displace food crops. There will be intense pressure to reduce costs and increase profits by cultivating it on higher quality arable land to obtain higher yields.

The potential of biofuels to meet global energy requirements is physically very limited (table 5.3). Only about 57% of total fossil fuel requirements could be met even if the entire global land area under major food crops was used for ethanol production (Rajagopal et al. 2007). Hence, countries should consider additional energy sources in their energy policy.

Table 5.3. Global potential of ethanol from principal grain and sugar crops

Crop	Global area (Mha)	Global average yield (t/ha)	Global product-ion (Mt)	Conversion efficiency (L/t)	Land intensity (L/ha)	Max. ethanol (billion L)	Gasoline equivalent (billion L)	Supply as % of 2003 global gasoline use (%)
Wheat	215	2.8	602	340	952	205	137	12
Rice	150	4.2	630	430	1806	271	182	16
Corn	145	4.9	711	400	1960	284	190	17
Sorghum	45	1.3	59	380	494	22	15	1
Sugarcane	20	65.0	1300	70	4550	91	61	6
Cassava	19	12.0	219	180	2070	39	26	2
Sugar beets	5.4	46.0	248	110	5060	27	18	2
Total	599					940	630	57

Source: Rajagopal et al. (2007).

Biofuel production will require additional use of land, water, and fertiliser. Adequate land, water, and other resources to produce biofuels on a large scale in Asia may not be widely available, especially if the food-fuel conflict is to be minimised. Many areas of Asia already suffer from severe shortages of land and water, so there is a potential for conflicts over alternative uses for them (Fritsche et al. 2006; Bergsma et al. 2006). Some Asian countries do have abundant human resources that could be employed in biofuel production, but labour intensive production methods may not always be the most economically efficient, depending on local conditions.

It is often overlooked that additional fertiliser use will be needed to significantly increase biofuel crop production in many areas of Asia. According to our estimates, India, where jatropha is being promoted for biodiesel production, will require an additional 14.9 Mt of organic manure and 2.6 Mt of fertiliser per year to meet its production target of 13.4 Mt of biodiesel by 2012. Such increased fertiliser use will reduce the GHG benefits as well as the cost effectiveness of biofuel production, even though the fertiliser rates assumed are based on recommended doses. To minimise GHG emissions, countries would have to use fertilisers more sparingly by enhancing overall efficiency.

The additional demand for land and resources would have to be met either by productivity enhancement of existing crops (vertical expansion) so that some land can be converted to biofuel production or, by physically expanding the amount of available agricultural land (horizontal expansion) by cutting down forests and bringing fragile ecosystems into commercial production, which may cause irreversible damage to the environment. Such potential resource conflicts illustrate the extent to which climate change responses can deviate from sustainable development, if they are considered in isolation of other development needs and priorities.

2.3. Poverty reduction and rural development

Poverty reduction, a key objective of sustainable development, is one benefit claimed by those promoting biofuels in the region. Biofuels could increase employment under the following conditions: (i) if more labour intensive production methods are used; (ii) if biofuel refining infrastructure is developed locally; (iii) if a significant share of biofuels are produced and consumed locally; and (iv) if biofuel production promotes the utilisation of previously unused land.

However, the contribution of biofuels to poverty reduction and sustainable rural development is very uncertain. Biofuel production may be capital intensive if biofuel production is dominated by large producers; if so, farmers and workers may suffer from increased inequality and income disparity, unsafe or worsened working conditions, and they may even end up losing their land (Ankumu 2007; Friends of the Earth 2008). Most of the current speculative interest in biofuels from private sector investors targets projects that are likely to be very large scale and tightly focused on achieving low costs of production, not poverty reduction or the use of sustainable production methods (Hazell and Braun 2006). In some cases, these could involve capital intensive production methods which make little contribution to employment. This does not mean that biofuels cannot be produced in a sustainable and cost effective way through labour intensive production methods. However, if governments want to prioritise sustainable development goals like poverty reduction and employment generation through biofuel promotion, then policies may need to be designed to encourage more labour intensive production methods. But if a government does this, it is important to keep in mind that, depending on local conditions, the cost to the government may be higher (compared to the market cost) if labour intensive production methods are not the most efficient.

2.4. Cost of biofuel production and prices

Broadly speaking, biofuels are currently more expensive than fossil fuels, although the magnitude of the price differential varies widely according to the cost of local inputs, feedstock productivity and productivity of other factors of production. According to one assessment, biodiesel is about $0.27 per litre of diesel equivalent[7] more expensive than regular diesel (Duncan 2003; Organisation for Economic Co-operation and Development 2007). The costs would be even higher if environmental costs and subsidies were also included (Organisation for Economic Co-operation and Development-International Transport Forum Round Table 2007). The main reason for the higher cost of biofuel is the cost of feedstock production, which constitutes more than half of biofuel production costs (Kojima et al. 2007). The higher feedstock production costs are in turn due to high prices of inputs including fertiliser and energy, low recovery of biofuel from the feedstock, and availability of a narrow range of inputs for biofuel production (Runge and Senauer 2007). Part of the higher feedstock prices is also due to competing demand for their use both as food and fuel. Brazil is the world's biofuel cost leader; the cost of production of its bioethanol is up to 50% cheaper than the global average, mostly due to energy co-generation, higher productivity of sugarcane, and cheaper labour (Valdes 2007). Like Brazil, some Asian countries may be able to lower biofuel production costs by using abundant cheap labour.

Biofuel prices are already cheaper than fossil fuel prices in some Asian countries. For example, in 2006, the government of India set a purchase price of $0.68 per litre of diesel equivalent for the oil distribution companies compared to a retail price of $0.76 per litre of diesel oil (Ministry of Petroleum and Natural Gas 2005). The price differences are due to differences in feedstock prices, farm subsidies, and fossil fuel prices. As fossil fuel prices increase, biofuels will become more competitive, and if they rise high enough, biofuels will become commercially profitable without government policy support. For example, ethanol could be profitable in China if the cost of fossil-based fuel reaches $0.79 per litre (Koizumi and Ohga 2007). Similarly, bioethanol will be profitable in New Zealand only if petrol is taxed (Denne and Hole 2006). Bioethanol and biodiesel in the EU will be competitive if oil prices are above $0.71 and $0.48 per litre, respectively (National Farmers Union 2006). In the long run, the competitiveness of biofuels is expected to increase along with corresponding declines in their prices as the range of potential feedstocks increases, and as large-scale efficient production plants are established (Steenblik 2007).

Since biofuels are generally more costly than fossil fuels, consumers will only use them if the cost is compensated by the government or if they are forced to. Most governments that promote the use of biofuels use some combination of subsidies, tariffs, fuel taxes (and tax exemptions), and blending mandates, so that the actual price of biofuels is about the same, or even lower, than the price of fossil fuels. This extra cost, regardless of who pays it or how, effectively pays for the policy goals that the government is trying to achieve, as well as any unintended effects from their production and use. A price premium for biofuels would make sense only if enough policy benefits can be achieved. However, if global crude oil prices increase further and biofuels become economically competitive, the rush to biofuels may accelerate without concern for environmental impacts or sustainable development.

2.5. Promise or peril?

In sum, first generation biofuels appear to have some potential benefits on all sustainable development criteria (economic, environmental, social), but whether they can be realised depends on the details, particularly the feedstock, production method, and the economic organisation of production. Therefore, policy intervention will be important to realise the promise of biofuels and minimise their perils.

It is widely agreed that so-called second generation biofuels, however, have significantly more potential for reducing GHG emissions and avoiding the food-fuel conflict (Worldwatch Institute 2007). They can be produced from a wider range of sources including agricultural, forest, some municipal and other waste, and micro-algae. To the extent that agricultural feedstocks are used, second generation biofuels will encounter similar limitations as first generation ones; for example, they will still use fertiliser and pesticide. However, the yield of usable material will be much higher since they use lignocelluloses, meaning the entire plant can be used, not just grains or oilseeds.

The wide availability of cellulosic feedstocks may make second generation biofuels a promising proposition for energy security. However, realising the full potential of second generation biofuels requires overcoming several limitations. These include the need for research breakthroughs to improve feedstocks and conversion processes, reduce the necessary scale of the processing facilities, and reduce costs, especially for transporting widely dispersed bulky feedstock. Moreover, second generation biofuels are not free from environmental impacts. Collection of stover and other crop residues from fields will deprive soils of necessary organic matter and make them more vulnerable to soil degradation and erosion, leading to reduced productivity. The problem could be more severe in tropical developing countries where organic matter decomposes faster in the soil, so more organic material is needed to maintain soil quality. Many peasant farmers in the region depend on these crop residues and other organic matter as a main source of plant nutrients. If second generation biofuels reduce the availability of organic matter, farmers could be forced to use more fertilisers to sustain crop yields. Biodiversity could be endangered if forest residues are collected from vulnerable areas. Forest litter collection could also expose forests to soil erosion and degradation (Graham et al. 2007; United Nations Conference on Trade and Development 2007; Wright and Brown 2007; Runge 2007). It has been suggested that some of these issues could be addressed by returning the inorganic residues from biofuel processing back to the soil (Tono et al. 2007). However, this may be only a partial solution since the organic matter would still not be available for agricultural use. The transition to second generation biofuels is also an issue since large investments in production of first generation biofuels may already have been made by the time the second generation biofuels can achieve significant scale. The United Nations Commission on Trade and Development (UNCTAD) believes second generation biofuels will take 20-30 years to be commercially viable, but by then it may be difficult for them to compete if large infrastructure investments in first generation biofuels have already been made.

Despite these limitations, some are optimistic about second generation biofuels, since there has been significant investment in research efforts for some time. One example is an effort to produce cellulosic ethanol by using a well established technology that has been used mainly for producing diesel from coal (United Nations Conference on Trade and Development 2007). Ideally, it would be best if biofuels could be produced from municipal and agricultural waste rather than specifically designated crops (Bensten et al. 2006). Biofuels would be much more attractive if they could help solve Asia's municipal waste problems or help address issues stemming from increased livestock waste due to increased meat consumption and production. However, none of these sources will be commercially viable without research breakthroughs. Although there are intensive research efforts and many demonstration projects underway around the world, the general consensus is that large scale utilisation will not be possible for at least several years.

3. Biofuel production and consumption trends in selected Asian countries

3.1. First generation biofuels

3.1.1. Current status

In a number of countries in Asia, governments and the private sector already have ambitious plans to rapidly expand the production and consumption of first generation biofuels. Indonesia and Malaysia have bold plans to produce biodiesel from oil palm. China and India are experimenting with different feedstocks for biofuels. The Philippines is focusing on biodiesel from coconut oil and ethanol from sugarcane. Thailand and Pakistan are also likely to become important future players. Japan is not yet a major player, although it has conducted considerable research, and is focusing on developing second generation biofuel technology based on cellulosic biomass.

The quality of data available on biofuel production, consumption, and feedstock utilisation in the Asian region is not very high. Data on biodiesel is especially scarce. Only rough estimates of biofuel consumption are available. Better data on production, sales, trade, and inventories of biofuels is needed, especially internationally comparable standardised country-level data.

Globally, it is estimated that bioethanol constitutes 90% of biofuel produced, at 36 billion litres per year (L/yr), and biodiesel constitutes 10%, or 4 billion L/yr (Rajagopal and Zilberman 2007). This is about 1% of the total global transport fuel market. The production and consumption of biofuels is expected to grow further, both worldwide and in the Asia Pacific region, along with the rising energy demand and fossil fuel prices.

Biofuels are increasingly used in the region's transportation sector. In 2004, on average, about 1.06% of total transport fuel came from biofuels in countries such as India, China, Pakistan, Thailand, the Philippines, Russia, Indonesia, the Republic of Korea, and Japan (Worldwatch Institute 2007). India topped the list with 3.01% of the transport fuel coming from biofuels, followed by China (2.51%).

The choice of feedstock in Asian countries has been based on existing crops, existing feedstock production and processing infrastructure, climatic conditions, and, in some cases, government policies. It has not necessarily been based on which crop makes the best feedstock in terms of efficiency, cost of production, or potential for GHG emissions reduction. Currently, sugarcane and oil palm are the most important feedstock crops for bioethanol and biodiesel production, respectively. Although cassava has the highest bioethanol production potential per hectare, the area under cassava cultivation is considerably smaller than sugarcane. Oil palm produces the highest amount of biodiesel per hectare followed by jatropha and coconut.

3.1.2. Production potential

Tables 5.4 and 5.5 provide estimates of the amounts of bioethanol and biodiesel that could be produced by various countries in Asia, if all the land currently being used to produce a particular crop was converted to biofuel production. Under this hypothetical scenario, China and Indonesia currently produce only 7% of their theoretical bioethanol potential followed by Thailand (5%), India (4%) and the Philippines (2%). In 2004, the fossil fuel demand for the Asian region (excluding Japan and the Republic of Korea) was 825 billion litres, and roughly 65% was utilised for transport (International Energy Agency 2004). Therefore, even if the entire crop area in tables 5.4 and 5.5 were converted to biofuel production, only about 33% of transport fuel could be replaced with bioethanol or biodiesel, and if 10% of the crop area were converted, then only 3% of transport fuel could be replaced. Therefore, first generation biofuels cannot be the main solution for the region’s increasing transportation energy needs.

Table 5.4. Bioethanol production potential from first generation feedstocks in selected Asian countries

Country	Feedstock	Total crop area in 2005* (Mha)	Ethanol yield** (L/ha)	Bioethanol production potential*** (ML)	Current ethanol production (ML)	Current production as % of potential
China	Corn	26.0	2,088	55.0	4,000	7
	Sweet Sorghum	1.0	380	0.4		
	Cassava	0.2	3,177	0.7		
India	Sugarcane	4.0	5,434 (Gonsalves 2006)	22.0	2,000	4
	Sorghum	9.0	3,469	32.0		
Indonesia	Cassava	1.0	2,465 (USDA Foreign Agricultural Service 2007b))	3.0	200	7
Philippines	Sugarcane	0.4	4,349	2.0	100	2
	Cassava	0.2	1,474	0.3		
	Corn	2.0	2,960	6.0		
Thailand	Sugarcane	1.0	3,252 (Dutta et al. 2007)	3.0	400	5
	Cassava	1.0	5,721 (Nguyen et al. 2007)	6.0		

Note: * Food and Agricultural Organization (2007); **Ethanol yield was obtained from different sources (USDA Foreign Agricultural Service 2007a); *** Potential production of bioethanol was obtained by multiplying the current crop area and ethanol yield per hectare.

Table 5.5. Biodiesel production potential from first generation feedstocks in selected Asian countries

Country	Feedstock	Total area* (Mha)	Biodiesel yield** (L/ha)	Biodiesel production potential*** (ML)
Philippines	Coconut	3.2	1,750	6,000
Thailand	Oil palm	0.3	3,800	1,000
Indonesia	Oil palm	3.7	3,800	14,000
	Coconut	2.7	1,750	5,000
	Soybean	0.6	320	200
India#	Jatropha	@ 13.4	1,892 (Rajagopal et al. 2005)	25,000

Note: * Food and Agricultural Organization (2007); ** Obtained from different sources, averaged if given as a range; *** Obtained by multiplying the current crop area with ethanol yield per hectare; NA: data not available; # Production is still in the pilot phase; @ area envisaged to be covered by the government of India.

3.2. Second generation biofuels

3.2.1. Current status

Acknowledging the limitations of the first generation biofuels, there is a move in the direction of second generation biofuels. The European Commission, which is currently developing rules requiring biofuels used in the EU to produce at least a 10% saving of GHG emissions compared to fossil fuels, would encourage the use of second-generation biofuels, possibly by giving them extra weight towards EU targets and providing more government support (Mason 2007). The 2007 U.S. Energy Bill mandates the blending of 136.3 billion litres per year of domestic alternative fuels into motor fuels by 2022, and calls for the share of cellulosic ethanol to reach at least 3% by 2012 and 44% by 2022 (Gardner 2007). Japan emphasizes the importance of biomass from waste and unutilised sources.[8] The government of Japan estimated that if technologies to produce ethanol from rice straw and lumber on a mass scale are realised, it would be possible to produce 1.8-2.0 billion litres of ethanol from herbaceous crops and 2.0-2.2 billion litres from wood-based material (Biomass Nippon Strategy Promotion Conference 2007). Another estimate suggests that Japan could supply 24.7 Mt of woody biomass from timber mill residues, construction waste, forest waste and low quality wood that cannot be used for economic purposes (Inoue 2007). With a conversion rate of 303 L/t of woody mass, Japan could produce 7.5 billion litres of cellulosic ethanol, constituting 3.4% of the total oil consumed in 2006.

In terms of large-scale production, biofuels from cellulosic biomass are still at the demonstration stage. Research has been conducted focusing on large-scale production in the USA, Canada, Germany, Sweden, China and Brazil (World Business Council for Sustainable Development 2007). It was previously believed that second generation biofuel technologies would not be available in the market until 2030. However, the World Business Council for Sustainable Development (WBCSD) believes that technological breakthroughs are possible in the near future depending on government funding (World Business Council for Sustainable Development 2007).

Box 5.2. Production of bio-ethanol from construction waste wood

Japan has several pilot projects to explore the potential of second generation biofuels. One example is Bioethanol Japan Kansai (BJK), founded by Taisei Construction Company, Marubeni, Tokyo Board, Daiei Environment, and Sapporo Beer. This project uses construction waste timber, which it calls “forest resources stocked in cities.” The ethanol produced is being sold as 3% ethanol blended gasoline (E3) at gas stations in Osaka Prefecture. The bioethanol production facility, which was constructed with the support of the Ministry of Environment, Japan, is one of the core industries of the “eco-town” promoted by Osaka Prefecture. Currently, it is possible to produce 1.4 ML per year by using 40,000 – 50,000 t/yr of waste wood (Sato 2007). Like other similar projects, this one is not commercially viable.

3.2.2. Production potential

India, Indonesia, China, Malaysia, Japan and Vietnam together could produce about 402 billion litres of ethanol by collecting the residues from rice, wheat, sugarcane and corn alone (Table 5.6). There is potential to produce even more if residues from other agricultural crops, timber mills, forests, grasslands and organic waste from urban and rural areas are included.

Table 5.6. Potential availability of agricultural residues for second generation biofuels in selected Asian countries

Crop	Residue type	India	Indonesia	China	Malaysia	Japan	Vietnam
Rice	Straw, husk	229	90	303	4	19	60
Wheat	Straw, husk	110	-	156	-	1	-
Sugarcane	Leaves, bagasse	119	15	44	-	1	8
Corn	Stalks, cobs, leaves, husk	14	13	140	0.1	0	4
Total residues (Mt per year)		472	117	643	4	21	71
Cellulosic ethanol* (billion litres per year)		143	35	195	1	6	21

Notes: * Using a conversion rate of 303 L/t of cellulosic residue material. Conversion rates can vary from feedstock to feedstock and thus this should be considered as a rough estimate. Crop yield for 2005 was sourced from the FAOSTAT database. Residues were obtained from harvest index values and biomass distribution in the above ground mass from different sources.

4. Biofuel-related policies in selected Asian countries

4.1. National policies in selected Asian countries

Many Asian countries have already instituted ambitious policies to promote biofuels. This has been mainly motivated by economic factors, including the need to meet increasing demand for transport fuel and enhance energy security in the face of rapid population and economic growth. In some countries, biofuel promotion was also motivated by potential export opportunities to the EU.

Policy measures include supply and demand stimulation, formal targets for biofuel usage, mandates to blend biofuels with standard gasoline or diesel, tax advantages, or other industrial promotion measures (Clark 2007a; Kojima et al. 2007). Some countries, including China, have become aware of the potential tradeoffs between biofuels and food, and have started to adjust policies to resolve this issue. Many countries are using trade policies, especially infant industry protection in order to promote domestically produced biofuels. Some countries, like Indonesia, are considering export tariffs to encourage biofuels to be used domestically instead of being exported.

This section reviews the main biofuel-related policies in selected Asian countries, especially focusing on formal numerical targets, fuel blending mandates, economic incentives to promote biofuels, and measures to facilitate non-food based biofuels.

Table 5.7 illustrates the current policies of nine Asian countries.[9] A number of countries have numerical targets for domestic consumption or production of biofuels, including China, Indonesia, Thailand, and Japan. Blending mandates have been introduced or planned in most countries except Singapore and Japan. Thailand and the Republic of Korea experienced opposition from industry when they tried to introduce blending mandates, and government plans were postponed or scaled back. The most commonly used economic incentives are taxes and subsidies. Thailand's policy to lower the taxes on ethanol blended gasoline (gasohol) was especially effective in leading to a large increase in consumption. On the other hand, Indonesia's subsidy structure has not been effective since it is offset by subsidies for fossil fuels. India is the only country in the list that has fixed the purchase price of ethanol and biodiesel.

Some countries have started to address the negative effects of using edible feedstocks for biofuel production. China drastically changed its policy in June 2007 by deciding not to approve any new projects using grain-based ethanol. Japan and Singapore are focusing on developing second generation biofuels. Other countries are investigating and promoting the production of biofuels from alternative feedstocks such as jatropha.

The policies of these selected countries are summarised as follows:

China, the world's third largest ethanol producer, previously promoted corn-based bioethanol. However, in May 2007 it issued a new policy that energy crops should not compete with grain. The government stopped approving new projects using food based ethanol and urged the current facilities to switch to new sources such as sorghum, batata, and cassava (Sun 2007). China plans to meet 15% of transportation energy through biofuels by 2020. The government mandated blending of 10% ethanol as a trial in some regions and provides incentives, such as subsidies and tax exemptions (Global Bioenergy Partnership 2007).

India is promoting bioethanol and biodiesel through phased mandates, fixed prices, and tax incentives. Due to a supply shortage from 2004 to 2005, the ethanol blending mandate was made optional in October 2004, but it resumed in 20 states from October 2006. A nationwide 5% blending mandate for diesel is planned (Global Bioenergy Partnership 2007). To address the fuel versus food issue, the government is considering production of ethanol from sweet sorghum, sugar beet, cassava, and tapioca, and production of biodiesel from non-edible seed bearing trees/shrubs like jatropha (Subramanian 2007). The national government considers the issue of potential food-fuel conflict to be very important, and the delay in announcing the new biofuel policy (as of February 2008) could be evidence that it is be approaching the biofuel issue cautiously. Some state governments are more active in promoting biofuels. Policy discussion focuses on planting biofuel crops on wastelands throughout the country and integrating production with rural development programs.[10]

Malaysia, one of the world's two major producers of palm oil along with Indonesia, is experiencing difficulty in enforcing its biofuel blending mandate (USDA Foreign Agricultural Service 2007d).[11] Although Malaysia has issued licenses for 91 biodiesel producers, due to high prices for crude palm oil, only four of them have actually begun operating (Nagarajan 2008). To promote sales, a plan to subsidise prices was announced (Mustapha 2008). The government is also encouraging additional feedstocks including jatropha, nipah, sago and oil palm biomass (Lunjew 2007).

Indonesia is experiencing falling oil production, and its oil exports are falling even faster due to increased domestic consumption, so the government wants to replace some domestic oil consumption with biofuels. It set a target to increase biodiesel use to 2% of its energy mix by 2010 (Legowo 2007). Blending is not mandated, but blending up to 10% is allowed. However, biofuel promotion is facing obstacles. Although the Indonesian state-owned oil firm is selling blended biodiesel, it cut the blend to 2.5% in April 2007 due to rising palm oil prices and continuation of fossil fuel subsidies set at the same level as for biodiesel (Daily Times 2007). NGOs are complaining about the lack of consideration of the impacts caused by Indonesia's expansion of crude palm oil production (Mahr 2007). Indonesia has imposed export taxes on crude palm oil to discourage exports and save it for domestic cooking use, and it has also recently imposed a 2% export tax on biofuels (Leow 2008; Commodity Online 2008).

Thailand, a low-cost sugar producer, plans to replace 20% of its vehicle fuel consumption with biofuels and natural gas within the next five years (Waranusantikule 2008). Tax breaks for 10% ethanol blended gasoline have been used to maintain a consistent price advantage, which has increased consumption 23-fold in 2004 and 11-fold in 2005. After consumption increases stalled, the government took steps to increase the price difference (Kojima et al. 2007). In January 2008, 15 service stations in Bangkok began selling 20% ethanol blended gasoline priced six baht per litre (about USD 0.19) cheaper than premium gasoline (Bangkok Post 2007). However, the government has not been able to fully implement the blending mandate for ethanol due to opposition from the automobile industry (Worldwatch Institute 2007). In contrast, a mandatory blend of 2% palm oil (B2) for diesel vehicles is planned in 2008 (Waranusantikule 2008).

The Philippines is the world's largest exporter of coconut oil, and a 2007 biofuel law mandates a 1% coconut oil blend for diesel and 2% by 2009. This law also requires the addition of at least 5% ethanol in other gasoline products by 2009 and 10% by 2011 (USDA Foreign Agricultural Service 2007e). It provides various tax incentives and financial assistance. The viability of jatropha methyl ester is now being seriously studied, and propagation of jatropha in military camps has been implemented (Marasigan 2007; Laur 2006).

Table 5.7. Biofuel policies in selected Asian countries

Country	Numerical targets	Blending mandate	Economic measures	Policies for second generation biofuels & alternative feedstocks
China	Biofuel share 15% of transportation energy by 2020.	Ethanol: trial period of 10% blending mandates in some regions.	Ethanol: Incentives, subsidies and tax exemption for production. Diesel: Tax exemption for biodiesel from animal fat or vegetable oil.	No new projects of grain-based ethanol to be approved. Experimenting with 2nd generation fuels.
India	No target identified.	Ethanol: Blending 5% in gasoline in designated states.	Ethanol: Excise duty concession. Ethanol and Diesel: Fixed prices for purchase by marketing companies.	Promotion of jatropha.
Malaysia	No target identified.	Diesel: Blending of 5% palm olein in diesel.	Diesel: Plans to subsidise prices for blended diesel.	Promotion of jatropha, nipah, etc.
Indonesia	Domestic biofuel utilisation; 2% of energy mix by 2010.	Diesel: Blending is not mandatory but blended fuels are being sold (currently 2.5-5%) and there is a plan to increase biodiesel blend to 10% in 2010.	Diesel: Subsidies (at the same level as fossil fuels).	Seriously considering jatropha and cassava.
Thailand	Plan to replace 20% of vehicle fuel consumption with biofuels and natural gas by 2012.	Diesel: 2% palm oil for all diesel vehicles from April 2008.	Ethanol: Price incentives through tax exemptions.	Utilisation of cassava.
Philippines	No target identified.	Ethanol: 5% by 2009, 10% by 2011. Diesel: 1% coconut blend, 2% by 2009 .	Ethanol and Diesel: Tax exemptions and priority in financing.	Studies and pilot projects for jatropha.
Republic of Korea	No target identified.	Diesel: 0.5% biodiesel blend to be increased to 3% by 2012.	Biodiesel: Tax exemptions.	Now identifying appropriate energy crops.
Japan	Plan to replace 500 ML/year of transportation petrol with liquid biofuels by 2010.	No blending mandate. Upper limits for blending are 3% for ethanol and 5% for biodiesel.	Ethanol: Subsidies for production. Tax exemptions are being planned.	Promotion of cellulose-based ethanol.
Singapore	No target identified.	No blending mandate identified.	Promoting investment in biodiesel plants.	Plan to focus on second generation biofuels.

Information as of January 2008. Sources: Worldwatch Institute (2007), GBEP (2007), Sun (2007), Kojima et al. (2007), Subramanian (2007), USDA Foreign Agricultural Service (2007a, b, c, d, e, f), Mustapha (2008), Lunjew (2007), Legowo (2007), Daily Times (2007), Waranusantikule (2008), Marasigan (2007), Ehrlich (2007), Seo (2008), Iijima (2007), Nikkan Kougyou Shimbun (2008), Nihon Keizai Shimbun (2007), Kolesnikov-Jessop (2007).

The Republic of Korea's target is still comparatively low, with a mandate of 0.5% biodiesel in domestic diesel, much lower than the initial goal of a mandatory 5% blend, which was successfully opposed by domestic refiners (Reuters 2007d). A plan to raise the content to 3% by 2012 was announced in September 2007 (Ehrlich 2007). A feasibility study for bioethanol was started in 2006 (USDA Foreign Agricultural Service 2007c).

Japan's Kyoto Protocol Target Achievement Plan aims to replace 500 ML per year of petroleum based transportation fuels with liquid biofuels by 2010.[12] Japan does not have a blending mandate but regulates the maximum blending of ethanol and biodiesel, allowing up to 3% for bioethanol and 5% for biodiesel (Iijima 2007). Bioethanol blended oils started to be sold in 2007. The government plans to introduce exemptions from the gasoline tax and other tax benefits for biofuel crop producers and refiners (Nihon Keizai Shimbun 2007; Nikkan Kougyou Shimbun 2008). The Japanese biomass strategy, revised in 2006, emphasises the importance of cellulosic biofuels, prioritises unutilised resources such as thinned lumber, and promotes "biomass towns" (communities where biomass is totally utilised) (Nihon Keizai Shimbun 2008; Reuters 2007b). Grassroots movements to use waste for biodiesel are also notable in Japan. Municipal governments and NGOs have developed community-based programmes for biodiesel utilising used cooking oil (box 5.3). The annual production of such biodiesel is estimated to be between 4-5 ML per year (Biomass Nippon Strategy Promotion Conference 2007).

Box 5.3 Biodiesel fuel production project in Kyoto

The city of Kyoto started to utilise biodiesel produced from waste cooking oil for 220 garbage collection trucks, just before the meeting of the Conference of the Parties of the UNFCCC in 1997. In 2000, it began to use 20% biodiesel blends for approximately 80 municipal buses. Kyoto has been using 1.5 ML of biodiesel annually, which is estimated to have reduced CO_2 emissions by about 4,000 t/yr. The household waste cooking oil scheme has expanded to the point that there are about a thousand collection points which collect a total of 0.13 ML per year. To ensure the quality of the fuel, a tentative standard called the Kyoto Standard has been developed by a panel of experts. A fuel production facility has been producing 5,000 litres per day since June 2004.

Source: Kyoto City 2007.

The future development of Japan's biofuel policies and markets is very significant. If Japan becomes a large consumer of biofuels, much of it will need to be imported, according to most observers. Thus, Japan's actions will have significant effects on countries that produce biofuels and biofuel feedstocks.

Singapore, the world's third-largest petroleum refining centre, has made efforts to jump-start biodiesel manufacturing on Jurong Island. Its biodisesel production output is expected to exceed 1 Mt/yr by 2010 (Clark 2007b). A field test to examine the feasibility of 5% palm oil methyl esters has been conducted by a group of companies in cooperation with government agencies (Communications DNA Pte Ltd 2007). The government intends to focus on promoting second-generation biofuels (Kolesnikov-Jessop 2007).

4.2. Regional initiatives related to biofuel policies in Asia

Some measures to promote biofuels have been implemented at the international level in Asia. In January 2007, Asian political leaders declared their collective intention to promote biofuels in the Cebu Declaration on East Asian Energy Security at the Second East Asia Summit. One of the measures in the statement was to "encourage the use of biofuels and work towards freer trade on biofuels and a standard on biofuels used in engines and motor vehicles" (East Asia Summit 2007).

In response to growing concerns about potential adverse environmental effects due to expanding biofuel production, various international organizations have started to participate in the development of biofuel sustainability certification schemes, including the European Commission, the Food and Agriculture Organisation of the United Nations, the United Nations Environment Programme, the Global Bioenergy Partnership, and the International Energy Agency (Dam et al. 2008). In Asia, the development of biofuel sustainability certification schemes has been taken up by "roundtables", which are organizing multi-stakeholder dialogues to help reach a consensus on appropriate criteria (Dam et al. 2008). The "Roundtable on Sustainable Palm Oil" (RSPO) was founded in 2004 as a global multi-stakeholder initiative on sustainable palm oil, with the principal objective "to promote the growth and use of sustainable palm oil through cooperation within the supply chain and open dialogue between its stakeholders." Members represent major players along the palm oil supply chain, including oil palm growers, palm oil processors and traders, consumer goods manufacturers, retailers, banks and investors, environmental/nature conservation NGOs, and social/development NGOs. Malaysian and Indonesian palm oil associations are among the members (Roundtable on Sustainable Palm Oil 2004; Kojima et al. 2007). A certification protocol was developed and the certification process was launched in November 2007 (RSPO 2007; Reuters 2007c).

The Roundtable on Sustainable Biofuels (RSB), led by EPFL (École Polytechnique Fédérale de Lausanne) Energy Center, is an international multi-stakeholder initiative which aims to develop standards for the sustainability of biofuels; its first stakeholder meeting was held in 2006. Currently the RSB is focused on the development of principles and criteria for sustainable biofuels production, and hopes that the draft standards will be available by mid-2008 (Roundtable on Sustainable Biofuels 2007). Other roundtable initiatives focusing on biofuel feedstocks include the Roundtable on Responsible Soy Association and the Better Sugarcane Initiative.

The "roundtable approach" provides opportunities to develop certification systems supported by a wide range of stakeholders. However, as the criteria developed by those roundtables are only voluntary commitments, this approach will be effective only if all stakeholders actually follow the criteria (Dam et al. 2008; Reuters 2007a). Another concern is the motivation of the participants. Some NGOs, such as Friends of the Earth, argue that the roundtables provide some governments an excuse not to take stronger, more direct measures to protect the environment and vulnerable populations (Reuters 2007a).

4.3. Implications of current biofuel-related policies in Asia

While many biofuel promotion policies of Asian countries are ambitious and well-intentioned, several things are not entirely clear:

(i) *Is it physically possible to implement the biofuel promotion strategies?* There may be insurmountable physical constraints. Land and water availability analysis has not been conducted, and there are doubts about whether there is enough available land in Asia to significantly increase biofuel production, especially without significantly increasing food prices. Countries are already having difficulty meeting biofuel consumption targets, which have been scaled back, and food prices are increasing.

(ii) *Can biofuel promotion strategies be implemented sustainably, i.e, actually reduce GHG emissions without causing other environmental or socioeconomic problems?* All national biofuel strategies declare that biofuels should be produced in a sustainable manner, but current policies do not include concrete mechanisms to ensure this. Even the EU has yet to agree upon sustainability standards, so it may be even more difficult for developing countries with limited capacity to regulate and implement them. Nevertheless, it is an important way to ensure that the benefits to be gained from biofuels will outweigh the costs of their potential negative impacts. Ultimately, sustainability standards must be agreed upon internationally and applied locally. Initiatives such as the RSPO and RSB should be supported by governments and utilised to strengthen their own policies. Currently, membership in the RSPO is voluntary and not yet mandated by law, so even though Malaysia is the prime mover of the RSPO, environmental NGOs are still highly critical about the biodiversity impacts of oil palm plantation expansion in forests because not all palm oil producers are required to follow RSPO best practices.[13]

Focusing on short-term gains simply shifts environmental problems from one sector to another, for example reducing GHG emissions in transport at the expense of clearing forests for biofuel plantations. Unsustainable practices will not only endanger the environment and lead to social problems, but also endanger the biofuel industry itself in the long run. It would be to the advantage of feedstock producing countries, especially developing ones, to set and adopt mandatory sustainability standards for the biofuel industry to follow from the outset. These would be more costly to implement later.

(iii) *Can biofuel promotion policies actually achieve the goal of promoting energy security?* At present, the contribution that first generation biofuels can make to energy security is physically very limited, comes at a considerable financial cost, and could have significant environmental and social costs. Second generation biofuels are much more promising, but they may also be financially costly in the short term. Since biofuel promotion currently requires significant government financial assistance, it would be advisable to ensure that this assistance promotes environmental and social sustainability of biofuel production.

Other observations on current biofuel promotion policies include:

(i) *Insufficient attention to quality standards*. Biofuels are not created equal. The national binding numerical targets and blending mandates are silent on biofuel quality standards. The Asian biofuel industry is in its infancy and production can barely meet domestic demand. For now, the lack of quality standards makes it easier to start up domestic biofuel industries. In the long run, a lack of standards will hinder development of the market, and could distort competition and trade, and export potential could be damaged.

(ii) *Insufficient attention to second generation biofuels*. Current policies are focused on first generation biofuels. Research on technology to increase productivity and yields will improve their cost benefit profile. But second generation biofuels will replace first generation ones as soon as the technology becomes commercially viable. Feedstock producing countries, including developing ones, should be prepared for this transition.

(iii) *Importance of international cooperation*. Ultimately, the success of national biofuel policies will depend on whether biofuels can be produced sustainably. National policies are not likely to attain this on their own, and international cooperation is important. Moreover, if each country develops its own standards, trade will become difficult. Potential exporting countries–mainly developing countries in Asia–especially may have difficulty finding markets if importing countries do not have confidence that an exporter's biofuels have been sustainably produced. An internationally agreed certification system would provide confidence that the benefits of biofuels in climate change mitigation, energy security and rural development are not being realised at the expense of the environment.

5. Conclusions and recommendations

There is no general consensus regarding the best policies for biofuels. Existing policy recommendations range from rapid promotion to cautious promotion (combined with more research) to a moratorium. Many policy recommendations relating to biofuels come from businesses with an interest in promoting (or restraining) them, or non-Asian NGOs and research institutes. Unfortunately, little serious policy analysis has been conducted by independent organisations in Asia or considering Asian conditions. This chapter concurs with one area of general agreement; waste-to-biofuels or so-called second generation biofuels based on cellulosic biomass have considerably more potential than first generation biofuels and are more consistent with sustainable development principles. Much technical research on second generation biofuels has been done in developed countries, including Japan, but more resources could be devoted to them, and little research has focused on their development in conditions specific to developing countries in Asia.

Nevertheless, it is still important to develop policies to address the issues posed by first generation biofuels, which many Asian countries have already decided to strongly promote. It is still not clear when second generation biofuel technology will be ready for large scale implementation, despite the existence of numerous pilot projects, and the processing technology for first generation biofuels is not easily converted to second generation biofuels.

It appears theoretically possible to produce biofuels sustainably in Asia, as long as the issue of land use change is addressed. In addition, biofuels could contribute to GHG reduction, energy security, and poverty reduction, at least to a limited extent. However, there are strong economic incentives to produce biofuels unsustainably, especially by destroying rainforests and peat lands, and it is unclear to what extent biofuel utilisation targets can be met by sustainable means.

Neither of the policy directions at both ends of the spectrum–a strict moratorium on biofuels on one hand, or accelerated large scale promotion on the other–appears to be necessary or realistic. Many Asian governments are already intent on promoting biofuels but production will not be enough to meet existing utilisation targets anyway. Nevertheless, strengthening targets or promotion measures without building in policy safeguards to ensure that additional biofuels are produced sustainably could lead to significantly accelerated deforestation or other environmental damage.

Therefore, in the near term, the policy priority should be to find ways to promote sustainable production methods for biofuel feedstocks, especially how to avoid direct or indirect deforestation. For some Asian governments, promoting sustainable production of biofuels and environmental protection may not be a high priority, especially compared to energy security and economic development considerations. If governments follow a short-term strategy to promote biofuels in an unsustainable manner, however, the resulting environmental damage, economic disruption, and intensified poverty could ultimately be counterproductive–the cure could be worse than the disease. Developed countries have a special responsibility to ensure that any imported biofuels are produced in a sustainable manner. Addressing domestic climate change commitments by causing environmental or social problems in biofuel producing countries is not acceptable.

Developing a system to certify sustainably produced biofuels may be a good first step to promote their sustainable production. This could be based on sustainability criteria developed through existing multi-stakeholder initiatives like RSB and RSPO. However, since these criteria would be voluntary, implementation may require additional action by governments to make them mandatory. Countries that mainly import biofuels, including advanced countries like Japan, could base domestic standards for biofuels on globally agreed sustainability criteria to promote sustainable production. Still, implementation of sustainability criteria will require international cooperation and independent monitoring to be fully effective. It will also require improved collection of data related to biofuels.

Until there is reasonable assurance that biofuels can be sustainably produced, it would be better to adopt a cautious approach. Likewise, clean development mechanism procedures and criteria for approval of biofuel-related projects should not be relaxed for the same reason. Policy finance or aid should focus on research and development or policies to promote sustainable production methods, especially on second generation biofuels, and not on increased production of first generation biofuels.

It is also important to consider the diversity of conditions (for example level of development, production conditions, consumption conditions, feedstock availability, climate, etc.) in Asia when considering biofuel related policies. The most appropriate policies may be different for each country, or even within countries.

Considerable policy discussion has focused on biofuel trade barriers, most notably the high US tariff on ethanol, and there have been many recommendations to reduce protectionist barriers to biofuel trade, and to consider the classification of biofuels as an environmental good at the World Trade Organisation. Reducing trade barriers will enhance economic efficiency and reduce distortions. For biofuels, however, the first priority is to ensure that they are produced sustainably, and reductions in trade barriers do not address that issue directly, and could even encourage more unsustainable production. Moreover, it will be difficult to agree on classification of biofuels as an environmental good until there is reasonable confidence that sustainably and unsustainably produced biofuels can be distinguished from each other, possibly through a globally accepted certification system. Therefore, it is not recommended to prioritise trade policy measures yet.

It is also not recommended to use infant industry protection to promote domestic biofuel production and discourage imports, as some developing countries appear to be doing, since it may be counterproductive. Here, there are tradeoffs between the goals of promoting domestic biofuel production, cost reduction, global environmental protection (GHG reduction), and poverty reduction. Infant industry protection would increase the costs of energy, transportation, and food, thereby undermining gains in energy security, and disproportionately harming low income people. Infant industry protection could also encourage more unsustainable production methods (which may be cheaper than sustainable methods). In contrast, prioritisation of GHG emissions reduction could imply promoting imports instead of domestic production, if imported biofuels are more sustainably produced (and possibly cheaper). Domestic production of biofuels may or may not be the best option economically and/or environmentally, and each country's situation should be analysed individually.

Finally, even if first generation biofuels could be produced sustainably and contribute to GHG emissions reduction, the contribution will remain small. Energy conservation and the promotion of other forms of renewable energy remain essential, and biofuels by themselves 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. All countries should place biofuels in the context of a comprehensive energy policy which includes conservation as well as the promotion of other renewable energy forms. Biofuel policies should also be embedded in broader sustainable development considerations, and the economic, social and environmental implications of any new policies should be more carefully assessed.

Future research agenda

Additional research on biofuels is needed in order to effectively inform future policies, especially in the following areas: (i) more comprehensive LCA studies of the environmental effects of biofuels; (ii) economic and social effects of biofuels; and (iii) more cost effective and environmentally friendly ways to produce biofuels, especially second generation ones. Advanced countries are already conducting considerable research, but developing countries should conduct their own research because results on these topics could likely be location specific. For example, each country has different potential feedstocks and production conditions for second generation biofuels.

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Endnotes – Chapter 5

[1] According to the Symposium on Sustainable Consumption, in Oslo, Norway, 1994, “sustainable production and consumption is the use of goods and services that respond to basic needs and bring a better qualify of life, while minimizing the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardize the needs of future generations” (Symposium on Sustainable Consumption. Oslo, Norway; 19-20 January 1994).

[2] Life cycle assessment refers to a comprehensive assessment of the impacts of a product throughout its life cycle, from production to consumption to disposal (cradle to grave).

[3] ETBE is an oxygenated fuel that can increase the combustion efficiency of gasoline and help in better air quality.

[4] This is because the co-product glycerine is produced in the trans-esterification process.

[5] Net energy value (NEV) stands for the net energy contained in the biofuel after making necessary corrections for the energy consumed in producing a litre of biofuel.

[6] This includes the conversion of existing crops from food use to fuel use.

[7] One litre of biodiesel contains 8.65% lower energy than diesel.

[8] Unutilised biomass includes non-food parts of agricultural crops and remaining materials in forest land, according to the Biomass Nippon Strategy.

[9] As of February 2008.

[10] Interviews with Indian government officials, February, 2008.

[11] In the European Union, B5 biodiesel blend contains 95% diesel combined with 5% methyl ester, not palm olein.

[12] The Kyoto Protocol Target Achievement Plan (2005) sets a goal of replacing 19.1 billion litres of petroleum oil with "new energy sources" to reduce approximately 46.9 Mt of CO2. The share of transportation fuels in this target is 2.6%.

[13] The Roundtable on Sustainable Palm Oil has issued a set of 8 principles based on best practices that are considered to enhance the sustainability of palm oil production.