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## Organic crops or energy crops? Options for rural development in Cambodia and the Lao People's Democratic Republic

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**Organic Crops or Energy Crops?  
Options for Rural Development in Cambodia and  
the Lao People's Democratic Republic**

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**Abstract**

This paper examines the prospects for organic agriculture (OA) and the production of biofuels as strategies for rural development in Cambodia and the Lao People's Democratic Republic (Lao PDR). Both agricultural activities are growing worldwide, although there are some questions as to how effective they are, environmentally and socially. These questions are discussed in the first part of the paper. The second part looks in detail at the potential for OA and biofuels in the two countries. The benefits of both activities in terms of poverty reduction and environmental sustainability to developing countries such as Cambodia and the Lao PDR are likely to be significant, although the full extent of that is subject to market access (particularly for organic foods) and the costs of certification. Poverty impacts appear to be greater for OA than for biofuel but since the growing areas do not generally overlap, both could be promoted. Since the present agricultural environment in both countries is generally regarded as 'clean' with a low level of chemical inputs, production of safe food for a high-value market may be a preferred strategy than to intensify agriculture through conventional methods and compete with more developed countries. Assistance from external organizations in overcoming challenges will be critical for the success of any programs to promote both OA and biofuels.

**JEL Classification:** Q01, Q12, Q17, Q18

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## I. INTRODUCTION

More than two billion people in the world today depend on agriculture for their livelihood. In Asia where poverty is largely a rural phenomena, governments are in a constant search for effective agriculture development strategies. In recent years, two important new developments have emerged strongly: the growth of organic agriculture (OA), and the increased use of land to grow energy crops (Biofuels). While both activities are still relatively small, they are expanding rapidly due to the growing demand for safe food and the rising price of oil. Because both developments are taking place largely in marginal areas where the majority of the poor reside, poverty and environmental implications from these two activities appear significant.

Using the cases of the Lao People's Democratic Republic (PDR) and Cambodia, the study compares the two options for the development of OA and biofuel with respect to a set of development goals; the focus of which includes not only the narrow economic benefit to the farmers, but also their impact on health, poverty reduction, the environment and sustainable development overall. There is considerable interest in both these farming enterprises in the two countries, and the public and private sectors are already engaged in a range of activities related to them. The report provides a description of these activities and looks at how effective they are—or they can be in the future, in promoting sustainable rural development.

The report is structured as follows. In Section II the general case for OA and biofuels in developing countries in general, and in Asia in particular, is made. Section III looks at the two options for Cambodia, and Section IV does the same for the Lao PDR. Section V provides several conclusions and offers recommendations.

## II. ORGANIC AGRICULTURE (OA) AND BIOFUELS IN DEVELOPING COUNTRIES

### II.1 OA in Developing Countries

The interest in OA is growing worldwide, including in developing countries, where it has been driven by disillusion with the sustainability of conventional high external input agriculture. The so-called Green Revolution may have increased yields over the past forty years, but these increases have slowed down or even been reversed in recent years due to decreasing soil fertility, degradation of water resources, and the build up of pest populations and resistance to pesticides (Rundgren, 2006). Furthermore, recorded damages to human health and the environment from conventional agriculture are also causing concern. All this has given rise to an interest in OA in developing countries; an interest that parallels that in developed countries, but is driven by somewhat different factors—more notably as a way of obtaining sustainable increases in production.

According to a survey by International Federation of Organic Agriculture Movements (IFOAM), SöL (Siftung Ökologie und Landbau) and Forschungsinstitut für biologischen Landbau [Research Institute for Organic Agriculture] (FiBL) in 2006, approximately 31 million hectares (ha.) of farmland are under organic management worldwide. A gain of around five million ha. since 2005 (Willer and Yussefi, 2007).<sup>1</sup> While the relative amount

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<sup>1</sup> The classification of land as organic is strict by International Federation of Organic Agriculture Movements (IFOAM) criteria and includes only land under certified organic production. Such certification requires third party inspection, and although specific standards vary across countries (55 of them have legislation that backs IFOAM type certification) the requirement is always for a complete absence of inorganic external inputs, chemical pesticides etc. It excludes, for example, land with good agricultural practices and low external inputs, which are also regulated in some countries—see the case of the People's Republic of China (PRC), where there are three categories: organic food, green food and non-polluting food (Qiao et al, 2007). If one takes a wider definition of "organic" to include land farmed with low external inputs, the amount would be much larger.

remains very small compared to conventional agriculture (CA)—about 0.6 percent of the world's 13 billion ha. of agricultural land, the rate of growth is high, at 11 percent per annum from 1998 to 2005, and 17 percent in the year 2005 to 2006 (European Commission [EC], 2005).

As a percentage of land area, the amount classified as certified organic<sup>2</sup> is highest in Europe at about 3.6 percent; ranging from as much as 11.6 percent in Austria to 0.7 percent in Ireland<sup>3</sup> (Willer and Yuseffi, 2006). Among the developing regions, we have seen the greatest growth in Africa and Asia, where the organic area has increased seven-fold over the period 2001-2003. Nevertheless the absolute numbers there are also small. In 2004 Asia had about 888,000 ha. under organic farming, representing only 0.07 percent of agricultural land and a mere 3.7 percent of the world's organically farmed land.<sup>4</sup> In 2005 Asia's share of the organic area increased dramatically to 13 percent (Willer and Yuseffi, 2006), largely because of the inclusion of forestland where organic non-timber forest products (NTFPs) are collected.

Three Asian countries—East Timor, Republic of Korea and Bangladesh—now have 2 percent or more of their agricultural land converted to organic agriculture. In Azerbaijan, People's Republic of China (PRC) and Sri Lanka, the share of OA in total agricultural land was between 0.4 and 0.5 percent. While Philippines, India, Pakistan and Vietnam had approximately 0.1 percent certified organic land in 2005. Data on the amount of land that is devoted to OA in Cambodia is not available on the same basis as above. For the Lao PDR, the amount classified as organic in the IFOAM database is merely 35 ha., but this must be seen a very low estimate of the land on which some OA is being practiced. Indeed there is considerable interest in both countries and a number of active programs in place. In the Lao PDR, agricultural planning in support of the National Economic Plan in 2006 explicitly aimed to develop OA in all upland areas. In Cambodia, OA export is highlighted in the National Export Strategy. These are discussed in sections III and IV respectively.

Most of the organic products from Asian countries are exported and the total sales amounted to approximately US\$800 million in 2006, representing a doubling within only 5 years. Furthermore, the potential for further growth is there. The global market reached US\$33 billion (estimated retail sales) in 2005 (Sahota, 2007), which was an increase of 43 percent from 2002. There is a growing undersupply of many organic products, from dairy and meat, to vegetables, fruits and beverages.

Japan remains the largest organic market in Asia, but domestic markets for organic products are growing in other Asian countries, including PRC, Thailand, Republic of Korea, Indonesia and Malaysia (Wright and McCrea, 2007). Supermarkets in cities such as Jakarta and Singapore have allocated space for organic products, and consumer awareness keeps rising. At present, many domestic markets in Asian countries are mainly supplied by imports and, given the right support, there is a potential for more local organic production. At the same time, the demand for organic products in North America and Europe is growing fast, and the larger organic markets in Germany and the United Kingdom (UK) have experienced exceptionally high growth since 2004. In Europe, the sale of organic products is now widespread through supermarkets and growing at rates of up to 14 percent per annum. At

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In 2002 a Greenpeace report indicated that land that was managed according to ecological principles was about 3 percent of agricultural land in developing countries, while that classified as organic was only about 0.7 percent (Parrott and Marsden, 2002). Thus the former could be as much as 4 times the latter.

<sup>2</sup> In this paper, Organic Agriculture (OA) refers to certified OA.

<sup>3</sup> The new accession countries are not included in this comparison. In general their share of organic agriculture covering a much wider range, with the Czech Republic having around 5 percent and Lithuania only 0.25 percent.

<sup>4</sup> Data on land area from different countries are not directly comparable as some countries convert large tracts of low value grazing land to OA, while in others it is high yielding crop land that is converted.

present over 6 percent of vegetable sales in Switzerland, Denmark and Sweden are organic products.<sup>5</sup>

Recent case-studies in India, PRC and Latin America indicate that the introduction of organic methods is often beneficial to small, resource poor farmers, and that the conversion to market oriented and certified organic agriculture can contribute to poverty alleviation and is well warranted (IFAD, 2002; Giovannuci, 2005). This also goes for other developing countries as well (Parrott et al, 2006; Pretty et al, 2006; Report from the Export Promotion of Organic Production from Africa [EPOPA] program in Africa (EPOPA, 2002<sup>6</sup>). Yields of OA are often higher— especially in marginal areas—and depending on market conditions, certified organic products can receive a price premium. Knowledge of how large a part this higher price actually benefits smallholders is, however, limited. While concluding that OA can help raise the productivity of low-input agricultural systems in developing Asia, the Economic and Social Commission for Asia and the Pacific ([ESCAP] 2002, p. vii.) notes that very few studies have analysed the socio-economic impacts:

“In many countries, resource-poor farmers practicing organic farming have not yet been the focus of government attention. At the same time, there seems to be a strong indication that the proliferation of OA could be a viable strategy to improve livelihoods in Asia’s rural areas. In addition, pro-poor organic agricultural policies appear to have the potential to improve local food security, particularly in marginal land areas. Comparative studies are however almost non-existent. This is a true shortcoming, and thus organic farming and its socio-economic impacts in rural areas are not well understood.”

Besides the price premium and the improved market links, other advantages such as improvement of soil fertility; enhancement or preservation of biodiversity; and improved health from the absence of chemical pesticides are widely reported from organic farming projects (Scialabba and Hattam, 2002; Halberg et al., 2006; Setboonsarng, 2006). The wider environmental benefits of OA, however, were subject to some controversy (Trewavas, 2001) in the late 1990s. Since then several studies have been carried out in Europe, comparing emissions of environmentally harmful substances, including greenhouse gases (GHGs), across a range of products produced under OA and CA. The method is based on a “cradle to grave” approach, which looks at all impacts, including those in the production of inputs that go into the different forms of agriculture (also referred to as Life Cycle Analysis [LCA]). These studies reveal that, in developed countries at least, OA outperforms CA with respect to its impacts on flora and faunal diversity; soil conservation; water leaching rates; and pesticide pollution to water (Sotlze et al, 2000, DEFRA, 2003).

The picture is less clear with respect to overall energy use per unit of output. In most cases OA uses less energy, but higher figures are found for potatoes and poultry meat (Williams et al., 2006; Federal Ministry for Food Agriculture and Forestry [Bundesministerium für Ernährung, Landwirtschaft und Forsten (BML)], 2000). In terms of GHG emissions, the BML study also found lower emissions per unit of output for OA.

All these studies look only at the farm gate impacts. Other studies have also looked at energy use and GHG emissions, including transport to the consumer, and here the use of airfreight is of particular concern. Thus OA produce, imported by air from a developing country, may have much higher emissions per unit weight than a conventionally produced local alternative transported a shorter distance by road. For example, Kenyan beans

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<sup>5</sup> See <http://www.organicmonitor.com//100142.htm>, accessed January 25<sup>th</sup> 2008.

<sup>6</sup> Export Promotion of Organic Production from Africa, [www.epopa.info](http://www.epopa.info)

produced for the UK market use about 1-2MJ/Kg at the farm gate, which is a little less energy use than in European production of the same commodity. But the packaging and shipping by air use 58MJ/Kg, which makes airfreight much less environmentally attractive (Jones, 2006).

This comparison, however, is subject to important qualifications. First, shipping by sea makes the comparison generally still favorable to OA, even with long distance transport. The same Kenyan beans would use only 2MJ/Kg for sea transport to the UK, and it appears that with new technologies this may be feasible without compromising the freshness of the product. Second, domestic production may not be available for some products, or only available under intensive greenhouse conditions, which would require lots of energy and make the comparison again favorable to the imported OA product—even with air transport. Third, these additional emissions may be part of the quota of the exporting country, which, if it is a developing country, will have some headroom to increase GHG emissions and still be well below those of the importing country. Thus freighting by air may be justified in some conditions, although it is likely that future developments in OA trade may have to respond to the call for lower emissions and impacts during transportation.<sup>7</sup>

Another issue raised by critics of OA, is that a significant shift in that direction from CA would result in the world not being able to feed itself, since yields on OA are sometimes lower than those on CA. This is, however, a misplaced concern, primarily because yields for OA are not lower in developing countries (although they can be in developed ones). A careful study by Badgley et al. (2007) shows that OA methods could produce enough food on a global *per capita* basis to sustain the current human population and potentially even a larger one without an increase in the agricultural land base.

The other global concern is whether there is enough organic fertilizer available that meets phytosanitary standards for such a massive shift in production. Again, the same study shows that leguminous cover crops could fix enough nitrogen to replace the amount of synthetic fertilizer in use. These results need confirmation, but they point to the fact that OA is not an impossibility on a global scale. Since it is unlikely we will ever have full conversion to OA, the current trends towards more organic production, OA should be sustainable for a long time to come.

In developing countries there are other, secondary, benefits from OA. The diversification of smallholder farms into growing a variety of crops, multipurpose trees combined with livestock enterprises and/or fish culture is shown to enhance the overall yield stability (so-called resilience) and therefore the food security of organic farmers. Thus, there are reasons to believe that smallholders and resource poor farmers may improve their asset building and livelihood through participation in certified organic production schemes. Moreover, organic agriculture (in principle) will enhance and preserve biodiversity and soil fertility, while reducing negative impacts on environment and health, compared to chemically based farming methods. As stated by Giovannuci (2005, p. 42),

Equally compelling on the macro scale is that organic agriculture can provide several public benefits that by most calculations should make it a very relevant multi-purpose tool for many Asian policymakers for whom health, food security, and improved incomes area at the top of their priority list.

Therefore, organic farming may contribute positively to the Millennium Development Goals (MDG) such as eradication of poverty and hunger, improved health, and ensured environmental sustainability (United Nations [UN], 2005). Moreover, for this purpose it may

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<sup>7</sup> The issue is currently high on the political agenda. There has been some discussion in Europe, for example, of not granting OA status to products that have been air freighted.

not be necessary to have full certification of the products. One cannot, however, expect a simple “yes/no” relationship between organic agriculture and MDGs; the relation will depend on the context. More knowledge is needed regarding the actual benefits for smallholder farmers and the environment of certified OA, including the necessary socio-economic conditions, organizational context, and market access.

## **II.2 Biofuels in Developing Countries**

There has been a significant growth in the use of biofuels (interpreted here to mean bioethanol and biodiesel—the two of which account for 90 percent of biofuel usage) as sources of energy to replace fossil fuels generally and petroleum products in particular. Worldwide production of bioethanol, which can be blended with gasoline, has increased from about 18 billion liters a year in 2000, to nearly 37 billion liters in 2005. Meanwhile, that of biodiesel has increased from less than one billion liters in 2000 to nearly four billion liters in 2005. The growth in demand is strongly motivated by the need to reduce dependence on imported oil, as well as a desire to reduce the GHG emissions from transport. The amounts of biofuels however, still make only a small impression on the transport demands for gasoline and diesel, which amounted to more than 1,200 billion liters worldwide in 2005.

So far, the major production sources of biofuels have been in the United States (US), Europe, Brazil and PRC. For ethanol: Brazil and the US account for around 45 percent each; the PRC for about 6 percent (2 billion liters); and the European Union (EU) for 4 percent. For biodiesel, the main production is in the EU, which accounts for almost all of it. Sources for bioethanol are grains or seeds (e.g. maize, cassava, wheat, potato), sugar crops (sugar beets and sugar cane) and lignocellulose biomass (which include a range of forestry products such as short rotation coppices and energy grasses); while sources for biodiesel are oilseeds such as rapeseed, soybean, sunflower, jatropha and palm oil. Production of biofuels in Asia (outside of the PRC) is still relatively small, and the region is therefore a minor player when it comes to determining trends in world markets. Thailand, for example, had a production capacity in 2005 of 273 million liters of ethanol (from sugarcane and cassava). The other countries in the Mekong region are at an early stage in the development of the industry. It is important to note however, that the governments harbor strong ambitions to expand production. Thailand, for example, has a target for 2008 of 3.8 billion liters for ethanol. Even with expanding worldwide production, such a level of production will make the country a major player in this market. The Lao PDR and Cambodia are beginning to look at biofuels, and there is believed to be considerable potential relative to the size of the countries' energy sectors. The potential for these countries is discussed in Section III.

While governments in many countries are actively promoting biofuels, there are several concerns about them. The cases for and against biofuels relate to their economic, social, and environmental implications.

### **II.2.1 Economic and Social Issues for Biofuels**

#### **Arguments in favor**

On economic grounds the arguments for more biofuel use are: (i) they can be a competitive source relative to gasoline and diesel, (ii) they can generate employment and growth in the economy by replacing imports with domestic production and (iii) they provide energy security by reducing dependence on imported fuels from politically unstable parts of the world. The competitiveness case depends critically on the world price of oil and on the taxation regimes for oil products relative to biofuels. Ignoring the tax dimension and looking at costs of production alone, an EU (2006) study indicates that costs of biodiesel are around

US\$900/ton of oil equivalent (toe), and those for ethanol are around US\$816-1080.<sup>8</sup> The lower figure for ethanol is based on the cost/insurance/freight (c.i.f.) included import price of ethanol (reflecting the lowest world production costs), while the higher figure is that of production within the EU. At the same time, costs of conventional diesel are US\$395 with an oil price of US\$28/barrel, and US\$939 with an oil price of US\$90/barrel. For gasoline the corresponding figures are US\$373 (low oil price) and US\$917 (high oil price). From this it is clear that even at the high oil price of US\$90, some subsidy may be needed to allow the market to adopt the biofuel. Table 1 below indicates the size of the subsidy required for the European market. That does not mean, of course, that the subsidy need be given in the EU. It could be provided by the exporter—although such a policy may run into difficulties with the World Trade Organization (WTO).

We should also note that there are significant expectations with regards to improvements in biofuel production efficiency. As Hausmann notes: “there is a lot of venture capital money being poured into finding more efficient ways of extracting energy from biomass. New technologies will be able to extract energy from cellulose, allowing the use of pastures such as switch grass.”<sup>9</sup>

**Table 1: Fuel Cost in US\$ Per Ton of Oil Equivalent (Toe), Excluding Taxes, Subsidies, External Costs and Benefits**

	Conventional Fuels		Biofuels	Subsidy Needed for Biofuels %	
	Low Oil Price	High Oil Price		Low Oil Price	High Oil Price
Diesel/Biodiesel	395	939	900	128%	-4%
Gasoline/Ethanol	373	917	816-1080	118% to 189%	-11% to 18%

Adapted from EU (2006, p. 33). “Low” Oil Price is US\$28/barrel. “High” oil price is US\$90/Barrel.

Such subsidies may be justified on the grounds of other economic objectives as well as the environmental and social benefits. The other economic objectives of job creation, growth and energy security are difficult to quantify, but nevertheless can be very real. Employment and growth effects are more likely in those developing countries where there is an agricultural sector inefficiency that can be exploited to increase production of biofuels, and where the environmental and economic consequences of shifting production to biofuels from other crops (discussed below) are not serious (Lanzini, 2007; UN, 2007). The case most cited is Brazil, the largest producer of ethanol, where there has been significant job creation in the sugar cane sector, which created 700,000 direct jobs and 3.5 million indirect jobs in 2004. The sector is one of the most efficient in creating jobs per unit of investment.

In any event, subsidies on biofuels in developed countries are already present and take many forms, including indirect ones such as mandating a minimum use of biofuels in mixture with gasoline or diesel.<sup>10</sup> The actual cost of support per liter of ethanol ranges from US\$0.29-US\$0.36 in the US, to around \$1 in the EU. Actual support for biodiesel varies from between US\$0.2 per liter in Canada, to \$1 in Switzerland.<sup>11</sup> This support is likely to continue and will create an opportunity for exporters from developing countries *as long as the subsidies are*

<sup>8</sup> The actual calculations were done in euros. An exchange rate of US\$1.2 to the euro has been used, reflecting the exchange rate prevailing at the time of the study.

<sup>9</sup> Hausmann, R. 2007. Biofuels Can Match Oil Production. *Financial Times*. 7 November.

<sup>10</sup> Subsidies are defined in Eurostat as *current unrequited payments from government to producers with the objective of influencing their levels of production, their prices or the remuneration of the factors of production*. They can take the form of income transfers to producers or consumers of a commodity, or price supports to producers. They can also be indirect, as in the case of biofuels, where demand for the product is artificially raised by mandating their use for transport; or they can be provided by placing tariffs on the imports of competitive products (as is the case with ethanol in the US).

<sup>11</sup> Wolf, M. 2007. Biofuels: An Everyday Story of Special Interests and Subsidies. *Financial Times*. 31 October.

*not only on domestic production.* The extent to which these markets will be open for exports of biofuels from developing countries is still under discussion.

While the full potential for biofuels in most developing countries depends very much on the developed markets being open to them, there are also important local opportunities for biofuels, based partly on replacing imported oil, and partly on using locally produced biofuels for rural purposes, such as pumping, agricultural machinery etc. Policies that encourage local farmers to expand production of oil seeds, such as jatropha, can yield local economic and social benefits, and developing countries are showing considerable interest in this source of biofuel. For example, India is now developing a major program to cultivate 8,000 ha. of wasteland that will produce 9 million liters of biodiesel a year, with major economic benefits going to small farmers and significant general environmental benefits being generated (Braun and Pachauri, 2006).

### **Arguments Against**

The major economic concerns about the expansion of biofuels are at the global level. Some argue that switching land to this use will reduce the amount available for food production. Either that or it will cause loss of protected land or forest land (Avery, 2006). Indeed a number of reports point to the clearance of rainforests in Indonesia to plant palm oil for biodiesel production. The data in support of a “land problem” are fragmented and sometimes anecdotal (e.g. the grain needed to fill a tank of a sport-utility vehicle (SUV) would feed one person for one year, or meeting electricity demands in 2052 from crops would require 80 percent of the earth’s surface to be under energy crops). Some data indicates that, based on current yields, it is impossible to meet some of the biofuel targets. For example, one calculation showed that if the 20 percent target for biofuels in Europe were to be met by planting rapeseed (one of the most productive oil crops in Europe) all over the continent, it would use up most of the available cropland and have a major impact on global food supply (EU, 2006).

While these views are commonly asserted, they do not go unchallenged. Hausmann, for example, claims that there are 95 countries that have between them 700 million ha. of good quality land not being cultivated. This could yield something of the order of 500 million to 1 billion barrels of biofuels – in the same range as oil production today.<sup>12</sup> In this regard one has to ask why this land is not already being used if it is such good quality land. It is likely that there are difficulties, which Hausmann is perhaps ignoring.

Whatever view one takes on the potential for biofuels, the studies to date suggests the need to be more careful about how future energy demands are to be met from this energy source, and at what pace and to what extent such fuels can meet our energy demands. For example, meeting biofuel targets from one crop inside a major fuel consuming area is not the way to go. Other more efficient sources must be exploited and international trade in fuels expanded. One must allow for and expect increases in efficiency in crop production,<sup>13</sup> (reflecting past trends), as well as in the technologies that will allow a wider range of feedstocks for biofuel production (especially second generation cellulosic ethanol). The extent to which these can change the potential for biofuels, and the comparative advantage of different countries in producing them, is not known. It is therefore desirable to be cautious in setting medium to long-term goals for biofuels.

Other arguments against biofuels are based on their social consequences. One of these arises from the shift in power amongst producers of energy and food crops. The production

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<sup>12</sup> Hausmann, R. 2007. Biofuels Can Match Oil Production. *Financial Times*, 7 November.

<sup>13</sup> In pursuing such gains in efficiency, however, one has to be careful. Strategies for increasing efficiency in crop production through the green revolution have caused collateral damage. Such damages must be avoided with biofuels.

of biofuels is more cost efficient on a large-scale, which has resulted in a concentration of ownership of ethanol plants in Brazil and the US. This in turn can put pressures on small farmers, dealing with large companies who have market power.

A second set of social consequences is related to the fact that the growth in demand for feedstocks is fuelling increases in the prices of food, which has a negative impact on the welfare of all except the farmers who grow the food. Estimates by the International Food Policy Research Institute (IFPRI) indicate that the rapid increase in biofuel production will push global maize prices up by 20 percent by 2010, and 41 percent by 2020. The prices of oilseeds, including soybeans, rapeseeds and sunflower seeds are projected to rise by 26 percent by 2010, and 76 percent by 2020. In sub-Saharan Africa, Asia and Latin America, where cassava is a staple, its price is expected to increase by 33 percent by 2010, and 135 percent by 2020.<sup>14</sup>

An increase in the price of feedstocks is a double edged sword. It benefits the farmers who grow the crops, but hurts the consumers. The benefits to the growers may be concentrated in the larger producers, and it will need a policy instrument to ensure that smaller farmers also benefit. As for the impacts on the consumers, a World Bank study estimates that caloric consumption among the world's poor declines by about half of one percent whenever the average prices of all major staples increase by one percent. If staples such as maize, wheat, potato, cassava and sugar increase in price because of the demand for biofuel production, other staples such as rice will also be affected (Runge, 2007).

Given these possible impacts, care must be taken not to switch production to biofuels at such a rate that the price effects become significant. Proper models of agricultural markets, linked to household expenditure surveys, must be used to analyze such movements carefully at the global and local levels. Where large movements are expected in international prices, governments need to provide social protection to those who are most hurt by the shifts. At the same time, those responsible for the shift to biofuels in the developed world should also be aware of the impacts they are having on the poor in developing countries, and adapt their policies accordingly.

### **Environmental Issues for Biofuels**

On the environmental side, biofuels are promoted as a way of reducing GHGs when they replace fossil fuels. In fact, the extent to which they have this benefit depends on the efficiency with which the raw fuel is converted into one that can be used as a replacement for gasoline or diesel, in addition to several other factors, such as the extent of use of fertilizer in growing the crops. Since these factors vary considerably, the net gains in terms of carbon dioxide (CO<sub>2</sub>) equivalent also vary a great deal. A review of different studies shows the following reductions in GHGs when there is biofuel substitution (European Commission [EC], 2006):

- Bioethanol from sugar crops: Minus 11% to Plus 75%
- Bioethanol from grain: Minus 6% to Plus 75%
- Biodiesel from rapeseed: Plus 16% to Plus 74%

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<sup>14</sup> These sharp increases in prices will be mitigated if crop yields increase substantially, or if biofuel production becomes based on other raw materials, such as trees and grasses. While there is little sign that the latter is imminent, the improvements in yields are noticeable. The average yield of maize in US has increased about 2 percent a year over the last 15 years, and the USDA (United States Department of Agriculture) projects a further improvement of 10 percent over the next 10 years for maize and 5 percent for soy. In Brazil's Sao Paulo region, sugarcane yields increased by 33 percent between 1975 and 2000. At the same time the efficiency of conversion from feedstock to biofuel have also been increasing – at about one percent a year for ethanol, and about 0.3 percent for biodiesel.

In the last year or so, Life Cycle Assessments (LCAs) have also been carried out for some feedstocks commonly grown in developing countries (other than sugar cane). In agreement with previous LCA reviewers, Larson (2006) found a wide range of values for GHG emissions, depending on whether:

- i. Land had to be cleared for the crop.
- ii. Indirect emissions had been accounted for (NO<sub>x</sub>, CO and non-methane organic compounds impact on ozone levels, which directly affects climate).
- iii. GHG emissions of N<sub>2</sub>O, which evolve from fertilizer application, have been account for.
- iv. Account had been taken of the extent of soil carbon build-up associated with growing biomass (e.g. if previously heavily tilled land is converted to an energy crop with lower tillage requirements, the soil carbon impacts are increased).

In view of all these factors, a strong plea has been made for standardization in the estimation of emissions from different biofuels and some work is ongoing in the UK.<sup>15</sup>

Apart from sugar cane, the other crop predominantly grown in developing countries that has been analyzed in detail is palm oil. Using the LCA methodology, McCormack (2007) found biodiesel from palm to generate 0.018 Kg CO<sub>2eq</sub> /MJ if there was no land conversion involved, and 0.143 Kg CO<sub>2eq</sub> /MJ if there was. By contrast conventional low sulfur fuel generates 0.091 Kg CO<sub>2eq</sub> /MJ—more than palm oil without land clearance, but less than palm oil with land clearance. On the other hand, palm oil (even without land clearance) is more carbon intensive than rapeseed, which is the commonest source of biodiesel in Europe and which generates 0.041 Kg CO<sub>2eq</sub> /MJ.

From the studies that have been conducted, one can therefore conclude that biofuels can generate some carbon saving, but that this is not guaranteed. The savings are greater if:

- i. The process of conversion uses the biofuel itself, or another renewable energy source instead of fossil fuel energy.
- ii. As well as biofuel, by-products such as glycerin (from biodiesel production), lignin (from bioethanol production) and animal feed (from both processes), are produced. Studies differ in the way they attribute the GHGs from the production processes between the biofuel and by-products. The more GHGs are allocated to the by-products the greater the savings that can be attributed to the biofuel.
- iii. The biofuel is used close to where it is produced; as its transport causes significant GHG emissions (biofuels cannot be piped).

Given the fact that GHGs are generated in processing the biofuels, and that the costs of production of biofuels are high anyway, the resulting costs per ton of CO<sub>2</sub> equivalent reduced by switching to biofuels is high—at around €40 to €100 (US\$48-US\$120) per ton of CO<sub>2</sub> avoided.<sup>16</sup> Since there are many options for reducing GHGs at a lower cost,<sup>17</sup> these

<sup>15</sup> <http://www.lowcvp.org.uk/assets/reports/carbon%20methodology%20and%20tool%20-%20final.pdf>.

<sup>16</sup> Some studies find even higher costs per ton of Carbon Dioxide (CO<sub>2</sub>) avoided. Wolf (2007) cites a range from US\$150 to US\$1000.

<sup>17</sup> The most recent IPCC (International Panel on Climate Change) Report estimates, based on bottom up studies, that between 16 and 31 gigatons of carbon could be removed at an economically acceptable cost in 2030. Of this 5-7 gigatons can be removed at a cost of less than US\$5/ton, 9-17 gigatons at a cost of less than US\$20/ton, 13-26 gigatons at a cost of less than US\$50/ton. The rest (3-5 gigatons) have a cost of between US\$50 and US\$100/ton (IPCC IV, 2007). Options at below US\$50/ton include: demand side management; improved efficiency in fossil fuel generation; efficient lighting, electric appliances and heating and cooling devices in buildings; more fuel efficient vehicles; heat and power recovery; and more efficient end-use equipment in industry; reforestation and afforestation; and landfill methane recovery.

figures have the important implication that as a GHG-reducing measure, a switch to biofuels is unlikely to be economic, at least in the short run. There must be benefits such as energy security, savings on foreign exchange by reducing imports, employment generation etc. to justify adopting biofuels as part of an economically efficient solution.

The other environmental impacts of the switch arise from the effects of: (i) feedstock cultivation and (ii) reduced emissions of pollutants harmful to health.

### **Biofuel Feedstock Cultivation and its Environmental Impacts**

The cultivation of feedstock has raised a number of concerns. As growing crops for biofuels becomes financially attractive, more land is taken into production, resulting in deforestation, erosion and unsustainable use of marginal land. In Brazil, for example, agricultural expansion is proceeding rapidly and causing deforestation in the Amazon Basin. Although that is not where sugar, which is the source of their bioethanol, is grown, one could argue that sugar cultivation is increasing the demand for agricultural land. Indeed, one of the products grown in the Amazon Basin (soybean) could be potentially used for biodiesel production. In South East Asia large tracts of forestland are being cleared to plant oil palms destined for conversion to biodiesel (Runge, 2007).

In Europe, studies of the environmental effects of biofuels note the following negative effects of feedstock cultivation: (i) loss of biodiversity as more set aside land is brought into production, (ii) increased demand for water as fast growing species are brought into production, (iii) increased use of pesticides; to the extent that farmers take less care to keep use to a strict minimum if residue testing is not carried out as it is for food crops, (iv) increased application of fertilizer causing runoff and associated problems of non-point pollution. On the positive side they note: (i) energy crops can allow a greater choice of crops to be grown with, for example, a possible shift of land under sugar beet production to land for cereals, which carry less risk of erosion and less input of chemicals, (ii) in certain regions energy crops may contribute to maintaining agricultural land in production, which may help prevent floods and landslides.

The most serious problems arising from feedstock cultivation is undoubtedly clearance of forest in developing countries. Where it happens, this is a serious repercussion of a switch to biofuels, and indeed such deforestation would negate many of the possible benefits from the switch away from fossil fuels. The main way to avoid such shifts is to implement "biofuel certification" (as for sustainable forest certification); so that developed countries only source such fuels from locations where sustainable agricultural practices have been followed.

Today, there are no green labels specifically tailored to biofuels and assessment of their whole value chain, as the only type of certificate that exists is a guarantee of a certain percentage of biofuel content in gasoline or diesel (EU: Sustainable biofuels program; White Paper 2006). However, there are plenty of activities going on in the context of Life Cycle Assessment (LCA) of biofuel. We can mention, for instance, the completed EU-study by the Joint Research Center (<http://ies.jrc.cec.eu.int/wtw.html>) as well as the ongoing Swiss Federal Office of Energy (SOFE) project (<http://www.esu-services.ch/bioenergy.htm>).

### **Local Air and Water Pollution Impacts of a Switch to Biofuels**

In terms of local air pollution and related effects, the picture is a mixed one, though generally favoring biofuels. Table 2 summarizes the findings of studies carried out by the United States Environmental Protection Agency (USEPA). It reports changes in emissions for a 85 percent ethanol blend, a 20 and 50 percent biodiesel blend, and a second generation biodiesel technology (the Fisher-Tropsch process) that comprises gasification of biomass feedstocks, cleaning and conditioning of the produced synthesis gas, and subsequent synthesis to liquid (or gaseous) biofuels. They show reductions in CO and PM in all cases,

reductions in sulfates, VOCs and NO<sub>x</sub> with bioethanol and biodiesel, and lower NO<sub>x</sub> emissions with bioethanol but higher emissions with biodiesel.

The authors also warn that particular difficulty could arise with respect to emissions of volatile organic compounds from ethanol blends in countries where there are no limits on vapor pressure.

Finally, we should note other studies that have shown that biodiesel and ethanol blends have significant impacts in terms of acidification and eutrophication of water (Lanzini, 2007).

**Table 2: Typical Biofuel Emissions Compared to Standard Fuels**

<b>Bioethanol (E85)</b>	<b>Biodiesel (B20 and B100)</b>	<b>Biodiesel 2<sup>nd</sup> Generation</b>
<ul style="list-style-type: none"> <li>• 15% reduction in VOCs</li> <li>• 40% reduction in CO</li> <li>• 20% reductions in PM</li> <li>• 10% reduction in NO<sub>x</sub></li> <li>• 80% reduction in sulfates</li> <li>• Lower reactivity of hydrocarbon emissions</li> <li>• Higher ethanol and acetaldehyde emissions</li> </ul>	<ul style="list-style-type: none"> <li>• 10% (B20) and 50% (B100) reduction in CO</li> <li>• 15% (B20) and 70% (B100) reduction in PM</li> <li>• 10% (B20) and 40% (B100) reduction in hydrocarbons</li> <li>• 20% (B20) and 100% (B100) reduction in sulfates</li> <li>• 2% (B20) and 9% (B100) increase in NO<sub>x</sub></li> <li>• No change in methane emissions with other blend.</li> </ul>	<p>Nitrogen oxide reductions Little or no particulate emissions Expected reductions in hydrocarbon and CO emissions.</p>

Source: Dufey, (2006)

Actual experience of a shift to ethanol is provided by data from Brazil, where around 20 percent of gasoline has been replaced by ethanol. Over the same period, ambient lead concentrations in the Sao Paulo Metropolitan Region has dropped from 1.4 g/M<sup>3</sup> in 1978 to less than 0.1 g/M<sup>3</sup> in 1991. In addition, carbon monoxide emissions fell from over 50 g/km to less than 5.8 g/km in 1995 (EU, 2006).

In summary, one can conclude that, based on most evidence, biofuels are beneficial in terms of CO and PM and ambient lead (where it has not been phased out in gasoline by law). On the other hand, acidification and eutrophication effects are greater and the outcomes in terms of other pollutants are not clear.

### **III. ORGANIC AGRICULTURE (OA) AND BIOFUELS IN CAMBODIA**

#### **III.1 Organic Agriculture in Cambodia**

The development of organic agriculture in Cambodia is in its early stages. The main focus is on rice, for which a national export strategy has been drawn up. The aim is “to develop the organic rice sector to further enhance economic growth in Cambodia as a whole, to generate employment opportunities for the landless and to reduce poverty among the rural population and improve well-being of farmers” (Ministry of Commerce, Government of Cambodia, 2006, p. 51). Until recently there were no national statistics on the extent of current organic production, or on the targeted levels for the next few years, although a very ambitious statement was made to the author during the mission in January 2007, to the effect that all rice production in Cambodia should become organic in 15 years.<sup>18</sup> Just recently, however,

<sup>18</sup> Pen Vuth, Director, Department of Agronomy and Agricultural Land Improvement, Phnom Penh.

an estimate has been made by the Cambodian Center for Agricultural Studies and Development (CEDAC) that 5,400 ha. of paddy are organic (only 0.02 percent of the total paddy) and only around 5,000 of the 1.8 million rice farmers practice organic farming.<sup>19</sup> It is also interesting to note that, recognizing the negative consequences of inappropriate use of agro-chemicals— particularly by poor farmers—the advertising of chemical fertilizers and pesticides by media has recently been made illegal in Cambodia.

In the absence of any national data, this analysis is based on information from the largest organic rice production program in Cambodia—that of CEDAC, which has been promoting a System of Rice Intensification (SRI).<sup>20</sup> SRI, brought to Cambodia with the donor support of Deutsche Gesellschaft für Technische Zusammenarbeit (German Institute for Technical Cooperation, or GTZ), is a method of practicing OA where some flexibility in the adoption of organic methods is allowed. It encourages the use of organic inputs, as well as promoting changes in the method of planting seedlings (fewer and younger seeds are planted in unflooded nurseries, instead of flooded ones. This implies less use of water—an important factor in Cambodia and the Lao PDR, where most agriculture is rain fed<sup>21</sup>) and other rice cultivation practices. In addition, farmers are encouraged to adopt good agricultural practices in the cultivation of vegetables and chickens. The system is based on trust and has no certification, so it would not qualify as organic according to standards laid out by international organizations such as IFOAM. But it represents a move towards low external inputs and advocates what would widely be regarded as good agricultural practices or GAP.<sup>22</sup> At present about 60,000 farmers in 15 of Cambodia's 20 provinces are engaged in the SRI program and production and numbers have been growing rapidly; rice output under the program has gone up from 20 tons in 2005 to 420 tons in 2006. About 30 percent of these farmers could be described as fully organic, while the rest have adopted a lower external input agriculture, with no or very little application of pesticides.

An evaluation of the program was undertaken by GTZ in 2004, comparing SRI farmers with control groups in five provinces (Kandal, Kampong Thom, Kampot, Takeo and Prey Vang).<sup>23</sup>

The main findings were:

- i. Adoption of SRI practices is not complete among SRI farmers, but is fairly substantial – the age of seedlings has dropped 67 percent and rates of planting by 67 percent.
- ii. Yields recorded for SRI farmers were 660 kg/ha. higher compared to control groups; an increase of 41 percent—from 1629 kg/ha. to 2289 kg/ha. This was achieved under a wide range of different agro-ecological environments, individual management practices, and varieties. The increase was seen across all five provinces and throughout the four years for which data was obtained, although the increases were greater where underlying endowments were better.

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<sup>19</sup> Presentation by Keam Makarady, Program Officer, Cambodian Center for Agricultural Studies and Development (CEDAC) to the Regional Conference on Organic Agriculture in Asia, 12-15 December, Bangkok, Thailand.

<sup>20</sup> There is also a contract farming program for rice under which a company (AKR) provides seeds in credit and agrees to buy the output at a minimum price. It covers about 1000 households but is not an organic program.

<sup>21</sup> <http://www.sciencedaily.com/releases/2007/10/071014202450.htm>

<sup>22</sup> Good agriculture practices in this study refers to production practices where appropriate use of agrochemicals is ensured i.e. using pesticides only when necessary and allow for sufficient grace period before harvesting. Good Agriculture Practice (GAP) in this study does not refer to a specific set of standards or certification used in international trade i.e. EUREPGAP, Japan GAP, or any other GAP.

<sup>23</sup> J. Anthofer et al. Evaluation of the System of Rice Intensification in Cambodia. Available: <http://ciifad.cornell.edu/sri/>

- iii. A risk analysis found that with SRI methods farmers' chances of getting a lower yield after changing from conventional practices was only 15 percent, while the chances of getting an increase were many times greater.
- iv. While SRI is more labor intensive in the earlier years when farmers are learning how to use the practices, in the longer term there was no consistent effect. Many farmers mentioned the additional labor requirement caused by the increased weeding operations, but at the same time several farmers expressed their appreciation about the overall labor saving effect during uprooting and transplanting. A quantification of the overall labor demand showed SRI to be more or less labor neutral with respect to family labor. However, it reduced the need for hired labor by a fairly small amount, although the effect was statistically significant.
- v. There was a clear advantage of SRI over conventional practices when gross profits/ha. were calculated. These went from US\$120/ha. with conventional methods to US\$209/ha. with SRI—an increase of US\$89, or 74 percent. This was composed of a US\$23/ha. saving in variable costs, like seeds and mineral fertilizer, and an increase in the income from higher yields of US\$66/ha.

The analysis concluded that if just 10 percent of Cambodian rice farmers would convert just 42 percent of their rice area to SRI, the economic benefit to the nation would be \$36 million, more than enough to justify an extensive program of training for SRI within the agricultural extension system. Moreover this conclusion is well supported by the data and analysis from other recent evaluations of SRI.<sup>24</sup>

Another study conducted by CEDAC itself was even more optimistic of the benefits of SRI. They found an increase in yields of 105 percent, increases in gross household incomes of 89 percent, and an increase in gross margins of more than 100 percent.<sup>25</sup>

Based on these results it is possible to estimate the potential benefits of a wider shift to “more organic” rice production in Cambodia. For this purpose, the following assumptions have been made:

- i. An extended program would provide SRI extension services to 20 percent of the wet season rice farmers in the country.
- ii. The program would tackle poor and non-poor farmers in proportion to their numbers in the communities in which it is carried out—i.e. there is no special targeting to better off farmers or worse off farmers.
- iii. In the case of poor farmers, around 19 percent are landless (World Bank, 2006). Since they do not own or rent land, the SRI program would not affect their income.
- iv. Incomes from rice cultivation would increase by 75 percent as a result of the program.
- v. Shares of income from wet season rice cultivation are as given in Table 3.

The table provides estimates of the increase in incomes in each of the five regions: Tonle Sap, Coastal, Mountain/Plateau, Plains and Phnom Penh as well as estimates of the number of households (HH) which will move out of poverty as a result of the project.<sup>26</sup>

<sup>24</sup> See, for example, Namara, Weligamage and Barker. 200X. *An evaluation of SRI in Sri Lanka*. The International Water Management Institute (IWMI). Research Report No.75.

<sup>25</sup> Mimeo. Provided by Dr. Yang Saing Koma, president, CEDAC, Phnom Penh.

<sup>26</sup> Tonle Sap consists of the provinces of Banteay Meanchey, Battambang, Kompong Thom, Siem Reap, and Kompong Chhnang/Pursat, The Coastal zone is made up of Kamot, Sihanoukville, Kep and Koh Kong provinces. The Mountain/Plateau region consists of Kompong Speu, Kratie, Mondul Kiri, Preah Vihear, Ratanak Kiri, Stung Treng, Oddar Meanchey and Pailin provinces. Finally the Plains region is made up of Kompong Cham, Kandal, Prey Veng, Svay Rieng and Takeo provinces.

**Table 3: Impacts of an Expansion of the System of Rice Intensification Program (SRI) by 20%**

Region	% of Income of Rural Households from Wet Season Rice	% Increase in Total Income	No. of Households Taken Out of Poverty By the Program
Tonle Sap	91.7	68.8	12,346
Coastal	98.3	73.7	1,538
Mountain/Plateau	0.9	0.7	196
Plains	51.8	38.8	7,201
Phnom Penh	99.7	74.8	35
Total	-	-	21,317

Source: Authors' Calculations. The method for the poverty reduction calculation is explained in Annex 2.

There are around 1.5 million rural households engaged in wet season rice production in Cambodia, so a 20 percent targeting of this group would involve 300,000 households. This is a feasible program, based on discussions with CEDAC, which claims the present program already covers 60,000 farmers in 1,700 villages.<sup>27</sup> Such a program would increase incomes of rural households by around 68 percent in Tonle Sap, 74 percent in the Coastal Regions and Phnom Penh (there are a few rural households in the capital city region), and 39 percent in the plains. The benefits are however negligible in the Mountain/Plateau region, because very little household income derives from rice cultivation there.

The impacts of the program on poverty reduction are also notable. The World Bank (2006) study defined rural households as being in poverty if they had access to less than 1753 riels per adult, per day in 2004 prices (US\$0.44 at the exchange rate of the time). Based on that, and on the distribution of poverty in the different regions, we have estimated the number poor households at around 690,000. An SRI program targeting 20 percent of the poor households would take about 21,300 out of poverty—i.e. reduce the rural poverty rate by about 3.3 percent.<sup>28</sup>

Details are not available, but the costs of such a program are likely to be modest. Based on similar programs in the Lao PDR we estimate the costs at around US\$150 million or about \$7.50 per family taken out of poverty.<sup>29</sup> In addition some support may be needed in the first two years of the program, when yields can decline and the benefits not be fully realized, although the GTZ and other surveys do not indicate this to be the case in the data they have collected. This is probably explained by the fact that yield decline is common where the areas being converted was previously farmed with high levels of agrochemicals. In Cambodia, where most land is under rain fed conditions using low levels of chemicals, introduction of OA should not cause declining yields.

The program would provide considerable benefits in addition to those already identified:

<sup>27</sup> CEDAC also plans a National Agricultural Program, which aims at enabling 4,000 farmers to go fully organic within three years. The program would increase total organic rice production from around 5,400 ha. to 9,400 ha., with additional organic output up by 2,000 tons in 2008/2009. This report has not estimated the benefits of this fully organic production program separately, although they are likely to be small relative to the benefits of bringing 240,000 households into SRI as estimated here.

<sup>28</sup> The number is relatively small partly because a number of poor households are landless and partly because of the depth of poverty. The increase in incomes can take some of them above the poverty line but by no means all. Furthermore we should note that the above assume an indiscriminate selection of households across all regions. A more targeted selection of poor households in rice growing areas would achieve a greater reduction in poverty.

<sup>29</sup> This is based on Lao data indicating a cost of around \$580 per household for a small program. Allowing for economies of scale we have taken a cost of \$500 per household. Unfortunately no data was available on the costs of the CEDAC program.

- i. **Food Security.** The program would increase food security considerably for those who adopted SRI. As noted, with SRI methods the farmers' risk of getting a lower yield after changing from conventional practices, are much smaller than the probability of getting a higher yield. Another indicator calculated by the GTZ study found the probability of *not achieving* a gross margin of \$100/ha. was 42 percent with conventional practice, but only 17 percent with SRI. The same study also looked at how many months out of each year the household was able to meet its rice and other food needs. Even with SRI being practiced on only a portion of farmers' total rice area, the proportion of farmers facing rice insecurity declined from 34 percent to 28 percent, while the proportion able to produce a surplus had increased from 20 percent to 33 percent. First-time farmers were using SRI on 21 percent of their total farm area, while those with more experience applied the new methods on 42 percent of their area.
- ii. **Access to Organic Markets.** The above estimates of income increases for SRI farmers depend only a little on higher prices for the products sold. Much of the production is for self-consumption and, according to CEDAC, the small amount that is sold in the market in Phnom Penh attracts a price premium of about 15 percent over conventional rice. The benefits of a program of certification and sale of organic rice to export markets therefore have still to be realized. Evidence from other organic sales in Thailand and the PRC indicate price premia of 10-40 percent for rice. In that case, if the lower end of the range prevails, a targeting of organic markets would not provide much more of a premium than can be obtained in the local market. Furthermore it would entail certification costs, which, in the case of Thailand amount to around US\$12/ha. This would eat into the additional gross profits from organic rice, which are currently at least US\$89/ha. according to the GTZ survey. One of the benefits of seeking certification, however, would be a greater market for the production; if production was expanded without certification one would be more or less restricted to the home market which probably cannot absorb such an increase. With certification exports are opened up, thus expanding the market. The switch to certified organic OA would thus also generate more foreign exchange for the country. Indeed, Cambodia is now self sufficient in rice and exports are a major government strategy. For example, if 20 percent of the current production of 6 million tons could be exported as GAP rice, at a price of \$150/ton (in 2004 Cambodian farmers were smuggling paddy rice across the border and receiving US\$135/ton), it would generate export earnings of US\$180 million, which would be an 8 percent increase in exports relative to 2003 levels.
- iii. **Other Benefits.** Although these have not been documented in the case of the SRI program, other studies in the region have found benefits to farmers of a shift to OA in the form of better health effects (less cases of pesticide poisoning, and a better diet as a result of higher output and incomes), more involvement of women on OA farms and higher incomes for the households (Setboonsarng and Markandya, 2007). They also found environmental benefits from the lower applications of pesticides and other external inputs.

### III.2 Biofuels in Cambodia

At present biofuel production in Cambodia is in its infancy. Possible feedstocks are cassava, soy, maize, sugar cane and jatropha. Cassava production in 2005-6 was 536,000 tons, grown mainly in Kampong Cham province. Soya is grown mainly in Battambang in the Tonle Sap region and in Kampong Cham in the Plains region of Cambodia. Production there in 2005-6 was 179,000 tons, much of which was exported. Maize is grown especially in Battambang in Tonle Sap and Pailin in the Mountain region. Output in 2005-6 was 248,000 tons. Sugar cane is grown mainly in Kampong Cham and Kampong Thom provinces, with

total output at 118,000 tons. All these outputs are of course dwarfed by the output of rice, which amounted to nearly 6 million tons.

### **Jatropha**

No data is available for jatropha production, and a survey to establish the baseline potential is urgently needed.

There have been three reviews of the potential for bioenergy in the country (De Lopez, 2003; Williamson, 2006; and Biodiesel Cambodia, 2007). All find a significant potential: Lopez focuses on biomass, especially agricultural residues from the production of sugar cane, maize and rice. As this report is not investigating biomass production these sources are not covered.

Williamson notes the potential for straight vegetable oils (SVO) from jatropha and most of his study lays out the commercial potential for this fuel. Unfortunately he does not provide an estimate of the potential output that is possible in the country, or the likely impacts on the livelihoods of Cambodian farmers.

The most optimistic assessment for jatropha is made by Biodiesel Cambodia (2007). It reports several private sector initiatives that include:

- A 20,000 ha. plantation of jatropha curcas planned by a multinational company called Pan Asia with a biodiesel refinery.
- 2000 ha. of jatropha nurseries that will be ready to plant in 2008.
- 3 local enterprises are in the preliminary planning stages of a total of 1000 ha. of land.
- Canadia Bank, the largest local Bank in Cambodia will be planting 3000 ha in Kompong Speu province next year.

None of these are as yet operational, but the interest is clear and Biodiesel Cambodia report new inquiries every week. The only operations that have actually taken place so far are: (i) a 10 ha. plantation in Kandal province and a 30 ha. plantation in Kompong Som province by Canadia Bank; (ii) a 10 ha. plantation by Biodiesel Cambodia for training purposes and for piloting techniques for pruning and fertilization and (iii) about 500 ha. of jatropha managed by 4 private local companies.

### **Cassava**

The other major development in Cambodia is a private sector initiative to produce ethanol. A Korean company (M-H Bio-Energy Group) has set up a facility 15 km from Phnom Penh with a production capacity of 40,000 kilo liters a year from 85,000 tons of tapioca chips. It aims to procure 300,000 tons of chips by 2010. This would amount to about 20 percent more than the total cassava production in 2005-6, which was 536,000 tons of fresh roots (about 45 percent of chips by weight are obtained from the roots). The fact that there is private sector investment, means that it is a financially viable option. In this study, however, we review it from a societal perspective.

In this section, we look at the potential of two sources of biofuel: jatropha and cassava. The aim is to see what impacts the growth in use of biofuels, at realistic levels, would have on the incomes of farmers and on the national economy.

### **Jatropha for Biofuel in Cambodia**

As Williamson and others have noted, there is considerable potential to grow jatropha in Cambodia, where it is a commonly found species that has no other commercial value. It is a drought resistant perennial which grows on marginal soil and lives for up to 50 years. The nut produces oil that has similar energy content to diesel oil and can be substituted directly in most types of diesel engine. The seed cake residue, left after expelling the seeds, can be used as a high-grade fertilizer. The plant also prevents soil erosion from wind and water and is used as a natural fence or hedge because animals do not eat it.

A major program for jatropha has been instituted in India, where the aim is to achieve an output of two million tons of diesel, from around 11 million hectares of land. There is considerable interest in the program from the private sector, which will need to invest around US\$6 billion to achieve this target. The PRC also has a major program, with wasteland in the three South Western Provinces (Guizhou, Sichuan, and Yunnan) being used for production. The aim is to produce 50,000 tons of biodiesel by 2010 and 7 million by 2020.<sup>30</sup>

In Cambodia we have noted several efforts under way to plant jatropha, some on a very large scale. The institutional arrangements fall into two broad structures:

- i. The private sector refiners agree contracts with smallholders and assist them by clearing land, providing the seed etc. These smallholders may be independent farmers already owning land, or land may be given to them by the state on condition they grow jatropha.<sup>31</sup> This is referred to as the “2+3” model, where the farmer provides the land and labor, and the contractor provides capital, materials and technical know-how.
- ii. The private sector acquires the land outright or on a lease from the state, and hires rural workers to farm it. This model is referred to as “1+4,” where the farmer only supplies the labor.

Both models have been adopted in the biofuel sector. One trade-off appears to be that the “2+3” model ensures a greater share of benefits to the poor, while the “1+4” model can produce greater output. In fact, concessions on land under the second option have run into a number of problems. A World Wide Fund for Nature (WWF) report (WWF, 2007) notes that concessions have been issued in Cambodia for thousands of hectares of pulp, rubber, sugar, cassava and palm oil plantations. It identifies a number of major legal and administrative failings in the current concessions process. Above all, there is a lack of clarity and transparency in the way concessions are awarded; without environmental and social impact studies or consultation with local people.

There are a number of factors that are responsible for these problems. They include; a recent trend towards decentralization (which has given provincial authorities significant autonomy and greater financial incentives to offer concessions and sign contracts directly with foreign investors<sup>32</sup>), an unclear division of responsibilities between national and provincial authorities, a lack of adequate land-use planning at a landscape level, a disregard for the results of land-use planning processes at the local level, the absence of formal review

<sup>30</sup> For details see <http://www.nedo.go.jp/kokusai/kouhou/190201/2-6b.pdf>

<sup>31</sup> An example is the Thai Agriculture Land Reform Office (ALRO) which has allocated land to poor households on condition they grow jatropha and sell the output to a given firm (Biodiesel Cambodia).

<sup>32</sup> Dupar, M. and N. Badenoch. 2002. *Environment, Livelihoods and Local Institutions: Decentralization in Mainland Southeast Asia*. World Resources Institute.

processes for large-scale concessions (or their ineffective implementation), and a lack of cooperation between agencies with overlapping responsibilities.<sup>33</sup>

The proliferation of industrial plantations is also creating a number of environmental and social problems. On the environmental front these include: increased threats to already-under-funded protected areas due to direct encroachment and the displacement of lowland farming communities by plantations; the fragmentation of ecologically important areas that lack formal protection; greater risks to connective corridors between protected and unprotected areas—which provide valuable habitat for wildlife species; and potential risks for watersheds and river systems.

In terms of social issues, there has already been a significant increase in conflicts between concessionaires and local communities over land and natural resources.<sup>34</sup> Another problem is the tendency towards policies that favor large-scale export agriculture (including industrial tree crops) over high-value smallholder crops, NTFPs, and other more sustainable options for rural development. Indeed, the broader goal of poverty reduction through rural development, promoted by both governments, may be undercut by the resultant surge in land conflict and the scramble for natural resources.

There is a growing perception that both countries are trading off some of their ecological assets (forests, minerals, water) in return for supposed benefits in terms of poverty reduction. Yet given the negative impacts of plantations on rural communities, which also depend on access to land and natural resources (as well as their mostly foreign ownership and external value chains), it is not clear whether a plantation strategy will help to alleviate poverty in rural areas. According to WWF it may further worsen poverty.

Even private sector operators (such as Biodiesel Cambodia) recognize the problems with concessions, citing land speculation and logging as important motives for buying concessions on the part of the private sector.

In view of this we would not recommend the present concession system as the way forward with biofuels. Nevertheless, even with contract farming there can be differences between a more “hands-on” approach—where the contractor specifies the methods to be used in great detail, purchases all of the output from the farmer who only produces jatropha and, in practice, treats the farmer as a worker—and a more “arms-length” approach—where the contractor or the government provide some guidance, materials, and even some credit, but the farmer continues to undertake other activities. The latter may entail lower productivity, but it represents a case of greater freedom for the farmer, and possibly less risk than going for a mono-cropping strategy.

In the section below we look at the possible benefits from the two approaches with jatropha production and expand on the scale indicated by the Biodiesel (2007) presentation. The following assumptions are made:

- i. The target allocations of land to jatropha will start from 10,000 ha. in 2008 and go to 20,000 ha. in 2009, and 40,000 ha. in 2010. Following the analysis in Williamson (2006), 56 percent of the land will belong to private farmers, and 44 percent to concessions or arrangements that mimic closely concession operations.

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<sup>33</sup> Schumann, G. et al, 2006, Study on State Land Leases and Concessions in Lao PDR. *Land Policy Study No. 4*. Lao- German Land Policy Development Project.

<sup>34</sup> Meixner, S. 2007. Land concessions leave thousands destitute in Cambodia's heartland. *Cambodia Daily*. 20 May.

- ii. Yields on private farmers' land are around 73 percent of those achieved from larger concessions (Williamson, 2006). The actual yields may vary: from as low as 1,248 liters per ha. to as high as 3,260 liters per ha. The higher figure is taken from Briones (2006), and is based on Indian data. On the other hand, experts in Thailand have indicated that the lower figure may apply, at least initially, in that country.
- iii. Costs and average yields are taken from a detailed study carried out for India and reported in Briones (2006). This takes the capital cost of a jatropha plant that processes 114,000 liters a year, as US\$34,000. Such a plant would be fed from an area of 35 ha. on average in the case of the high yield, with a correspondingly larger area if the land is owned by the farmers, and a smaller area if it is owned by a concessionaire. In the case of the lower yield, the investment would cover an area of around 80 ha. The investment cost in growing the trees is around US\$25,000, and the variable costs of harvesting and operating the plant are \$40,000. Time to profitability is 3-4 years.
- iv. In the case of smallholders, credit is provided to cover both the investment cost and loss of earnings for the period until the trees planted are profitable. The terms of the credit are 15 percent interest, 3 years grace and 15 years repayment. For the concessionaires, credit is from normal commercial channels at 12 percent over the same period.
- v. The output from the plant is sold as diesel at a price of US\$0.40 per liter, the current price in Cambodia. In addition, oil seed and glycerin, by-products from the processing, are sold at US\$0.013 per liter of diesel produced. The market price of diesel in Cambodia is US\$0.64 per liter, but this includes taxes. The price net of tax is around 40 cents a liter.
- vi. Farmers invest 15 percent of their land for jatropha. Furthermore the program targets smallholders with an average holding of 1.5 ha. (i.e. the average amount of land held by poor rural households).
- vii. Farmers share in any surplus from the sale of biodiesel and its by-products, in proportion to their capital investment.

The opportunity cost of participating in the program is the gross profit lost from conventional rice production, taken as US\$46/ha. This is equal to the average land rent in Cambodia and is probably a high-end estimate of the opportunity cost, as the land used for jatropha will have a lower rental value.

- viii. The percentage of poor farmers who engage in jatropha production are around 37 percent of the total number so engaged. This is based on projections of poverty from the World Bank Poverty survey (2006).

Table 4 provides some of the key indicators of the benefits and costs of the first stage of such a program (i.e. 10,000 ha.).

**Table 4: Impacts of Jatropha Biodiesel Program in Cambodia**

	Units	Smaller Holder Program	Concessionaire Program
Area	Ha.	5618	4382
Year of Planting	Year	2008	
Year of First Return	Year	2011	
Farmers' Investment	\$Mn.	6.0	-

No. of Farmers Engaged	No.	24,970	-
Investment per Farmer	\$	240	-
Investment in Processing & Planting	\$Mn.	5.35	8.24
Output of Biodiesel	Mn. L.	5.88 to 13.36	6.28 to 14.27
Value of Output (*)	\$Mn.	3.12 to 7.08	3.33 to 7.56
Net Gain to Farmers	\$Mn.	0.74 to 2.5	-
Gain per Farmer	\$	30 to 100	-
Cost of Production of Biodiesel	\$/L.	0.48 to 0.57	0.32 to 0.40
No. Employed in Processing	No.	231 to 524	180 to 408
No. Employed in Harvesting Etc.	No.	-	1,609 to 3,655
No. of HH Taken Out of Poverty	No.	6,470 to 7,910	-
No. of Workers Taken Out of Poverty	No.	81 to 194	1,409 to 1,513

Ha.= hectare(s), L.= liter (s), Mn.= million(s), No.= number,

(\*) Includes sale of oil seed and glycerin.

As the table shows, the results depend significantly on the yields obtained. In the case of the smallholder component the farmers would make a gain of US\$0.7 million with the bottom end of the yields but would make a gain of around \$2.5 million with the upper end of the yields. In the former case the number of households taken out of poverty is around 6,500 whereas in the latter case is about 7,900. The program also provides employment to between 230 and 520 persons in the processing of the oil. Of these, between 80 and 190 would be taken out of poverty. There is an investment to be made by the farmers if this route is followed, and it carries a risk; if, for example, the yield turns out to be at the lower end of the range. The amount involved, however, is fairly modest—around US\$240 per farmer.

The concession component has a higher output from a smaller area of land but does not generate as much in benefits to rural households. Between 1,400 and 1,500 rural working households are taken out of poverty as a result of the program. It does, however, create between 1,600 and 3,600 jobs. The macroeconomic benefits of the small program are also noteworthy; production of between 12 and 27 million liters (low and high yields respectively) would represent between 9 and 20 percent of official imports, but a significantly smaller percentage of actual consumption.<sup>35</sup>

If this program is replicated at a larger scale as indicated above, the benefits will increase in proportion. In 2012, for example, with another 20,000 ha. under jatropha, and in 2013 with another 40,000 ha., the total benefits will be as shown in Table 5. Up to 193 million liters of biodiesel can be produced, enough to meet a significant part of the country’s needs. At the same time 32,000 jobs will be created and around 60,000 rural households can be taken out of poverty. The costs of the program are fairly modest, rising from around US\$20 million in 2008-2011, to US\$87 million in 2010-2013. Some of this can be provided by the private sector, but part of it—especially providing micro-credit to small farmers—will need some public sector support.

**Table 5: Benefits of a Program to Produce Jatropha on 80,000 Hectares.**

	Units	2011	2012	2013
Biodiesel Production	Mn L.	12.1 to 27.6	36.3 to 82.9	84.7 193.2
Value of Output	\$Mn.	6.4 to 14.6	19.2 to 43.9	44.8 to 102.4
Jobs Created	No.	4,066 to 4,587	12,198 to 13,761	28,462 to 32,109
No. of Farmers and Rural Families Out of Poverty	No.	7,976 to 9,607	23,928 to 28,821	55,832 to 67,249

<sup>35</sup> Official import data for 2005 showed imports of around 130 million liters, but actual consumption was much higher. A long ago as 1995 estimated consumption was 149 million liters and it has certainly gone up significantly since then.

Annual Investment Required (*)	\$Mn.	14.9 to 20.2	29.8 to 40.4	66.4 to 90.1
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L= liter(s), Mn.= million(s), No.= number.

(\*) The planting component of the investment is required three years earlier.

Other issues related to the program worth noting are the following:

- i. **Carbon Credits.** The possible carbon credits for a program like this have to be worked out, but the likelihood is that some benefits can be derived from the replacement of diesel with jatropha. This will depend on the processing of the biodiesel, including how much of the produced jatropha oil is used at that stage. To date, however, no Clean Development Mechanism (CDM) project has credited carbon savings from biofuels, although there have been several where biomass has replaced fossil fuels. At the workshop on Biofuel Assessment in Cambodia in October 2007, it was reported that a price of US\$10 per ton of CO<sub>2</sub> in the CDM market would translate into a benefit to the producer of jatropha of around US¢4 to US¢5 per liter. This would make the economics of production significantly more attractive.
- ii. **Environmental Benefits.** These have been noted qualitatively but should be evaluated in a quantitative manner as well. Reduced erosion and better management of animals should also produce benefits to the farmers, which have not been included in the analysis.
- iii. **Risks.** The project has risk in the form of possible failure of the planting program because farmers cannot devote the time and effort required for its success. Another risk is that of a fall in the price of diesel, which would make the program uneconomic. At a price of around US¢40 per liter (before taxes), the smallholder program carries a full financial cost in the first year of around US¢48 per liter with the high yield, and a full financial cost of US¢56 at the lower yield. The concession program on the other hand has a financial cost of only US¢32 in the high yield case, and US¢40 in the low yield case; making it more viable. This makes the financing of the smallholder project problematic, although not impossible, if governments provide some support especially in the initial years, and if improvements in returns occur over time and prices increase in the future. If the price drops even a little however, programs such as these could be in difficulty. Given this relatively tight margin, a risk guarantee component for the project may be considered, which would provide compensatory support in the event of a fall in the price to one below a cut-off value. We would not favor a subsidy in the form of exemption from Value Added Tax (VAT), as proposed by the investors, although reduced tariffs on equipment and raw materials should be considered to make the programs more viable. Any carbon credit that can be obtained will also help make investments financially viable.
- iv. **Capacity Building and Research.** These are essential components of a program like this, as farmers and workers need to be instructed in the best methods of planting and management of the jatropha trees. There is also a need for capacity building on fulfilling certification requirements, as applicable to OA, biofuel and GAP. Finally, as many experts have noted, jatropha plantations have many local factors that determine their success. A lot of research is needed to find out the most suitable methods, seeds etc., for Cambodian conditions. Donor support on a significant scale will be needed for all these purposes.

#### Cassava for Bioethanol in Cambodia

The production of cassava in Cambodia was around 536,000 tons in 2005-06, representing an increase of 48 percent over the previous year. Yields average 17.8 tons/ha., which are comparable to, but slightly lower than those in Thailand (20.3 tons/ha. in 2004-05). It is

believed that Cambodian yields can be raised substantially. Thailand started with lower yields of around 14 tons/ha. in the late 80s, but achieved large increases through adopting new high-yielding and high-starch varieties. It is also worth noting that yields in the Mekong Region are much higher than the world average, which is about 11 tons/ha.

Until the start of this year cassava was a feed crop, with some small quantities exported. Data on returns per ha. are not available for cassava for Cambodia, but in Thailand the costs are an estimated US\$341.7/ha. for the average farmer. If the yield is 17.8 tons, and the root price is US\$21.6/ton,<sup>36</sup> the farmer can expect to get a gross income of US\$384.4/ha. and a net return of US\$42.7/ha., which is slightly below the average for all crops in Cambodia (US\$46.3) and well below that of rice (around US\$100/ha.). Consequently one would expect farmers to grow cassava on land that is not suited to rice or some of the other higher value crops. Fortunately it is suited to poor soil and water conditions, and hence can complement other activities.<sup>37</sup>

Currently a private sector initiative is seeking to develop ethanol production from cassava, partly by leasing land to grow the plant, and partly by buying from farmers. In this section we compare the benefits to the country, the farmers and workers, of the two methods of acquiring the feedstock. We also look at possible export benefits from the ethanol that would be produced and most of which will be exported.

The analysis investigates a program where production of cassava in the country is increased from around 535,000 tons fresh root in 2005, to nearly a million tons by 2011. This increase will be used to produce ethanol and some by-products, notably CO<sub>2</sub>. Production of the increased cassava is undertaken partly by smallholders and partly by concessions given to the companies producing the ethanol. One such concession has already been granted to the Bio-Energy Group, who will procure 175,000 tons of feedstock from army and other government land, yielding 80,000 cassava chips.

The assumptions of the analysis are as follows:

- i. Yields, which average 17.8 tons/ha will be increased by improved harvesting, application of fertilizer, and adoption of better varieties (Watananonata and Howeler, 2006). The estimate is that yields can be increased by about 5 percent to 22.8 T/ha by 2012.
- ii. The price of fresh roots, which is given as around US\$26/ton in 2006, will also increase as world demand for the feedstock grows. An IFPRI study (Rosegrant et al., 2006) predicts increases of about 33 percent by 2010, and further increases of between 20 and 100 percent by 2020. We take a more conservative estimate of increases of 33 percent to 2010, and 20 percent to 2020, and apply the increases linearly for intermediate years.
- iii. The costs of production are taken from Watananonata and Howeler (2005), and adjusted for inflation. After 2006, further increases are at 8 percent in nominal terms

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<sup>36</sup> Data are from Watananonata and Howeler, 2005. In fact the price of cassava has risen since then, making the crop more attractive.

<sup>37</sup> An issue that has been raised with cassava is its contribution to soil erosion especially in upland areas. Some of this soil moves to lower spots as well as lowlands and delta areas, benefiting them. But there are also negative effects, including loss of fertility in the upland areas where cassava is grown, as well as deposition of eroded sediments in irrigation systems, reservoirs and harbors. The Food and Agricultural Organisation (FAO) reports that while it is known that cassava has such effects, the magnitude cannot be estimated from the sediment loads of the main drainage basins. (<http://www.fao.org/docrep/007/y2413e/y2413e0a.htm>). Yield data for cassava in South East Asia, however, do not show any declining trend over the period 1983 to 2005 (Watananonata and Howeler, 2005).

for labor (which makes up about half the costs of production), and at 3 percent for other components. These increases refer to the US dollar costs of production.

- iv. The opportunity cost for land that is shifted to cassava from other uses is taken at US\$46/ha. This is increased at 8 percent in real terms, to reflect general growth in the economy.
- v. The impacts of the program on the poor are estimated based on the previous calculation of the number of poor rural households and assumed to affect about 37 percent of the total. This percentage is expected to decline 5 percent reflecting national poverty reduction programs. It is further assumed that the share of farmers who are poor in the program is the same as the national average. The estimates of the numbers brought out of poverty are calculated on the same basis as for the rice program (see Section III.I above).
- vi. Average holdings are taken as 1.5 ha., which is equal to the national average.
- vii. Concessional land is taken as 10,000 ha., which is roughly what the current private sector initiative plans to use.
- viii. Wages are set as US\$3.75/day, increasing at 8 percent per annum.

The resulting calculations are shown in Table 6. We note the following:

**Table 6: Effects of Cassava Ethanol Program on Incomes, Poverty Etc.**

	Units	2006	2008	2009	2010	2011
<b>Cassava Grown By Smallholders</b>						
Output	T (000)	536	647	758	869	980
Yield	T/ha.	17.9	18.8	19.7	20.7	21.7
Price of Fresh Root	US\$/T	26.0	30.3	32.4	34.6	35.1
Cost of Production	US\$/H	340.8	359.4	379.0	399.6	421.4
Opportunity Cost for New Farmers	US\$/Ha.	46.0	49.7	53.7	58.0	62.6
Increase in Income of Smallholders (*)	%	-	68.8	24.5	21.4	8.2
Net Income of Farmers	\$Mn.	3.7	7.0	9.5	12.6	14.5
No. of HH that are Poor	%	37	35	33	32	30
No. of HH Engaged in Production	No.	19983	22980	25645	28005	30082
No. of New HH Taking Up Cassava Production	No.		2996	2666	2360	2077
No. Taken Out of Poverty By Program	No.		3292	1467	1339	594
<b>Cassava Grown Under Concession</b>						
Output	T (000)	188	197	207	217	228
Yield	T/ha.	17.9	18.8	19.7	20.7	21.7
Area	Ha.	10000	10000	10000	10000	10000
Employment	No.	2080	2080	2080	2080	2080
Earnings	\$Mn.	-	2.9	3.1	3.3	3.6
<b>Production of Biofuels and By-products</b>						
Ethanol	Mn. L.	-	53.5	66.8	80.3	93.9
Value of Ethanol	US\$ Mn.		32.1	42.9	55.0	65.3
CO2	Mn. T		35.3	44.1	53.0	62.0
Value	US\$ Mn.		7.1	8.8	10.6	12.4

Ha.= hectare(s), HH= households, L= liter (s) Mn=million(s), No.= number, T=ton(s)

(\*) The increase in 2008 is with respect to 2006. For other years it is with respect to the previous year.

- i. The smallholder component of the program would increase net farmer income by nearly US\$10 million from 2006 to 2011. This would represent an increase in the household income of participating farmers of 69 percent in the first year, rising to 114 percent by 2011.
- ii. Such increases would reduce poverty in about 7,300 of the participating 30,000 households. Recall that only about one-third of the households are actually poor in the first place, so the program effectively reduces poverty in the group by 73 percent. Part of the benefits arise from the higher price for the cassava, part from the higher yield, and part from the increased local demand created by the ethanol program. Without the increase in yields, the number taken out of poverty is only about 3,000, so that component is very important. Without the additional demand from the ethanol program, the increase would be about 5,700, so the ethanol program itself only contributes to about 1,600 of the total reduction.
- iii. The concessionaire program is smaller, involving 10,000 ha. instead of 15,000 ha. under the stakeholder program. Its social impact, however, is proportionately even smaller. Employment is created for about 2100 persons, who would almost certainly be moved out of poverty as a result of this employment. Earnings generated go up from US\$7 million to US\$12 million, which is comparable to the additional net incomes of the smallholders.
- iv. The production of ethanol from the cassava would realise exports of US\$32 million in 2008, rising to US\$65 million by 2011. In addition, local sales of about US\$7-10 million are generated from the CO<sub>2</sub> produced.
- v. Other minor benefits include some employment created in the processing of the cassava chips to ethanol.

Issues that need to be addressed in such a program are the following:

- i. **Carbon Credits.** The possible carbon credits have to be worked out, but the likelihood is that some benefits can be derived from the replacement of gasoline by ethanol. This will depend on the processing of ethanol, as well as the efficiency of the processes used. An analysis of these possible benefits should be carried out.
- ii. **Risks.** The project has risk in the form of the possible failure of the program that is designed to increase yields. Amongst others, another risk is that of a fall in the price of gasoline, which would make the program uneconomic, but this is unlikely. At US\$60/liter, ethanol from this source is more expensive than from Brazilian sugarcane (ca. US\$21/liter), but less than from EU sugar beet (US\$77/liter). At current oil prices (ca.US\$90/barrel), one would not need a subsidy to ethanol for it to be competitive—but at a price of US\$28/barrel, a subsidy would be needed. Given the extensive program of subsidies being introduced in developed countries, cassava is likely to remain competitive as long as it has access to the Organisation for Economic Co-operation and Development (OECD) country markets.
- iii. **Capacity Building.** This is an essential component of a program like this, as farmers and workers need to be instructed in how to increase yields for cassava. A major program would be needed for this purpose and should be costed carefully.

## IV. ORGANIC AGRICULTURE (OA) AND BIOFUELS IN THE LAO PDR

### IV.1 Organic Agriculture in the Lao PDR

The level of certified organic production in the Lao PDR is very small, although in practice much of the agriculture is free of pesticide use and has low levels of external inputs in the form of inorganic fertilizers. There is also a strong policy commitment to “Clean Agriculture” through a differentiated regional approach. The policy is to promote certified organic agriculture in the Upland regions, to go for pesticide free production in the Mid-stream regions, and to target Good Agricultural Practices (GAP) and Integrated Pest Management (IPM) in the downstream or lowland regions.

In support of these goals a large number of Non-Government Organisations (NGOs) and donors are providing some assistance, much of which is small-scale and not particularly well coordinated (Helevetas, 2005). A review of the main stakeholders reveals significant differences in opinion on what is feasible and desirable in promoting OA or GAP, more generally.

The main commodity where OA can be developed is rice, although there is also some potential being realized for coffee and mulberry. For rice, the potential is for both white rice and sticky rice. Since the Lao PDR has the highest number of varieties of sticky rice in the world, this product has the potential to be marketed as unique products from the Lao PDR, a so called Geographical Indications (GI) product under WTO.

In this section we only look at rice, which is probably the one with the most potential.

The issues to be resolved in developing OA in the Lao PDR are basically to respond to the question: Can farmers improve net incomes if they go organic? This in turn will depend on what happens to yields, prices and the efficiency with which the products are marketed. Each is considered in turn below.

#### Impacts of OA on Yields

One the main areas of difference is over views about the impacts of low external input agriculture on yields. Some agents argue that yields can be increased with such a shift, as long as farmers are given training and supporting extension services. The Mennonite Central Committee, for example, which runs two programs in support of sustainable agriculture in Bolikhamxay, Pakngum and Xaythany, have helped the farmers find new sources of organic compost and, with better seeds, have increased yields of rice from 2 to 4 tons per hectare in the 4 villages where they are active. Likewise an Oxfam program promotes SRI, which has been discussed in greater detail for the Cambodian case. Their project sites are in Vientiane Province, Salavane and Xekong. One farmer using SRI reported a yield of 6 tons/ha., which may be exceptional, but is indicative of what can be achieved.

On the other hand a number of stakeholders have expressed doubts about the scope for increasing yields. The Lao Agro Processing Associations and the Champa Lao Company deal in the marketing of organic and other rice, including exports to Thailand and Vietnam. Yields for the wet season rice (which is the only one that can be grown organically) are only around 1.3 to 3 tons per hectare, which compares with 3.65 tons/ha. for unirrigated lowland rice, and 4.44 tons/ha. for irrigated conventional lowland rice. In the interviews carried out by Helevetas (2006), a farmer from Nakey village who farms 2 ha. of wet season rice with yields of 4.2 – 5tons/ha., (using 200 kg/ha) stated that turning organic would reduce yields to 3 tons/ha. The farmer does not have enough cow dung to raise the yields above 3 t/ha.. Making compost from weeds (e.g. *Chromolaena odorata*) is a possibility, but would require much more work. Other researchers note that there are other substitutes to cow dung. At the Thasano Research and Seed Production Center just North of Savannakhet, the director

recommends cowpea and mung bean as the most likely green manure species for local conditions. Other inputs for soil fertility management available within the Lao PDR include guano and rock phosphate.

Several experts have recommended a move to lower external inputs rather than a complete ban on inorganic fertilizer. This was the position taken by the National Rice Research Program (IRRI), who argued that some fertilizer is needed to maintain yields. Similarly the Director at the National Agriculture and Forestry Research Institute (NAFRI) notes that varieties suitable for organic production are unlikely to exceed 2-3 tons/ha. without some external inputs. In this context, it is useful also to look at rice yields in NE Thailand, where background conditions are similar, and where some farmers have adopted certified organic practices for rice. Setboonsarng, Leung and Cai (2006) cite data showing yields at around 2.4 tons/ha. for conventional farms and 2.6 tons/ha. for farms that have been certified as organic. So at least some evidence indicates that a move to OA can sustain yields.

Dr. Phouangparisack, Director General (DG) of the Directorate of Planning in the Ministry of Agriculture, Lao PDR, sees a relatively small role for OA. He sees more potential in conservation agriculture, which constrains the practice of tillage. The scope for such agriculture has been investigated in some detail by the Lao National Agro-Ecology Programme (PRONAE), in collaboration with Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) of France. The aim is to develop innovative systems that will reverse the present resource-mining practices used in southern Xayabury, and to develop alternatives systems for higher plains and remote areas like those in Xieng Khouang province. This holistic approach emphasizes the process of adaptation and validation by farmer groups, meaning that priorities are defined by smallholders in light of the constraints of their farming systems and the overall environmental conditions. Pilot schemes in the high plains have been successful with mixed farming dominated by livestock, producing income equivalent to a rice yield of 1.8 tons/ha., which is considered good for that region (Lienhard et al., 2007).

Expanding conservation agriculture of this kind is seen by the government of the Lao PDR as complementary to attempts to foster OA and GAP systems such as SRI. A demonstration project has been expanded to cover 1000 ha. in the Upland and Mid-stream regions. The method does use some fertilizer and pesticides, but in limited quantities and under controlled conditions. There is presently a market for the output of such farms in France, where buyers will accept products with slightly higher residues than OA certification would allow. Similar deals may be possible within the Association of Southeast Asian Nations (ASEAN).<sup>38</sup>

### **Impacts on Prices**

The common view is that OA rice can be sold at a premium in the markets of the developed countries and also perhaps in Thailand. A study by Helevatas (Roder, 2004) looked at the potential for the Swiss market. They concluded that organic rice attracts a premium there in the range of 10-150 percent, which is of course a very wide range. Moreover the amount of this premium that would go back to the farmer is unclear. That will depend on the costs of certification, and the margins of the agents involved at other stages of the delivery chain. If the experience from Thailand in 2003 is anything to go by, premiums for rice to certified organic farmers are likely to be in the region of 40 percent (Setboonsarng, Leung and Cai, 2006). More recent Thai studies however, have come up with lower premiums of around 10 percent, although this fall may be partly due to the government's rice subsidy program.

In the case of Cambodia, interviews with experts from CEDAC indicate that rice, which may not meet the full organic certification, can nevertheless be sold at a premium in domestic and

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<sup>38</sup> Dr. Phouangparisack, Director General (DG), Directorate of Planning in the Lao PDR, personal communication.

even international markets (Cambodian rice from the SRI program, for example, is exported in small quantities to France). The premium quoted is only around 10 percent. If this is correct, it has the important implication that, as far as the farmer is concerned, there will be benefit in going for the OA option as long as the premium is in the order of the 40 percent found in Thailand—even if yields are a little lower. If, however, yields are better maintained with GAP, and the price premium from OA is at the lower end of the range found in Thailand, the benefits of moving to GAP may be greater. This could be the case in some locations, particularly in lowland, irrigated rice ecosystems. On the other hand, for marginal upland farmers it may be appropriate to go for certified OA, in conjunction with continuing inputs support and help in obtaining certification. In both cases, as has been shown in a recent study for several Asian countries (including Cambodia and Lao PDR [Cai and Leung, 2007]), contract farming is likely to increase incomes.

### **Efficiency in Marketing**

It is essential for an OA strategy that a market be identified for the products, and that the farmers be an integral part of the product chain. Often this is achieved by contract farming, in which the ultimate buyer contracts the farmer to produce according to certain conditions, sometimes supplying the farmer with key inputs, and guarantees to take the output on agreed terms. In other cases, a farmer may not be contracted, but nevertheless needs support to market the products, and ensure their output is delivered to the next stage in the chain in a timely and efficient manner. At present the rice market in the country is poorly developed, with weak transportation and communication links. This results in prices that vary a lot from one region to another, with supplies from regions of surplus to ones of deficit not always being made as needed. Often farmers will travel long distances by tractor to sell their rice, thereby adding to their costs. This results in higher margins for the middlemen and lower prices for the farmers (Lao Consulting Group, 2004).

### **Promoting Organic Rice in the Lao PDR<sup>39</sup>**

In the Lao PDR, organic rice is being developed under the “ProRice Program,” referred to as PROFIL. The program is being carried out by Helevatas and the Department of Agriculture. The goal is to produce and market good quality organic rice produced in the marginal rain fed rice growing environments of the Lao PDR. It aims to do this by:

- Providing farmers with the rice varieties that are demanded in the market, and giving them the production technologies necessary for this purpose.
- Assisting farmers with the management of soil fertility under organic conditions.
- Organizing producers so they can have a voice in the marketing of the rice and in the terms of the certification.
- Establishing appropriate and responsible structures, so that the rice can be sold under credible labels in the national and international markets.

The project started in 2006 and will be completed by 2009. By the end it will involve 600 producers, producing 850 tons, of which 800 will be exported. Since the aim is to help farmers in the poorer areas, the project will have to pay considerable attention to the logistics of collecting the surplus production and transferring it to the relevant distribution points. Yet the budget for the projects is relatively modest – about US\$350,000 over the four years. If the project can achieve the goals set out, it should increase the incomes of the farmers considerably, although no estimate has been made of that increase.

<sup>39</sup> In this report we focus only on OA and GAP rice production. We have not looked at the economic potential for conservation agriculture in detail, due to lack of data. This does not mean, of course, that such a system cannot complement SRI or other rice growing systems.

Another project that is seeking to do something similar under the ProRice program is being implemented by the Government in 10 villages in Santhong district, close to the Thai border. It covers 958 families, who derive 70 percent of their income from lowland rice. The total area is 952.6 ha., of which 83 percent is lowland rice, and 8.5 percent upland rice. The program aims to improve yields within an organic context, to develop a better relationship between millers and farmers, and to promote the output under a local certification label. The cost of this component of the ProRice program is not known.

Given these initiatives, what is the potential for organic rice and how much can farmers hope to gain from it? This is difficult to answer given the limited data, but a rough estimate based on the two Missions to the Lao PDR and on the data provided, is given below.

First, we recognize that the Lao PDR is now at a stage where it can reasonably hope to export a significant amount of its rice production. Until a few years ago the Lao PDR was an importer of rice, but with increased productivity, the country now exports rice to Thailand, Vietnam and PRC. Since exports are largely unofficial, it is difficult to get an accurate measure of how much is being exported. One estimate says 100,000 tons per year go to Vietnam and more than 50,000 tons to Thailand. According to government officials in provinces bordering the PRC, there has been a big increase in the export of sticky rice there in recent years. In terms of self-sufficiency, the Lao PDR needs about 160 kg per person (Helevatas, 2005); making the minimum domestic requirement about 0.9 million tons. In 2005, paddy production was almost double that, and although some areas were ones of deficit and some of surplus, transfers were not always carried out effectively from the one to the other.

Given the partial information, one can conclude that an official export target of 250,000 tons by 2010 is not unreasonable. Of this, 25 percent could be organic and the rest GAP rice. With improved efficiency in marketing and distribution, farmers can expect a 10 percent premium on the current price rice in both cases. In addition one can expect some gains from the improved marketing and communication. We conservatively put those gains at 5 percent of the price, making the total premium 15 percent. If yields do not decline (and there is a reasonable expectation that, with support in the form of extension services the yields will not decline) we can estimate the increase in incomes and the numbers taken out of poverty as follows (Table 7):

- i. The average holding of farmers is 1.6 ha. (Govt. of Lao PDR, Agricultural Statistics, 2006).
- ii. 50 percent of the households in the program are in the lowlands and 50 percent in the uplands.
- iii. The average yield in the lowlands is 3.0 t/ha., while that in the uplands is 1.8 t/ha. (Helevatas, 2005).
- iv. Gross income per ha. in the lowlands is US\$450 at present, while in the uplands it is US\$270 (Helevatas, 2005). Net income figures are not available, but based on Cambodian data, one could expect them to be around US\$120 in the lowlands and around US\$40 in the uplands.<sup>40</sup>
- v. The poverty rate among lowland farmers is the same as the national average (39 percent. World Development Indicators [WDI, 2006]). The poverty rate among upland farmers is taken as 100 percent.

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<sup>40</sup> The yields in the uplands are 60 percent of those in the lowlands and labor inputs are almost double per hectare.

Based on these assumptions the impacts of the proposed program are given below.

The program would benefit about 105,000 households and generate an additional US\$5.6 million in incomes. The lowland household incomes would increase by 56 percent, but those in the uplands would double (given the lower initial net income in the uplands, the gain in price is worth more in percentage terms). The estimated impacts on poverty are speculative, but the figures indicate that perhaps about 7,300 rural lowland households could be taken out of poverty, while as many as 26,000 upland households would benefit.

**Table 7: Impacts of an Enlarged ProRice Program in the Lao PDR**

	<b>Lowland Unirrigated</b>	<b>Upland</b>	<b>Total</b>
Output of OA and GAP Rice (Tons)	156,250	93,750	250,000
Area Covered (Ha.)	83,333	83,333	166,666
No. of HH	52,083	52,083	104,166
Increase in Net Income with Program (US\$Mn.)	3.5	2.1	5.6
Increase per HH as %	56%	101%	-
No. of HH taken Out of Poverty %	7,291	26,171	33,462

GAP= Good Agricultural Practice, Ha.= hectare(s), HH= households, Mn.= million(s), No.= number.

Source: Authors' Own Calculations. The method for the poverty reduction calculation is explained in Appendix 1.

The costs of such a program can be estimated roughly, based on a scaling-up of the Helevatas project, which deals with 600 households and costs US\$350,000, while allowing for some economies of scale (see similar calculations for Cambodia). The scaled up cost would be about \$52 million. However, with annual benefits of at least 5.6 million the "rate of return" would be about 7.5 percent.<sup>41</sup> This may not seem high, but the benefits are to low-income households and there is clearly a premium in equity terms that needs to be taken into account. There are also other benefits in terms of an improved environment, better health of the households, and the demonstration effect on other households (who would copy some of the practices introduced to the selected farmers).

## **IV.2 Biofuels in the Lao PDR**

### **Jatropha**

The government of the Lao PDR has chosen to develop jatropha as the crop of choice for the production of biodiesel. Research and development is being undertaken on the entire supply chain and about 8,000 ha. were being targeted for production this year. The aim is to cover 40,000 ha. by 2008. Based on the calculations reported for Cambodia, the former would yield between 10 and 26 million liters of biodiesel, or between 3 and 8 percent of fuel oil imports. The areas selected for the program are in the wastelands of the country, not suitable for agriculture. But there is also a potential for intercropping on some agricultural land.

Similar to Cambodia, the interest in jatropha from the private sector is strong in the Lao PDR. The Ministry of Energy and local private companies involved in renewable energy, such as Sunlabob, report many inquiries from private investors. A Korean company "Kolao" has "plans" to invest US\$30 million to produce 400,000 tons of biodiesel (implying a need for plantations covering at least 144,000 ha.!). The program was initiated 3-4 years ago, but so far there has been virtually no production and only 200 ha. have been planted.

<sup>41</sup> The estimate assumes that the US\$52 million is spread over four years, and the increases in incomes build up to the maximum of US\$5.6 million over those four years. The benefits are taken over 30 years.

Overall, one is left with the strong impression that the expectations for expanding jatropha production are grossly exaggerated. Discussions with Sunlabob, a company that is undertaking research into jatropha in the Lao PDR, revealed that a great deal of R&D is needed before successful large scale production can be implemented. In its view, the necessary research will take in the order of 3-4 years, and the goal of having 8,000 ha. in production this year and 40,000 ha. by 2008, are totally unrealistic. It has prepared detailed plans for its own program, carried out through its research branch, Lao Institute for Renewable Energy (LIRE). This is estimated to cost about US\$2 million.

The Ministry of Energy is allocating some modest resources to research in renewable energy. It is also in the process of drafting a policy for bioenergy, which should be available soon. At present, the only government program in this area is in Sanyaburi province, where a 10 kilowatt (kW) biodiesel generator has been installed.

As in Cambodia, an important issue for the government's bioenergy policy is to decide how to structure involvement by the private sector. And as in Cambodia, there are serious concerns with the allocation of large concessions to private developers. These have already been given for many activities in the areas of hydropower, mining, agriculture and forestry. A Lao-German land policy report concludes that there is a lack of transparency about the process of giving concessions, and indeed a comprehensive land inventory is missing. Model agreements that meet international leasing standards are only available for hydropower. Furthermore, concession fee rates, usage charges for natural resources and royalties do not reflect supply and demand and are not determined according to any clear set of guidelines (Schumann et al., 2006). The WWF (2007) report identifies similar problems with land concessions in the Lao PDR and Cambodia—a lack of clarity in awarding contracts, conflicts with local communities, and increased environmental damage. As one commentator has written, "the current process for allocating concessions in the Lao PDR is far from clear and administrative responsibilities are ambiguous."<sup>42</sup>

In view of these observations, one has to conclude that much preliminary work has to be done on the institutional side, in addition to the physical science and technology side, before major growth in the production of jatropha can be realized. There is no doubt, however, that the potential exists, not only for the use of biodiesel for transport and operating machinery, but also for supply of electricity. Sunlabob estimates that jatropha, along with other energy crops, could supply up to 40 percent of the country's rural off-grid electricity needs.

In terms of benefits, the program's economics should be similar to those in Cambodia. Smallholder programs can generate benefits of US\$30 to US\$98 for an average farm of 1.5 ha. if 15 percent of their land is allocated to jatropha; the exact amount depending on the yield achieved. Taking the lower end of the range, farmers' net incomes from land would go up 25 percent in the lowlands, and 75 percent in the uplands. This would guarantee that most farmers participating in the program, who were poor, would be taken out of poverty. With programs involving large concessions, employment generated could be around 0.9 persons per ha. devoted to jatropha. All such people should be able to earn enough to take them out of poverty. Exact estimates of the numbers who benefit and are taken out of poverty, however, are not possible given the data available. The problems facing any program will be the economics of obtaining a reasonable return on the capital invested. This in turn will depend on the price of biodiesel. At a price of US\$40/Liter the Cambodian program was only marginally viable for smallholders, but was viable for concessions. As in

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<sup>42</sup> U. Pandey, 2007, 16 June. Laos opening its doors to investors. *Bangkok Post*

——— 2007, 10 May. Foreign investment exceeds expectations. *Vientiane Times*.

Indeed many copies of the local English paper *Vientiane Times* report stories of conflicts with local communities over land concessions.

the case of Cambodia, some subsidy or support may be needed for smallholders if the program is to be viable.

### **Cassava**

Although the government has not targeted cassava as a biofuel crop, there can be significant benefits from providing advice and support to increase yields and to assist in the transport and marketing of the chips for export. At present cassava is the third most important crop in the Lao PDR (after rice and maize) and production is in excess of 56,000 tons on 8,000 ha. (data are from Food and Agriculture Organisation Statistics (FAOSTAT) for 2004) representing a yield of 6.8 tons/ha. As we noted in the previous section yields in Cambodia are in the range of 17.8ton/ha. and there is believed to be scope for raising them further. Indeed the Lao PDR has the lowest yield for cassava in Asia, with the exception of Timor-Leste (Howeler, 2006).

A simple calculation can show substantial benefits from increasing yields and improving the marketing of cassava root for export. Assuming current yields of around 6.8 tons/ha., and assuming an increase of 50 percent can be realized through extension and support, we would see a further 27,200 tons of roots available for sale. If current production is enough to meet domestic needs for food and animal feed, the surplus can be exported. Currently prices in Thailand for cassava roots are around \$26/ton. There are duties levied on sales to Thailand of around 20 percent, which would make the price (net of duties) that could be received by the Lao seller \$20.8/ton. Even with this disadvantage, the net gain to growers is US\$560,000, or an additional US\$70.7/ha.. We do not have access to detailed net income data per hectare for the Lao PDR, but such an increase is certain to be large relative to current returns. Moreover, the contents of a program to improve yields are well known and could be put in place relatively easily. The program may also be tied in with private investors interested in buying and processing the roots into alcohol, modified starches, etc. The calculations for Cambodia show that such investment, while desirable, is not essential to realize a major part of the benefits of improving cassava yields and the infrastructure for marketing the output.

## **V. CONCLUSION**

This report has looked at the options for organic agriculture and biofuels in Cambodia and the Lao People's Democratic Republic (PDR), in the context of the wider developments in these two markets worldwide. The broader context points to strong and growing demand in both areas, especially in developed countries. The benefits of this to developing countries such as Cambodia and the Lao PDR are likely to be significant, although the full extent of that is subject to market access and (particularly for organic foods) the costs of certification. **Indeed, one of the main recommendations from the study is to assist these countries in building capacity for certification in both areas—Organic Agriculture (OA) and biofuels—as it will be required for both strategies. In addition to a formal certification system using a third party inspection body, an alternative certification system based upon existing social capital should be used, particularly for domestic market.**

In the case of organic foods, one possible concern for the future that could be relevant to Cambodia and the Lao PDR relates to energy costs of transportation, especially by air. This will be relevant to the extent that the market for the products is in the developed countries of Europe and the United States (US), but it could be reduced to the extent that the potential market is in the region, i.e. in Thailand, Malaysia, Singapore and People's Republic of China (PRC), where OA is currently being imported from Australia and Europe. In fact, if "regional" organic products replace those being imported from Australia and Europe, there are environmental benefits generated to the international community as well.

Issues of available organic fertilizer for a major expansion of OA in the developed world appear to be misplaced, as do those of a decline in aggregate food production if all farmers go organic.

In the case of biofuels, the main concern that Cambodia and the Lao PDR should keep in mind is the problem of getting carbon credits for the shift, when the biofuels are processed with considerable fossil energy. One should also note that the local environmental impacts of the shift need careful analysis. The other concern with biofuels—that of an increase in the price of cereals—remains a global issue, but it is unlikely to be affected by the amounts produced in the Lao PDR and Cambodia. **It is recommended that international institutions, such as Asia Development Bank (ADB), support the countries in (i) identifying the likely carbon benefits of biofuels produced in these two countries, (ii) promoting the technologies and processes that generate measurable and acceptable benefits, and (iii) preparing the case for them to the Clean Development Mechanism Executive Board of the United National Framework Convention on Climate Change.**

### Cambodia

The detailed consideration of options in Cambodia indicate that a move to a more organic agriculture is desirable through the System of Rice Intensification (SRI). The program promotes Good Agricultural Practice (GAP) when used along with a program supporting full OA in more exclusive or isolated areas. The analysis indicates that the combination is already yielding considerable benefits. Therefore an expansion of the present program, to convert 20 percent of wet season rice farmers to SRI (i.e. about 300,000 units), would increase their incomes by 40 to 70 percent depending on the region. About 21,000 households could be taken out of poverty even if the program was not particularly targeted at the poor. There is a potential for export sales of up to \$180 million, although all this is unlikely to be realized. The program would also increase food security and provide environmental benefits. These have not been quantified but are very real.

Thus while an expanded SRI program is recommended, one should also recognize its market limitations. The amount of chemical-free rice that can be sold at a premium in the local market is limited and demand outside the country may be small. **For this reason, promotion of certified OA in Cambodia can proceed alongside the GAP program, with the government supporting initiatives where contract farming is introduced to produce certified OA products for niche markets.** The potential for certified OA has not been fully evaluated, but there are good reasons to believe that Cambodia may have a comparative advantage in these markets, given that most land areas presently contain a limited amount of inorganic residues.

On the biofuels side, two options are attractive for Cambodia. One is a Jatropha Program, which has been analyzed for a plausible case where 10,000 ha. are converted to the tree in 2008, with further subsequent increases of 20,000 in 2009, and 40,000 ha. in 2010. The proposed program works partly with smallholders, owning 1.5 ha. of land, of which only 15 percent is allocated to jatropha. The other part is land given under concession to commercial growers and biodiesel processors.

The smallholder program is more attractive than the concessionaire program in terms of benefits to farmers. It could take somewhere between 6,500 and 7,900 households out of poverty, whereas the concessionaire program would take some 1,400 to 1,500 workers out of poverty. On the other hand, the smallholder program produces less biodiesel (27 percent less) and is not viable in financial terms, especially if the lower end of the yield range is realized. **Thus some form of subsidy is likely to be needed for a smallholder program.** The investment costs of converting 10,000 ha. to jatropha and refining the product to biodiesel are around US\$15-20 million, based on 44 percent coming from concessionaries

and 56 percent coming from smallholders. Scaling up the program would increase benefits proportionately. Issues to be addressed are: (i) identification and processing of the carbon credits, (ii) reduction of risks of failure in case of oil price falls through a price guarantee program and (iii) a capacity building support program (the costs of which have not been estimated).

Cassava is the other biofuel to be developed in Cambodia, and there is already private sector interest there. **The recommendation is to develop a program to increase yields from the current 17.8 tons/ha. to 22.8 tons/ha. by 2012.** This will need an extension and advice program of a fair size. The program would have two components, similar to the Jatropha program: a smallholder part and a concession part. The smallholder part would target 20,000 households initially, going up to 30,000 by 2011. It would take about 7,000 households out of poverty and increase the net incomes of farmers by US\$3.7 million in 2006, going up to US\$14.5 in 2011. The concessionaire component is more effective in terms of yield, but has less of a social impact; it would create about 2000 jobs. The roots would partly go for ethanol production, for export, generating earnings of US\$32 million in 2008, up to US\$65 in 2011. The rest will continue to be used as animal feed and as an input for starch production. The project needs to be costed in terms of the support program, and analyzed with respect to the possible carbon credits.

There is a trade-off in the biodiesel projects between efficiency, which supports concessions, and equity, which may support smallholders. **At present the system of concessions is unsatisfactory and reforms are urgently needed. These should address the concerns of transparency and proper procedures—with respect to consultations, environmental and social assessment.** With reforms, it may also be possible to envisage institutional arrangements where farmers can participate on a more equitable basis.

**All three of these initiatives can be pursued simultaneously, but if funds are limited the highest priority should go to the rice project, because it generates the greatest increases in poverty reduction for the least outlay. This should be followed in terms of priority by jatropha, and finally cassava.**

### The Lao PDR

Data for the Lao PDR were not as comprehensive as those for Cambodia, so the analysis is less rigorous and the recommendations more generic.

It is clear from what is known however, that the Lao PDR has much to recommend it as a center for OA. Indeed, present agriculture involves very low external inputs and the agricultural environment is generally regarded as clean. Thus production for a high-value market may be the preferred strategy, rather than to intensify through conventional methods and compete with other more developed countries.

This study has looked at the OA potential for rice alone, although there is a small market for coffee and some other products as well. There is also a major initiative on conservation agriculture (which looks at livestock and mixed farming systems), and which should contribute to a more sustainable agriculture.

For rice, unlike Cambodia, there is not the same evidence in favor of an SRI approach raising yields, and indeed the reviews show a wide divergence of opinions. Having looked at this, we conclude that a shift to OA should not cause a fall in yields as long as it is supported by suitable advice from well-qualified experts. This is even more likely to be the case if the aim is not OA in a formal sense, but GAP, with some permitted external inputs. In fact both GAP and OA can run together in a program, following the regional demarcations laid out by the government.

If yields can be maintained, and if marketing and communication improved as indicated in the surveys, a 15 percent increase in farmer incomes is easily feasible. With a program covering around 100,000 households, half of which are upland and half lowland, an increase in incomes of about US\$5.6 million is feasible. This should take about 33,000 households out of poverty. The likely cost of the program would be about \$52 million, possibly less, based on data from small-scale ongoing efforts.

On the biofuels side, two options are attractive for the Lao PDR—but both need further investigation and development before they can be realized. The present targets are unrealistic, and the government and the international community need to devote more resources to supporting research on jatropha and cassava. It also needs to improve the framework for concessions of land to private investors, if these are not to cause conflict and even hardship to local communities.

In terms of benefits, the program's economics should be similar to those in Cambodia. Smallholder programs would guarantee that most participating farmers who were poor would be taken out of poverty. With programs involving large concessions, all employees should earn enough to take them out of poverty. Exact estimates of the numbers who would benefit and be taken out of poverty are, however, not possible given the data available. The problems facing any program will be the economics of obtaining a reasonable return on the capital invested. This in turn will depend on the price of biodiesel, with a price of US\$40/liter not being enough to make the smallholder program viable, but probably being enough to make the concessionaire program viable. As in the case of Cambodia, some subsidy or support may be needed for smallholders if the program is to be viable.

For cassava, a program to increase yields from their very low levels of 6.8 tons/ha. (one of the lowest in Asia) is recommended. The potential is surely there, given yields in Cambodia that are in the range of 17.8 tons /ha. If such a program could achieve a 50 percent increase, the surplus production could be exported as root or processed chips. The potential to the growers could be around US\$70.7 per hectare, which would make a major change in their livelihoods.

In terms of priority, as with Cambodia, the GAP rice development should take first place, with certified OA programs being developed where market niches can be identified. On biofuels, further investigations are needed before a judgment can be made on which is the more attractive.

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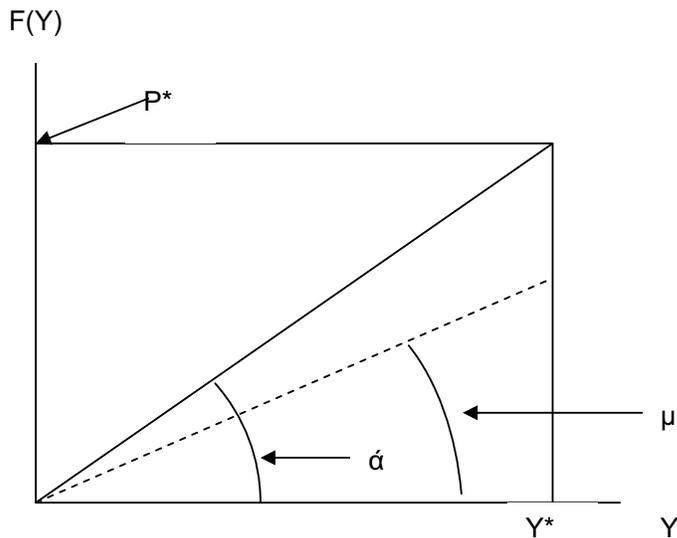
**APPENDIX I: ESTIMATING THE NUMBER OF HOUSEHOLDS TAKEN OUT OF POVERTY**

The number of households that are poor (P) with income below Y are F(Y).

The cut off limit for households to be poor is Y\*.

In the absence of knowledge of the function F(Y) we assume a linear cumulative density function as shown in Figure 1.

An increase in incomes of  $\gamma$  percent would shift the line to the dashed line on the right as shown in the same figure.



On the original line, given by  $P = \alpha Y$  the number of poor with income below  $Y^*$  is  $P^*$  where:

$$P^* = \alpha Y^*.$$

On the new line with increased incomes that are  $\gamma\%$  higher for all households the value of Y below which  $P^*$  households have an income of less than Y is given by:

$$P^* = \mu(1 + \gamma)Y^*$$

Hence

$$\mu = P^*/((1 + \gamma)Y^*)$$

So  $\mu$  is given by

$$\mu = P^*/((1 + \gamma)Y^*).$$

Hence the value of P corresponding to  $Y^*$  on the dashed line is given by  $P^{**}$ :

$$P^{**} = \mu Y^* = P^*/(1 + \gamma). \quad Y^* = P^*/\alpha$$

In other words, the number still in poverty is reduced by a factor of  $1/(1 + \gamma)$ .

This approximation has been used as we do not have the distribution function for the poor households. It is likely to underestimate the number taken out of poverty, as a lognormal distribution would have more households closer to the poverty line than this linear approximation suggests.

**APPENDIX II: LIST OF ABBREVIATIONS**

ASEAN	Association of Southeast Asian Nations
ALRO	Agriculture Land Reform Office (Thailand)
BML	Bundesministerium für Ernährung, Landwirtschaft und Forsten (Federal Ministry for Food, Agriculture and Forestry [Germany])
CA	Conventional Agriculture
CABI	Centre for Agriculture and Biosciences International
CIAT	International Centre for Tropical Agriculture
CIF	cost, insurance and freight
CEDAC	Cambodian Center for Agricultural Studies and Development
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
DG	Director General
DEFRA	Department for the Environment, Food and Rural Affairs
EC	European Commission
EU	European Union
EPOPA	Export Promotion of Organic Production from Africa
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	Food and Agricultural Organisation
FEEM	Fondazione Eni Enrico Mattei
FIBL	Forschungsinstitut für biologischen Landbau (Research Institute for Organic Agriculture)
GAP	good agricultural practice
GHG	greenhouse gas
GI	geographical indications
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Institute for Technical Cooperation)
IGER	Institute for Grassland and Environmental Research
IFAD	International Fund for Agricultural Development
IFOAM	International Federation of Organic Agriculture Movements
IPCC	International Panel for Climate Change
IRRI	National Rice Research Program (Lao PDR)
LCA	life cycle assessment
LIRE	Lao Institute for Renewable Research
MDG	Millennium Development Goals
MJ	mega joules
NTFP	non-timber forest product
OA	organic agriculture
OECD	Organisation for Economic Co-operation and Development
PRC	People's Republic of China
PRONAE	Lao National Agro-Ecology Programme
PROFIL	ProRice Program (Lao PDR)
SFOE	Swiss Federal Office of Energy
SöL	Siftung Ökologie und Landbau
SRI	system of rice intensification
SUV	sport utility vehicle
SVO	straight vegetable oil
TOE	ton of oil equivalent
UK	United Kingdom
UN	United Nations
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
WDI	World Development Indicators
WTO	World Trade Organization
WWF	World Wide Fund for Nature