GREATER MEKONG SUBREGION
ECONOMIC COOPERATION PROGRAM

Integrating Biofuel and Rural Renewable Energy Production in Agriculture for Poverty Reduction in the Greater Mekong Subregion

AN OVERVIEW AND STRATEGIC FRAMEWORK FOR BIOFUEL DEVELOPMENT

GREATER MEKONG SUBREGION
ECONOMIC COOPERATION PROGRAM

Integrating Biofuel and Rural Renewable Energy Production in Agriculture for Poverty Reduction in the Greater Mekong Subregion

AN OVERVIEW AND STRATEGIC FRAMEWORK FOR BIOFUEL DEVELOPMENT

Mercedita A. Sombilla
Southeast Asian Regional Center for Graduate Study and Research in Agriculture

Urooj S. Malik, A. K. Mahfuz Ahmed, and Sarah L. Cueno
Southeast Asia Department, Asian Development Bank

Printed in the Philippines

ISBN 978-971-561-845-8
Publication Stock No. RPT090356

Cataloging-In-Publication Data

Asian Development Bank.
Integrating biofuel and rural renewable energy production in agriculture for poverty reduction in the Greater Mekong Subregion: an overview and strategic framework for biofuels development.
Mandaluyong City, Philippines: Asian Development Bank, 2009.

1. Biofuels. 2. Renewable Energy. 3. Greater Mekong Subregion. I. Asian Development Bank.

NOTE

In this report, "$" refers to US dollars.

Asian Development Bank
6 ADB Avenue, Mandaluyong City
1550 Metro Manila, Philippines
Tel +63 2 632 4444
Fax + 63 2 636 2444
www.adb.org

For orders, please contact:
Department of External Relations
Fax +63 2 636 2648
adbpub@adb.org

Contents

Abbreviations

ADB	–	Asian Development Bank
B5	–	mixture of 5% biodiesel and 95% fossil diesel
bbl/day	–	barrel per day
E5	–	mixture of 5% ethanol and 95% gasoline
EU	–	the European Union
GHG	–	greenhouse gas
GMS	–	the Greater Mekong Subregion
ICRISAT	–	International Crops Research Institute for the Semi-Arid Tropics
KWh	–	kilowatt-hour
Lao PDR	–	the Lao People's Democratic Republic
mt	–	million tons
mtoe	–	million tons of oil equivalent
PRC	–	the People's Republic of China
UNDP	–	United Nations Development Programme
US	–	the United States

Acknowledgment

The study "Strategy for Integrating Biofuel and Rural Renewable Energy Production in Agriculture for Poverty Reduction in the Greater Mekong Subregion" is a successful result of the close collaborative work among affiliates and friends of the Greater Mekong Subregion Economic Development Initiative. The study was made possible by funding from the Asian Development Bank (ADB) and the International Fund for Agricultural Development (IFAD). Special thanks are also due to the Food Agriculture Organization of the United Nations (FAO); and to its Regional Office for Asia and the Pacific (FAO RAP) in Bangkok for its assistance in organizing and hosting a number of workshops and meetings that brought together collaborators and partners to discuss the emerging issues confronting the development of the Greater Mekong Subregion (GMS).

The study was led and coordinated by Mercedita A. Sombilla of the Southeast Asian Center for Graduate Study and Research in Agriculture (SEARCA) and could not have been completed without the strong support of the governments of the GMS countries, particularly the national biofuel assessment teams composed of the following eminent experts and technical personnel:

Luyna Ung, Hay Sovuthea, and Sophiak Siek of the Supreme National Economic Council; and Sar Chetra of the Ministry of Agriculture, Forestry and Fisheries for the assessment study "Status and Potential for the Development of Biofuels and Rural Renewable Energy: Cambodia";

Jikun Huang, Huanguang Qiu, and Jun Yang of the Center for Chinese Agricultural Policy, Chinese Academy of Sciences; Yuhua Zhang and Yanli Zhang of the Institute of Rural Energy and Environmental Protection, Chinese Academy of Agricultural Engineering; and Yahui Zhang of the Center of International Cooperative Service, Ministry of Agriculture for the assessment study "Status and Potential for the Development of Biofuels and Rural Renewable Energy: the People's Republic of China";

Kham Sanatem of the Forestry and Agriculture Promotion Center, Ministry of Agriculture and Forestry; Bouathep Malaykham of the Electric Power Management Division, Department of Electricity, Ministry of Energy and Mines; Phouvong Phommabouth, Department of Trade Promotion, Ministry of Industry and Commerce; Sounthone Ketphanh, National Agriculture and Forestry Research Institute, Ministry of Agriculture and Forestry; and Keophayvan Insixiengmai, Technology Research Institute, Science and Technology Agency for the assessment study "Status and Potential for the Development of Biofuels and Rural Renewable Energy: the Lao People's Democratic Republic";

U Hla Kyaw of the Department of Agriculture and Planning, Ministry of Agriculture and Irrigation; Thandar Kyi of Yezin Agricultural University; San Thein, Myanma Industrial Crop Development Enterprise, Ministry of Agriculture and Irrigation;
U Aung Hlaing, Department of Agricultural Planning; and U Tin Maung Shwe, Myanmar Academy of Agriculture, Forestry, Livestock and Fishery Sciences for the assessment study "Status and Potential for the Development of Biofuels and Rural Renewable Energy: Myanmar";

Suthiporn Chirapanda, independent consultant; Sudarat Techasriprasert, Office of Agricultural Economics; Somjate Pratummin, Ministry of Agriculture and Cooperatives; Samai Jain, Ministry of Science and Technology; and Prapon Wongtarua, Ministry of Energy, for the assessment study "Status and Potential for the Development of Biofuels and Rural Renewable Energy: Thailand";

Nguyen Do Anh Tuan, Nguyen Anh Phong, Nguyen Nghia Lan, and Ta Thi Khanh Van of the Institute of Policy and Strategic Agricultural and Rural

Development, Ministry of Agriculture and Rural Development (MARD); Tran The Tuong of the Department of Crop Production, MARD; Phan Dang Hung, Department of Forestry, MARD; Vi Viet Hoang, Department of Cooperation and Rural Development, MARD; and Ha Van Chuc, Department of Livestock Production, MARD, for the assessment study “Status and Potential for the Development of Biofuels and Rural Renewable Energy: Viet Nam”; and

Jikun Huang, Jun Yang and Huanguang Qiu of the Center for Chinese Agricultural Policy, Chinese Academy of Sciences; Scott Rozelle of Stanford University; and Mercedita A. Sombilla of SEARCA, for the projection study “Global and Regional Development and Impact of Biofuels: A Focus on the Greater Mekong Subregion”.

The country reports were consolidated in the report entitled “Integrating Biofuel and Rural Renewable Energy Production in Agriculture for Poverty Reduction in the Greater Mekong Subregion: An Overview and Strategic Framework for Biofuel Development” by Mercedita A. Sombilla of SEARCA; and Urooj S. Malik, A. K. Mahfuz Ahmed, and Sarah L. Cueno of the Southeast Asia Department, ADB.

During the course of this study, the team received valuable advice and guidance from many individuals and agencies. Special thanks are due to Urooj Malik, Director, Christopher Wensley, Officer-in-Charge, and Mahfuz Ahmed, Senior Agricultural Economist of the Agriculture, Environment, and Natural Resources Division, Southeast Asia Department, ADB; Thomas Elhaut, Director, Asia and the Pacific Region, IFAD; Hiroyuki Konuma of FAO RAP, Bangkok, Thailand; and the members of the GMS Working Group on Agriculture: San Vanty, Under Secretary of State, Ministry of Agriculture, Forestry and Fisheries, Cambodia; Tang Shengyao, Director of Asia and Africa Division, Department of International Cooperation, Ministry of Agriculture, the People’s Republic of China; Phouangpharisak Pravongviengkham, Director General, Department of Planning, Ministry of Agriculture and Forestry, the Lao People’s Democratic Republic; U Than Thay, Deputy Director, Department of Agricultural Planning, Ministry of Agriculture and Irrigation, Myanmar; Dounghatai Danvivathana, Director, Foreign Relations Division, Office of the Permanent Secretary, Ministry of Agriculture and Cooperatives, Thailand; and Le Van Minh, Director General, International Cooperation Department, MARD, Viet Nam.

Technical and logistical support was provided by the GMS Working Group on Agriculture Secretariat based at ADB headquarters, composed of Marilou Drilon, Sununtar Setboonsarng, and Sarah Cueno. Thanks go also to the ADB Resident Offices for facilitating the workshops and team meetings in the GMS countries.

The initial editing of the reports was done by Mercedita A. Sombilla. The manuscript editor was Caroline Ahmad, and the copy editors were Corazon Desuasido and Toby Miller. The final review of the studies was done by Urooj Malik.

Financial management and accounting support was provided by Oscar Badiola. Imelda Batangantang and SEARCA’s accounting unit monitored the project’s financial flow.

Finally, many thanks are due to the numerous other colleagues, partners, and stakeholders who provided valuable comments and information which added to the richness of the documents.

Introduction

High fossil fuel prices, energy security concerns, and environmental issues—particularly climate change—have motivated countries across the world to explore alternative sources of energy, including biofuels. The countries of the Greater Mekong Subregion (GMS), namely Cambodia, the People's Republic of China (PRC), the Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, and Viet Nam, are poised to embark on, or have already begun, biofuel development. But this initial enthusiasm has been dented by the food crisis of 2008, which singled out the diversion of food crops to biofuel production as one of the factors responsible for driving up food prices. This allegation is partly correct and serves to highlight a potential pitfall of introducing biofuel policies without duly assessing their overall implications on the agricultural sector.[1]

It is also the prime motivation for a study undertaken in the GMS that aimed to (i) preliminarily assess the economic and market potential of biofuels to assist in the identification of promising areas for investment to promote rural development; (ii) assess the adequacy of current technology for biofuel systems development and identify needs for research and development, training, and human capacity-building; and (iii) review current policies on promoting biofuel development and identify the policy levers that can promote sustained growth in the subsector, especially in relation to strengthening public–private partnerships, encouraging investment, and promoting cross-border trade. Five critical areas were analyzed: (i) the market outlook for biofuel development, (ii) characterization of the resource base, (iii) prioritization of potential feedstocks, (iv) agribusiness development schemes, and (v) existing policies and regulations in support of biofuels development. The final output of the study is a framework of strategies and options to develop alternative renewable sources of energy with a focus on biofuels that would promote both energy security and diversification in agricultural production. This in turn would help raise incomes, primarily of small farmers, and hence strengthen food security and reduce poverty.

This report presents a synthesis of the results of the individual country assessment studies and sets out the subregional strategy for biofuel development in the GMS. The terms of reference and methodology of the country assessments are described in Appendix 1. The timeline of activities and the workshop schedules and comments are given in Appendixes 2 and 3; and the participants are listed in Appendix 4.

---

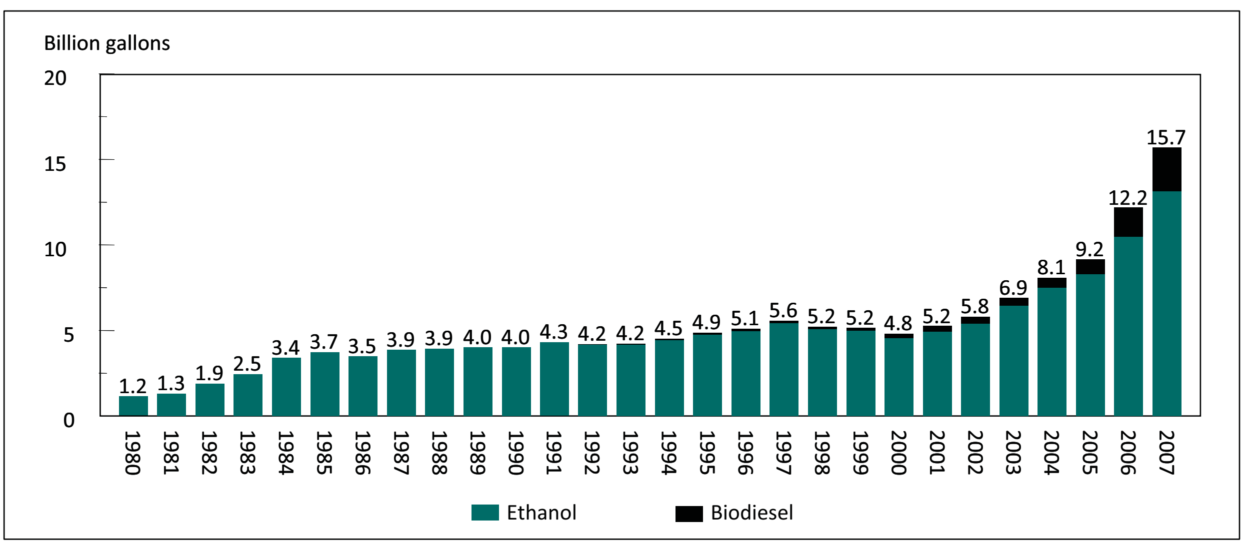
[1] United Nations Conference on Trade and Development (UNCTAD). 2008. *UNCTAD's position on biofuel policies and the global food crisis.* www.reliefweb.int/rw/rwb.nsf/db900SID/LSGZ-7FNHWY?OpenDocument

Global Prospects for Biofuel Production

The global outlook for biofuels rests on a number of interrelated factors, including the future price of oil, the availability of low-cost feedstock, technological breakthroughs that could reduce the cost of second-generation biofuels, competition from unconventional fossil fuel alternatives, and sustained commitment to supportive policies by governments. The price of oil is a key factor since high oil prices make the production of alternative energy sources, including biofuels, competitive. The price of crude oil declined in the first quarter of 2009 to a low of a little under $45 per barrel (/bbl) from its peak of about $140/bbl in the third quarter of 2008. However, it is unlikely that the price will further decline to the $16/bbl level of the late 1990s. World energy demand continues to increase, particularly for transport, more than doubling from 1,020 million tons of oil equivalent (mtoe) in 1971 to 2,106 mtoe in 2006.[2] The International Energy Agency predicts a further increase to 5,582 mtoe (116 million bbl/day) in 2030, given the continued strong economic growth of countries such as those in Asia.

Unless the rate of oil demand slows and dependable alternative sources of energy are developed, the price of oil will remain under great pressure. Meanwhile, production of certain biofuels using currently available technology remains competitive even at an oil price of $45–$50/bbl. In addition, there is potential to further reduce the cost of feedstocks and improve the efficiency of biofuel processing. This includes the development of second-generation biofuel production technology based on cellulosic materials from crop residues such as crop stovers, wood chips and wood waste, fast-growing grasses, and municipal wastes. When fully developed, biofuel production is expected to become more cost-efficient and less of a threat to food security.

Figure 1: Global Biofuel Production, 1980–2007 (billion gallons)



Sources: International Energy Agency, FO Licht, updated: February 2008.

[2] International Energy Agency. 2008. *Key World Energy Statistics.* Paris.

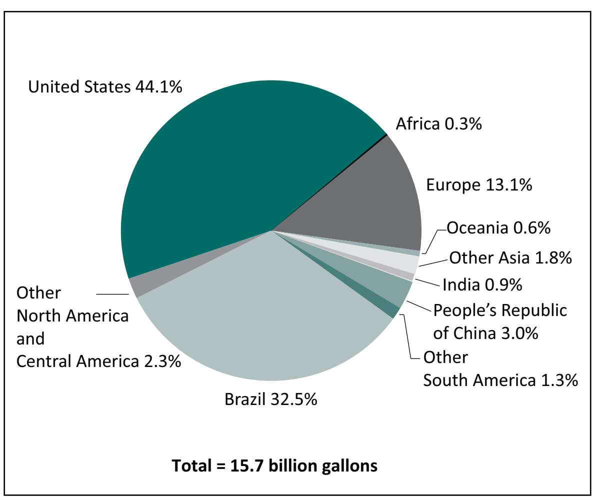
Perhaps the most critical factor influencing the growth of biofuels is the level of commitment of national governments. This may take the form of investment in production capacity and infrastructure to improve the efficiency of biofuel production; or it may involve the strengthening of existing policies or the formulation of new ones to promote the sustained development of biofuels and to create an environment in which biofuel businesses—whether large or small in scale—can flourish without compromising food production and inflating food prices.

Production of and Demand for Biofuels

Global biofuel production more than tripled from 4.8 billion gallons (gal) in 2000 to 16.0 billion gal in 2007 (Figure 1). However, biofuels still account for less than 3% of the global oil supply channeled to transport alone. Moreover, production is still concentrated in Brazil, the European Union (EU), and the United States (US). These three producers contribute about 90% of world biofuel production. In 2007 Asia's share was 6%; but this is set to increase as the PRC, India, and Thailand expand their production (Figure 2).

Global biofuel production is expected to further expand. As shown in Table 1, the blending targets of some of the more advanced biofuel-producing countries vary from 5% to 25% for ethanol and from 2% to 10% for biodiesel. A simple calculation shows that a blending ratio of just 5% applied to the projected oil consumption of 116 million bbl/day in 2030 would amount to a biofuel requirement of about 5.8 million bbl/day (179.8 million gal/day) or 2.1 billion bbl/year (65.6 billion gal/year). This is more than 4 times the biofuel consumption in 2007. This estimate may be surpassed as some countries aim to introduce a blending ratio of 10%.

Figure 2: Biofuel Production Share by Region and Country, 2007 (%)



Note: Includes only ethanol.

Source: FO licht.

Pros and Cons of Biofuel Production

Since the food crisis of 2008, the pros and cons in biofuel production have been the subject of much debate. Indeed, the development of this subsector presents both opportunities and risks, the balance of which will depend on the unique context of the country and the specific policies adopted.

The main advantage is reduced dependence on foreign oil and consequent savings on energy expenditure that could instead be invested in other development activities. Biofuel production thereby helps boost a country's energy security.

A second advantage is the potential of biofuel production to promote rural development. Biofuels present an opportunity to diversify agriculture and, if properly planned, can attract investment and new technology to invigorate agriculture. The diversification of agriculture and the establishment of processing plants create job opportunities which translate into increased household income and improved welfare. This is especially the case when the poor are able to reap the benefits; hence the integration of small farmers in the biofuel market chain is critical. Government support is essential to help small farmers expand production and access markets. This may take the form of investment in infrastructure, research and technology development, making credit and rural finance available, and strengthening market information, institutions, and the legal system.

Some also argue that biofuels generate the additional benefit of reduced smog-inducing carbon monoxide and greenhouse gas (GHG) emissions compared with fossil fuel. However, this has been refuted by other studies. Several detailed life-cycle

Table 1: Biofuel Blending Targets of Selected Countries and the European Union

Country	Feedstocks: Bioethanol	Feedstocks: Biodiesel	2007 Production Forecast (million gallons): Bioethanol	2007 Production Forecast (million gallons): Biodiesel	Blending Targets
Brazil	Sugarcane, soybeans	Castor seed, palm oil	4,966.5	64.1	E25 by 2007; B2 by early 2008; B5 by 2013
Canada	Corn, wheat, straw	Animal fat, vegetable oils	264.2	25.4	E5 by 2010; B2 by 2012
PRC	Corn, wheat, cassava, sweet sorghum	Used and imported vegetable oils, jatropha	422.7	29.9	Five provinces use E10; five more provinces targeted for expanded use
EU	Wheat, other grains, sugar beets, wine, alcohol	Rapeseed, sunflower, soybeans	608.4	1,731.9	5.75% bioethanol share of transport fuel by 2010, 10% by 2020
India	Molasses, sugarcane	Jatropha, imported palm oil	105.7	12.0	E10 by late 2008; B5 by 2012
Indonesia	Sugarcane, cassava	Palm oil, jatropha	—	107.7	B10 by 2010
Malaysia	None	Palm oil	—	86.8	B5 used in public vehicles; government plans to mandate B5 in diesel-consuming vehicles and in industry in the near future
Thailand	Molasses, cassava, sugarcane	Palm oil, used vegetable oil	79.3	68.8	Plans call for E10 consumption to double by 2011 through use of price incentives; palm oil production will be increased to replace 10% of total diesel demand (B10) by 2012
US	Primarily corn, soybeans	Oilseeds, animal fats, recycled fats and oils	6,498.7	444.5	Use of 7.5 billion gallons of biofuels by 2012; proposals to raise renewable fuel standard to 36 billion gallons (mostly from corn and cellulose) by 2022

— = negligible production, E25 = 25% blend of bioethanol in gasoline; E10 = 10% blend of bioethanol in gasoline; E5 = 5% blend of bioethanol in gasoline; B10 = 10% blend of biodiesel in diesel; B5 = 5% blend of biodiesel in diesel; B2 = 2% blend of biodiesel in diesel; Lao PDR = the Lao People's Democratic Republic, PRC = the People's Republic of China, US = the United States.

Source: FO Licht, and United States Department of Agriculture.

assessments have highlighted the GHG reduction benefits from biofuels.[3] Brazilian sugarcane-derived ethanol, for example, results in the emission of only about 25 grams carbon dioxide equivalent (CO_2eq) per kilometer (km) using a 1.6 liter vehicle. By comparison, the GHG emissions resulting from the use of standard European gasoline under the same conditions and with the use of the same vehicle

[3] Rickeard, D. J., G. Punter, J-F. Larivé, R. Edwards, N. D. Mortimer, R. Horne, A. Bauen, J. Woods. 2004. *WTW evaluation for production of ethanol from wheat.* London: Low Carbon Vehicle Partnership. FWG-P-94-024:1-39. www.lowcvp.org.uk; Woods, J., and G. Brown. 2005. *Bioethanol greenhouse gas calculator: user's guidebook.* London. UK. HGCA (Cereals and Oilseeds Sector of the Agriculture and Horticulture Research Forum). pp 1–38. www.dft.gov.uk/pgr/roads/environment/rtfo/; Farrell, A. E., R. J. Plevin, B. T. Turner, A. D. Jones, M. O'Hare, and D. M. Kammen. 2006. Ethanol can contribute to energy and environmental goals. *Science*. 311. pp 506–508.

would have been 170 grams/km of CO_2eq. Corn-based ethanol produced in the US, on the other hand, emits 150–170 grams/km of CO_2eq, i.e., a less than 10% reduction compared with gasoline on a full life-cycle basis. These studies underline the significance of feedstock selection for reducing GHG emissions and hence generating greater environmental benefits from the use of biofuels.

The effect of biofuel production on food prices has attracted the greatest attention and criticism due to competition with the food and livestock feed markets for the same crops. Any threat to food security could have serious consequences for the more than 800 million people worldwide who face persistent hunger and spend more than half of their incomes on food. The escalation in corn prices in 2008 confirmed these fears. A doubling in corn prices caused social unrest in Mexico where corn tortillas are a dietary staple. High agricultural commodity prices can have negative impacts on developing countries, especially those that are highly dependent on imports to meet their food requirements; however the extent to which higher crop prices will hurt or help poor people in developing countries is likely to vary from region to region.[4]

[4] ADB. 2008. *Strategies and Options for Integrating Biofuel and Rural Renewable Energy Production into Rural Agriculture for Poverty Reduction: the People's Republic of China.* Consultant's report. Manila.

Biofuel Development in the Greater Mekong Subregion

The development of biofuels in the Greater Mekong Subregion (GMS) was prompted by high oil prices and energy security concerns. Rapid economic growth in the subregion has fuelled a significant rise in energy demand. The annual increase in gross domestic product averaged more than 6% during 1993–2005, except in Thailand, where it was 3.8% (Table 2). The overall growth in energy consumption in the subregion averaged 8% over the same period. The Lao People's Democratic Republic (Lao PDR), Myanmar, and Viet Nam surpassed this growth rate, while Cambodia maintained an annual average growth rate in energy consumption of 1.1%.

Transport accounts for the most rapid growth in energy consumption in the subregion and elsewhere. The consumption of gasoline in the GMS rose by 149% in 1990–2005, while diesel consumption rose by 177% in the same period (Table 3). These rates of increase in fuel oil demand greatly outstripped production, leading most countries to depend heavily on imports, the supply of which has become increasingly volatile (Figure 3).

The GMS is now confronted with the challenge of meeting the rapid growth in its energy demand to sustain economic development. The broader use of alternative energy resources, both renewable and nonrenewable, is seen as an important option to allay concerns about rising oil prices that affect access to increased oil imports. Vast energy resources exist in the subregion, but the extent of their exploitation and development have differed primarily because of the countries' varying levels of development and their varying need for and use of energy.

Table 2: Average Annual Growth in Gross Domestic Product and Energy Consumption, 1993–2005 (%)

Country	GDP	Energy Consumption
PRC	7.5	6.6
Yunnan Province	9.4	9.2
Guangxi Zhuang Autonomous Region	10.2	8.8
Viet Nam	7.6	10.2
Thailand	3.8	6.6
Myanmar	9.9	8.5
Lao PDR	6.6	8.2
Cambodia	8.0	1.1

GDP = gross domestic product, Lao PDR = the Lao People's Democratic Republic, PRC = the People's Republic of China.

Source of GDP data: ADB. 2007. *Asian Development Outlook 2007*. Manila; sources of energy data: IEA. 2007. *World Energy Outlook 2007*. Paris; and China Data Online. www.chinadataonline.

Table 3: Transport Fuel Demand Growth, 1990–2005 (%)

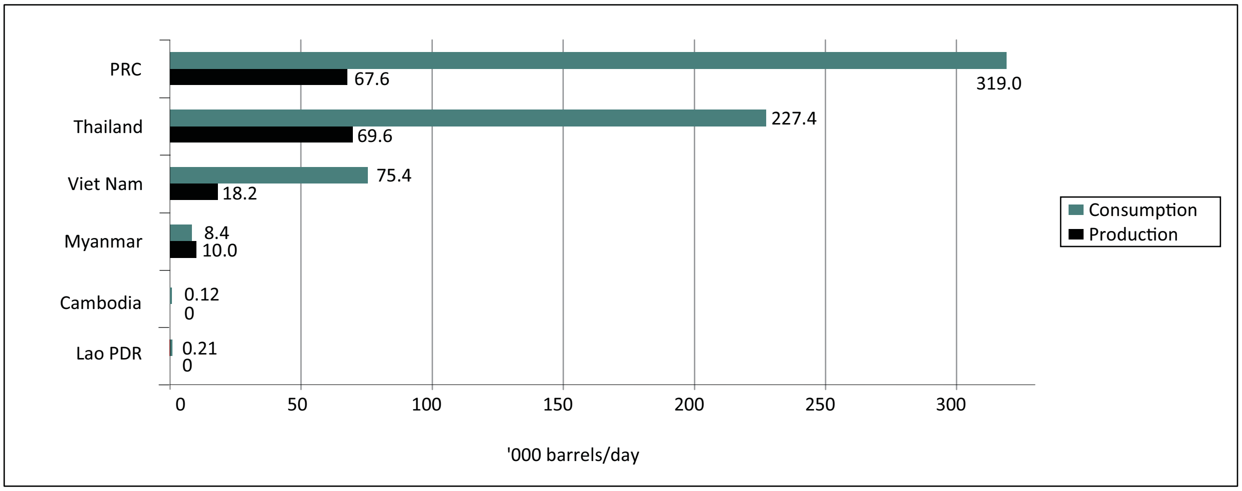
Country or Region	% increase, 1990–2005 Gasoline	% increase, 1990–2005 Diesel
GMS	149	177
Yunnan Province, PRC	129	720
Guangxi Zhuang Autonomous Region, PRC	341	492
Viet Nam	328	365
Thailand	97	101
Myanmar	155	311
Cambodia	3	230

GMS = Greater Mekong Subregion, PRC = the People's Republic of China.

Note: Data for Cambodia is for 1995–2005.

Source: Organization for Economic Cooperation and Development. 2007. www.oecd.org/home/0,2987,en_2649_201185_1_1_1_1_1,00.html; and China Data Online. www.chinadataonline.org

Figure 3: Increase in Oil Consumption and Production in the Greater Mekong Subregion in 2001 and 2005 (‘000 barrels per day)



Lao PDR = the Lao People’s Democratic Republic, PRC = the People’s Republic of China.

Source: Energy Information Administration. http://eia.doe.gov/; and ADB. 2008. *Strategies and Options for Integrating Biofuel and Rural Renewable Energy Production into Rural Agriculture for Poverty Reduction: the People’s Republic of China*. Consultant’s report. Manila (TA 6324-REG).

Nonrenewable Energy Resources of the Greater Mekong Subregion

Crude oil, coal, lignite, geothermal, and natural gas are among the most common nonrenewable sources of energy in the GMS. In the People’s Republic of China (PRC), coal contributes 76% of total energy production. This is followed by crude oil with a decreasing percentage contribution to total energy production. The PRC also has a small natural gas deposit that is augmented by imports (footnote 4). Myanmar boasts about 12 trillion cubic feet of natural gas deposits tapped primarily for export to the PRC and Thailand.[5] Viet Nam also taps coal, crude oil, and natural gas. Its coal and crude oil deposits are relatively sizeable and are both exported; however, its crude oil reserves are expected to be depleted in 30 years.[6] Cambodia and the Lao PDR do not currently produce crude oil. Exploration is currently being undertaken in areas where possible deposits have been identified. Cambodia produces coal from its limited deposits.[7]

Renewable Energy Resources of the Greater Mekong Subregion

There are numerous renewable energy sources in the GMS, but only biomass and hydropower have been tapped on a large scale. Biomass, especially in the form of fuelwood, remains the major source of energy for lighting and heating in most of the GMS countries (except Thailand), especially in the rural areas. Biomass is used by 56% of the rural population in Viet Nam, 85% of households in Cambodia, 92% of households in the Lao PDR,[8] and 42% of urban households and 93% of rural households in Myanmar.[9]

5 ADB. 2008. *Strategies and Options for Integrating Biofuel and Rural Renewable Energy Production into Rural Agriculture for Poverty Reduction: Myanmar*. Consultant’s report. Manila (TA 6324-REG).

6 ADB. 2008. *Strategies and Options for Integrating Biofuel and Rural Renewable Energy Production into Rural Agriculture for Poverty Reduction: Viet Nam*. Consultant’s report. Manila (TA 6324-REG).

7 ADB. 2008. *Strategies and Options for Integrating Biofuel and Rural Renewable Energy Production into Rural Agriculture for Poverty Reduction: Cambodia*. Consultant’s report. Manila (TA 6324-REG).

8 ADB. 2008. *Strategies and Options for Integrating Biofuel and Rural Renewable Energy Production into Rural Agriculture for Poverty Reduction: the Lao People’s Democratic Republic*. Consultant’s report. Manila (TA 6324-REG).

9 See already cited consultant’s reports for the relevant country, and ADB. 2008. *Strategies and Options for Integrating Biofuel and Rural Renewable Energy Production into Rural Agriculture for Poverty Reduction: Thailand*. Consultant’s report. Manila (TA3624-REG).

Table 4: Electricity Use per Capita in 2007 (kWh)

Country or Region	kWh per capita
Cambodia	8.7
PRC	1,886.7
Guangxi Zhuang Autonomous Region	1,100.0
Yunnan Province	1,252.0
Lao PDR	499.8
Myanmar	112.4
Thailand	1,785.8
Viet Nam	437.5
Average, including all parts of the PRC	788.5
Average, including Guangxi Zhuang Autonomous Region and Yunnan Province only	742.3

kWh = kilowatt-hour, Lao PDR = the Lao People's Democratic Republic, PRC = the People's Republic of China.

Source: United Nations Development Programme. 2008. *Human Development Report 2007/2008. Fighting climate change: human solidarity in a divided world.* hdr.undp.org/en/media/hdr_20072008_en_complete.pdf, and China data online

Household electrification in the GMS is at a very low level, averaging 788 kilowatt-hours (kWh) per capita (Table 4). This is below the minimum electrification threshold of 1,000 kWh per capita recommended by the United Nations Development Programme (UNDP). This average masks the wide variation in the per capita electricity consumption within and between the countries.

The Potential of Biogas

Biogas is a clean, cheap source of energy that gives rural households access to more modern lighting and heating. Moreover, it helps reduce pressure on forest resources and dependence on fossil fuels. The PRC's biogas development initiative is probably the most extensive in the GMS. Biogas facilities that are currently used by about 26.5 million rural households generate about 1.02 billion cubic meters of methane. The implementation and use of biogas in the PRC has been so successful that the technology is being extended to other GMS countries, including Cambodia, the Lao PDR, Viet Nam, and Myanmar, where the initiatives are mostly pilot projects supported by the government of the Netherlands.

Hydropower Resources

Hydropower ranks second in importance in the subregion after biomass as a source of renewable energy. In Viet Nam, 97% of electricity generated comes from hydropower; while almost 50% of installed electricity in Myanmar is contributed by hydropower. In Cambodia, the amount of energy generated from hydropower resources is low, but it has a potential installed capacity of 1,825 megawatts which could generate around 9,000 gigawatt-hours of electricity per year. Hydropower in the Lao PDR, on the other hand, has been developed primarily for the export of electricity to Thailand, in spite of the large portion of households that lack access to electricity. The exploitable hydropower potential in the Lao PDR is estimated to be 23,000 megawatts, primarily from the Mekong River and its tributaries.

Solar, Wind and Geothermal Resources

The development of other renewable sources of energy, such as solar, wind, and geothermal, has been relatively slow because of the high investment cost involved. Most of the initiatives are at a pilot or experimental stage. Solar energy is used extensively only in the rural areas of the PRC. Myanmar has 51,974 terrawatt-hours per year potential solar energy to be tapped, especially in the central dry zone area, and other countries in the subregion have a similarly favorable climate and solar power potential.

Status and Prospects for Biofuel Production

The development of alternative renewable energy resources, such as wind, solar, biomass (including biogas), and hydropower, is needed to expand local access to power and enhance energy security. But these renewable sources of energy cannot cater to the immediate fuel needs of the fast-expanding transport sector. To date, biofuels represent the most feasible alternative to liquid fossil fuels. Hence, the countries of the subregion have drawn up biofuel production plans and targets to accelerate their production (Table 5). These targets provide an indication of the

Table 5: Biofuel Development Plans and Targets in the Greater Mekong Subregion

<table>
<tr><th></th><th colspan="9">Year</th></tr>
<tr><th>Country</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>Up to 2020</th></tr>
<tr><td rowspan="5">Thailand</td><td colspan="9">Bioethanol based on molasses (sugarcane) and cassava:</td></tr>
<tr><td colspan="4">E10 and E20: 0.39– 0.74 mt/year</td><td colspan="5">E20: 1.09–2.48 mt/year</td></tr>
<tr><td colspan="9">Biodiesel based on Palm Oil:</td></tr>
<tr><td colspan="3">B2 and B5: 0.36–0.43 mt/year</td><td colspan="3">B5: 0.94–1.03 mt/year</td><td colspan="3">B5: 1.06–1.29 mt/year</td></tr>
<tr><td colspan="9">Biodiesel based on jatropha</td></tr>
<tr><td rowspan="5">PRC</td><td colspan="9">Bioethanol based on maize and cassava : 1.7 mt/year</td></tr>
<tr><td colspan="9">Bioethanol based on non-grain feedstocks (cassava, sweet sorghum, sweet potato):</td></tr>
<tr><td colspan="5">5 mt/year</td><td colspan="4">10–12 mt/year</td></tr>
<tr><td colspan="9">Biodiesel based on waste vegetable oil: 0.2 mt/ year; Rapeseed: 4–5 mt/year by 2020</td></tr>
<tr><td colspan="9">Biodiesel based on jatropha from 2008 onwards: 6 mt/year</td></tr>
<tr><td rowspan="4">Viet Nam</td><td colspan="9">Bioethanol based on sugarcane and sweet sorghum:</td></tr>
<tr><td colspan="3">5 t/year</td><td colspan="5">100 t/year</td><td>540 t/year after 2015</td></tr>
<tr><td colspan="9">Biodiesel based on fish fat and jatropha:</td></tr>
<tr><td colspan="3">3 t/year</td><td colspan="5">150 t/year</td><td>1,090 t/year after 2015</td></tr>
<tr><td rowspan="2">Myanmar</td><td colspan="5">Small to medium-scale bioethanol plants in rural areas to be established</td><td colspan="4">Long-term plans for bioethanol production to be developed</td></tr>
<tr><td colspan="2">Jatropha cultivated on about 3 million hectares.</td><td colspan="7">No clear plans for biodiesel production. Long-term development plans to be formulated.</td></tr>
<tr><td rowspan="3">Lao PDR</td><td colspan="8">Bioethanol based on sugarcane: E10</td><td>Bioethanol based on sugarcane: E20</td></tr>
<tr><td colspan="9">Biodiesel based on jatropha:</td></tr>
<tr><td colspan="3">B2</td><td colspan="2">B5</td><td colspan="3">B10</td><td>B15</td></tr>
<tr><td>Cambodia</td><td>Formal declaration of support by the government</td><td colspan="7">Biofuel production based on jatropha and cassava for export. Blended fuel to be imported.</td><td>Domestic biofuel production and blending for local consumption</td></tr>
</table>

Lao PDR = the Lao People's Democratic Republic, mt/year = million tons per year, PRC = the People's Republic of China, t/year = tons per year.

Note: B indicates biodiesel; the associated number indicates the percentage of biodiesel blended in regular diesel fuel; therefore B15 is a diesel blend containing 15% biodiesel. E indicates ethanol, and the number represents the percentage of bioethanol added to regular gasoline; therefore E10 is a gasoline blend containing 10% bioethanol.

Source: Country reports; production targets for Thailand from 2012 to 2020 are from the Ministry of Energy.

stage of biofuel development in the six GMS countries. The PRC and Thailand have taken earlier and more ambitious steps, and are therefore at a more advanced stage of biofuel development than the other countries.

The People's Republic of China

The PRC is the third-largest bioethanol producer in the world, with a production level of 1.33 million tons (mt) generated at four large-scale bioethanol plants with a combined capacity of 1.5 mt/year (footnote 4). A fifth plant was constructed in 2007 with a production capacity of 0.2 mt/year using cassava as feedstock. The four other existing plants are based on maize and/or wheat. The bioethanol produced is blended with gasoline for use as a transport fuel. The PRC's biodiesel production capacity of 0.2 mt/year is very minimal. The 10 biodiesel processing plants primarily use waste vegetable oil as a feedstock. The biodiesel produced is used to run factory equipment and construction machinery, and is not used as a transport fuel.

The PRC aims to slowly shift its feedstocks for biofuel production from grain to non-grain (Table 5). The country aims to produce about 5 mt of ethanol by 2012 from 1.29 million hectares (ha) of marginal land planted to cassava, sweet sorghum, and sweet potato. It plans to expand production further to reach 12 mt by 2020 from 3.32 million ha of land. These targets are optimistic, and may be adjusted on the basis of the capacity of resources (e.g., soil and water) to sustain economic production of the necessary feedstocks. The level of investment to improve the infrastructure for feedstock collection, transport, and storage will also have a bearing on these targets.

The PRC plans to plant rapeseed on a winter fallow area of 2 million ha to produce 4−5 mt/year of biodiesel by 2020. Jatropha plantations are also being developed to provide an additional 6 mt/year of biodiesel production in 2020. Around 0.83 million ha of energy trees (mainly jatropha) will be planted from 2008 to 2012, and the area will be further increased to 13.3 million ha by 2020. In undertaking these plans, precautionary measures will be considered in the development of biodiesel feedstocks.

Thailand

In 2007 nine bioethanol plants were operating in Thailand, with a combined capacity of 1.26 million liters per day (l/day) (0.39 mt/year) and an actual production of about 0.98 million l/day (0.30 mt/year).[10] This is line with the demand for gasohol,[11] estimated at approximately 10 million l/day or and the equivalent of 3.1 mt/year (Table 5). Most of these plants use molasses from sugarcane as feedstock. More bioethanol plants will operate by the end of 2008, with a registered production capacity of 1.7 million l/day (0.53 mt/year). Most of these newer plants are based on cassava. The bioethanol development program targets 2.4 million l/day in 2011 (0.74 mt/year), expanding further to 8.0 million l/day (2.48 mt/year) in 2020 (Table 5).

The actual capacity of existing biodiesel plants in operation is about 0.5 million l/day, which is below the forecast for 2008 (Table 5). Thai Oleochemicals, and Pure Biodiesel are scheduled to begin operations by 2008, each with a production capacity of 300,000 l/day (0.09 mt/year). With these additional plants in operation, the demand for biodiesel can be easily met. However, the biodiesel program is set to expand further, aiming to reach 4.15 million l/day (1.40 mt/year) in 2020. This will necessitate an expansion in the production capacity of existing plants or the construction of additional plants.

The competition for resources between food and feedstock has not been an obstacle for Thailand in achieving its bioethanol production targets because the country has persistently been a major net food exporter to the rest of the world. However, most bioethanol producers have been affected by large fluctuations in local feedstock prices due to the sensitivity of the crops to price changes on the international market.

Different challenges confront biodiesel producers. The choice of palm oil as the main feedstock has put biodiesel processors in direct competition the suppliers of cooking oil. The Government of Thailand is therefore considering new oil palm plantings, and is planning to diversify biodiesel feedstock sources by growing other energy crops, such as jatropha. In

[10] ADB. 2008. *Strategies and Options for Integrating Biofuel and Rural Renewable Energy Production into Rural Agriculture for Poverty Reduction: Thailand*. Consultant's report. Manila (TA6324-REG).

[11] Gasohol is gasoline with a 5%–10% bioethanol blend.

the interim, jatropha seeds could be imported from neighboring countries such as Cambodia, the Lao PDR, and Myanmar.

Viet Nam

Viet Nam officially began to develop its biofuel subsector in 2007. A broad strategy known as the "Strategy for Developing Biofuel for the Period 2006–2015 and Vision to 2025–Decision 177/QD–TTg" was formulated which set out Viet Nam's biofuel production milestones as follows (footnote 6):

(i) 2010: introduction and mastering of the technology and creating the feedstock production bases.

(ii) 2011–15: taking the initiative, research for technology and productivity improvement, experimentation and testing of B5 and E5, and training of human resources.

(iii) Vision 2025: improving technology to make the quality of the product world-class, and biofuel production to fulfill 5% of total demand for gasoline and diesel.

In accordance with this strategy and milestones, the government set biofuel production targets as indicated in Table 5; i.e., 5 tons per year (t/year) of bioethanol and 3 t/year of biodiesel from 2008 to 2010, increasing to 540 t/year of bioethanol and 1,090 t/year of biodiesel by 2020. Sugarcane and cassava are the chosen feedstocks for bioethanol production. The choice of these crops poses some threat to the supply of sugar for human consumption and inputs for livestock feed. However, the government aims to overcome this through area expansion and yield enhancement so that the supply of these crops will be sufficient to meet the domestic demand for food, feed, and fuel.

In 2007 there were about 70 small processing plants in the Mekong River Delta that produced biodiesel from fish fat. The annual catfish yield averaged 1.00 mt and around 0.60 mt of by-products were produced from the processing of the catch into fillets. These by-products yielded 0.15–0.20 mt of catfish oil. Biodiesel produced so far from fish oil is of low quality and is used only to run small fishing vessels.

So far, no impact of fish oil use on food security has been reported, but conflicts can occur if aquaculture ponds expand over agricultural land used to grow food. Moreover, fish oil and residues are also processed into cattle feed, so their use as biodiesel feedstock could have an impact on the livestock industry. Jatropha is also being considered for biodiesel production.

Cambodia, the Lao People's Democratic Republic, and Myanmar

Cambodia, the Lao PDR, and Myanmar have all expressed a desire to pursue biofuel production, although they have yet to set out specific targets. Biofuel production in these countries is still on a pilot-project basis or at an experimental stage.

In Myanmar, bioethanol based on sugarcane is produced on a limited commercial scale. A production plant located in Maunggone, Sagaing Division, yields 36,000 t/year. This processing plant is about 200 miles from Mandalay, and is also relatively far from Yangon. Both cities have high demand for petroleum and diesel, but transporting ethanol to these cities is problematic because of the high cost. Demand for bioethanol is thus very limited. The Myanmar Economic Corporation—a military-based commercial entity—established two large bioethanol plants with a total capacity of 1.8 million gal/year. Commercial production, distribution, and use started in April 2008. A large private company—Great Wall—is completing a 3,700 gal/day bioethanol-processing plant. Another new factory will be constructed by an associate company of Great Wall in Katha Township. This private company applied for a license and sought government policy on distribution, delivery, and marketing of bioethanol. Meanwhile, other private entrepreneurs are remaining alert to any policy announcement from government bodies.

Besides sugarcane, the other potential crops for bioethanol production are maize, cassava, and sweet sorghum. To date, however, sugarcane is still the most appropriate choice in the context of Myanmar, considering available technology and the structure of existing and newly operating plants that produce bioethanol from molasses. Sweet sorghum is a potential alternative but it is still under experimentation.

Biodiesel production is still at a pilot project stage. Although the country has begun cultivation of jatropha with a view to planting more than 3 million ha by 2010, plans have not been drawn up to establish processing plants due to some uncertainties in relation to the economic viability of jatropha as a feedstock. Research on both feedstock production and biodiesel processing are still needed to ascertain the crop's potential. Government support is also being awaited, both on the policy and investment fronts.

Experience with biofuel processing in Cambodia is project-based. This is true especially in biodiesel, where technology is available to extract oil from seeds to produce biodiesel for diesel engines. The technology for bioethanol production is not available in Cambodia, but it could be obtained through the sharing of knowledge and technology by neighboring countries such as Thailand.

Biofuel production in the Lao PDR, though recognized by the government as a priority area, will be started by Kolao, the biggest agriculture company in the country. In 2006, Kolao initiated a plan to plant jatropha on several hundred hectares of land, primarily slash-and-burn areas. The seeds will be harvested for biodiesel production. However, by 2008 only a few hectares of land had been planted.

The Selected Crops and their Viability

Sugarcane is currently the most significant feedstock for bioethanol, supplying 40% of global production (Table 6). Next in order of significance are maize and cassava. Some countries, such as the PRC and the United States (US), use other cereals, such as wheat, are used to produce bioethanol.

The primary feedstock for biodiesel is rapeseed—a temperate crop which is largely grown and processed in Europe. Tropical feedstocks for biodiesel, such as oil palm, are being used in countries whose climates are conducive, because of their high yield. However, this crop can only be grown in lowland areas with adequate water supply. Sunflower seed and the castor oil plant offer promising alternatives due to the high yield observed in tropical countries. In general, biodiesel feedstocks require less extensive tracts of land for efficient production than bioethanol feedstocks, and some can be grown in combination with other crops. These aspects make biodiesel feedstock crops ideally suited for small farms and farmers. Two crops are becoming popular as alternative feedstock crops: sweet sorghum for bioethanol production and jatropha for biodiesel production. Both are nonfood crops.

Table 6: Major Energy Crops Worldwide

Country	Bioethanol	Biodiesel
Brazil	Sugarcane	—
United States	Maize	Soybean
PRC	Maize, wheat, sweet sorghum	—
Germany	Sugar beet	Rapeseed, sunflower seed
France	Sugar beet	Rapeseed, sunflower seed
Italy	—	Rapeseed, sunflower seed
Canada	Cereals	—
Thailand	Sugarcane and molasses, cassava	Oil palm
Spain	Sugar beet	—
Denmark	—	Rapeseed, sunflower seed
Czech Republic	—	Rapeseed
Australia	Cereals, sugarcane	Sunflower seed

— = negligible production, PRC = the People's Republic of China.

Source: United States Department of Energy. 2008. bioenergy.ornl.gov/main.aspx

The current and potential feedstocks of the GMS countries are indicated in Figure 4. Sugarcane, cassava, and palm oil are used in Thailand; and cassava, maize and wheat are used in the PRC. The use of maize and wheat is now increasingly regulated, however, because of possible repercussions for the food and feed markets. The PRC is evaluating sweet sorghum and jatropha as potential alternative feedstocks; and most of the other GMS countries are considering expanding the use of these nonfood crops. Myanmar's proposal to use broken rice (in addition to cassava, sweet sorghum, and jatropha) as a feedstock for bioethanol is being contemplated because of the huge surpluses of the commodity, and is pending further analysis.

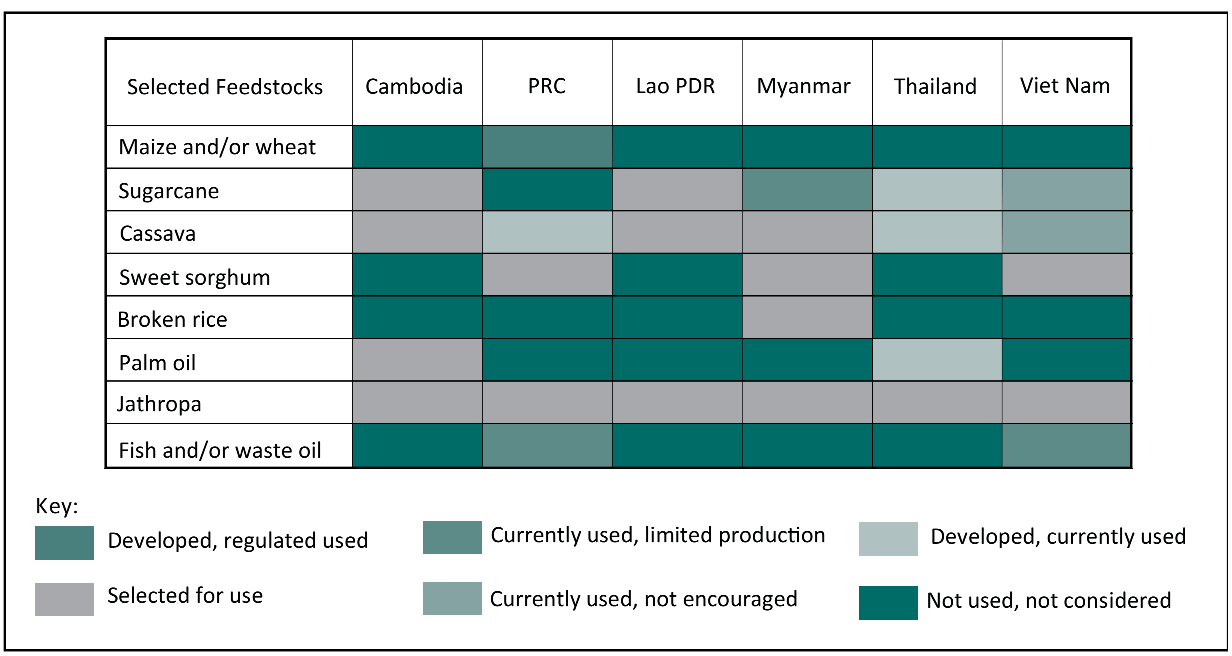
With the exception of sweet sorghum and jatropha, cultivation of these crops is extensive in the GMS, hence farmers are very familiar with them. The other key factors influencing their selection as feedstocks for biofuel production include their current supply and demand situation; their potential for further production increases, either through area expansion primarily in marginal areas or through yield increases; the availability of suitable technology for biofuel production; and their market profitability.

The Supply of and Demand for Feedstocks

Table 7 shows the production and demand status of selected biofuel crops in the GMS. The statistics show an ample supply of sugarcane and cassava, but since these crops are used both as food and animal feed they may create pressure on food prices and food security if used as feedstocks for bioethanol production. This threat is possibly less for sugarcane because molasses—the by-product of sugar production—is the feedstock, rather than the sugarcane itself. However, the demand for sugar is rising. Per capita sugar consumption in Viet Nam, for example, more than tripled from 5 kilograms (kg) in 1992 to 17 kg in 2006 (footnote 6). This consumption rate is still below the world average of 25 kg per capita.[12] The situation is similar in the other GMS countries, except Thailand, where annual per capita sugar consumption is already 33 kg. Thailand is the world's fourth-largest producer of sugarcane and also a major exporter of sugar.

Cassava is a root crop that can be processed into flour and nonfood products, such as degradable plastics. It is also processed into pellets which are often exported

Figure 4: Potential Feedstocks for Biofuel Production



Lao PDR = the Lao People's Democratic Republic, PRC = the People's Republic of China.

Source: Compiled by the authors using information obtained from the country reports.

[12] Food and Agriculture Organization of the United Nations (FAO). 2003. FAOSTAT: *Food and Agricultural Commodities Production.* faostat.fao.org

Table 7: Production and Production/Demand Balances of Selected Feedstocks

Item	2008			2003
	Area Harvested ('000 ha)	Yield ('000 tons/ha)	Production ('000 tons)	Production/ Demand Balances ('000 tons)
Cassava				
Cambodia	74.1	21.2	1,572.6	191.6
PRC	265.2	16.0	4,235.1	113.8
Lao PDR	13.5	9.9	133.6	(79.0)
Myanmar	16.3	12.7	206.5	8.3
Thailand	1,069.6	20.5	21,978.0	6,161.6
Viet Nam	489.2	15.8	7,753.3	301.8
Malaysia	40.7	10.3	420.0	30.0
Indonesia	1,214.4	16.2	19,619.6	801.0
Philippines	2,06.5	8.5	1,754.5	222.2
Asia	**36,63.9**	**17.7**	**64,971.5**	**6,081.6**
World	**18,514.3**	**11.8**	**219,377.8**	**10,951.0**
Sugarcane				
Cambodia	7.8	18.5	143.3	(46.9)
PRC	1,271.9	77.1	98,088.2	(439.3)
Lao PDR	5.9	35.9	211.5	83.4
Myanmar	142.0	50.9	7,229.0	(1,015.3)
Thailand	1,014.3	53.1	53,870.0	187.0
Viet Nam	278.8	55.7	15,542.4	157.2
Malaysia	12.0	70.8	850.0	(598.2)
Indonesia	353.3	75.2	26,566.7	2,800.0
Philippines	387.1	69.8	27,015.0	4,405.5
Asia	**9,022.7**	**64.9**	**585,239.1**	**5,044.2**
World	**20,814.9**	**68.3**	**1,421,028.6**	**40,279.1**
Maize				
Cambodia	95.3	3.5	334.9	122.2
PRC	27,175.4	5.4	145,693.0	4,448.4
Lao PDR	104.9	4.0	424.2	19.0
Myanmar	289.2	3.1	885.7	76.8
Thailand	956.7	3.9	3,767.3	36.2
Viet Nam	1,078.1	3.7	3,962.7	(99.5)
Malaysia	25.3	3.1	79.3	(2,391.8)
Indonesia	3,474.4	3.5	12,172.0	(1,071.9)
Philippines	2,577.5	2.3	6,021.8	(171.4)
Asia	**47,804.2**	**4.3**	**204,770.6**	**(30,087.7)**
World	**150,788.2**	**4.9**	**733,295.2**	**1,928.6**

continued on next page

Table 7: *continued*

Item	2008 Area Harvested ('000 ha)	2008 Yield ('000 tons/ha)	2008 Production ('000 tons)	2003 Production/ Demand Balances ('000 tons)
Oil Palm				
PRC	46.7	14.2	663.3	10.0
Thailand	379.7	17.0	6,453.4	1,000.4
Malaysia	3,673.3	20.8	76,250.0	2,775.0
Indonesia	4,130.0	17.1	70,751.8	10,600.0
Philippines	27.6	11.9	328.1	6.0
Asia	**8,257.4**	**18.7**	**154,446.7**	**14,391.4**
World	**13,319.3**	**13.7**	**182,233.9**	**15,738.2**
Sorghum				
PRC	576.0	4.5	2,584.1	4.5
Thailand	39.0	1.8	68.3	(0.3)
Philippines	0.1	2.3	0.2	0.0
Asia	**10,271.8**	**1.1**	**10,950.4**	**(1,831.6)**
World	**43,469.0**	**1.4**	**60,662.3**	**(1,539.4)**

( ) = negative number, ha = hectare, Lao PDR = the Lao People's Democratic Republic, PRC = the People's Republic of China.

Source: Food and Agriculture Organization of the United Nations.

and are used as a maize substitute in animal feed. Diversion of cassava to biofuel production can cause an immediate spike in the price of the commodity. The same is true when maize is diverted for biofuel production and the demand for cassava pellets for feed use consequently increases. This was Thailand's experience in late 2007 when a large part of the maize supply (especially in the US and the PRC) was diverted to bioethanol production. The rise in the price of cassava caused concern at the country's bioethanol processing plants which were poised to use this supposedly low-priced crop as a feedstock for bioethanol production.

Despite the existence of huge surpluses, great caution must still be exercised in using sugarcane and cassava as biofuel feedstocks because of their varied uses. Fortunately, their production can be increased in the GMS. An important limitation to cassava production must be noted, however: the crop has a tendency to deplete soil nutrients and to pollute water bodies when its wastes are processed. Hence any increase in production through area expansion should be planned carefully.

The use of oil palm as a biodiesel feedstock is probably the most sensitive because the supply of edible oil in the subregion does not meet the demand for cooking oil. While Thailand has so far only used palm oil for biodiesel production on a relatively small scale, the demand for palm oil from the biodiesel producers has risen rapidly. Unless oil palm production is greatly enhanced, the trend could have considerable repercussions for the supply of cooking oil. Thailand experienced an edible oil shortage in late 2007 which led to a dramatic rise in its domestic price and hoarding by large companies.

The choice of sweet sorghum and jatropha as potential feedstocks is primarily due to the fact that they are not food crops. Jatropha seeds are believed to have high oil content and the tree is considered a minor crop, grown sporadically along roadsides, railway tracks, borders of farmers' fields, and as residential fences. Sweet sorghum stalks can be used for ethanol production. Both jatropha and sweet sorghum grow well in marginal areas as they have high tolerance for drought and poor soils, and sweet sorghum can also withstand waterlogging. All aspects of these nonfood feedstocks need further research and analysis.

Viet Nam produces 150,000–200,000 t/year of fish oil. Biodiesel from this quantity of fish oil could partially meet the fuel needs of domestic transport. The production of fish oil is predicted to increase considerably once Viet Nam's aquatic products become recognized internationally. The only potential threat to further expansion would be a backlash against the conversion of agricultural land to aquatic cultivation for the export of aquatic products and production of biodiesel from fish waste.

The Availability of Land for Biofuel Crop Establishment

Table 7 shows the cultivated area of the selected feedstocks in the subregion and Table 8 gives the total agricultural area (both arable and permanent crops) and an estimate of available uncultivated agricultural land by country. The combined area planted to sugarcane and cassava in Thailand was about 1.5 million ha in 2008 and about 1.3 million ha in Viet Nam. This represents about 11% of the total agricultural land in Thailand and 8% in Viet Nam (Table 8). If maize and oil palm areas are included, the percentage of the agricultural land area planted to these four crops increases to 18% in Thailand, and 19% in Viet Nam. The equivalent figure in the Lao PDR is 7%—a relatively large number compared with other GMS countries such as the PRC, for which the figure is only 5.2%. In Cambodia the figure is about 3%, and in Myanmar it is 4%. Expanding the area of sugarcane and cassava in Thailand and Viet Nam is expected to be difficult. Some potential areas remain for additional cultivation of these crops in Cambodia and Myanmar; whereas further area expansion for maize in the PRC and the Lao PDR is expected to be difficult.

Estimates show that there are about 17 million ha of uncultivated agricultural land in the subregion, if the whole of the PRC is included, or 9.8 million ha if the PRC is excluded. These lands are therefore potentially available for additional crop cultivation including crops for biofuel production. It should be stressed, however, that these areas are likely to be marginal, with poor soil quality and adverse environmental conditions which may make it difficult to obtain reasonable crop yields. They are therefore more likely to be suitable for sweet sorghum and jatropha production because these crops can thrive in marginal environments. Moreover, these lands may be in remote areas with inadequate infrastructure, which make it difficult to transport the harvest.

Table 8: Total Agricultural Area and Available Land for Crop Cultivation in the Greater Mekong Subregion in 2008 ('000 ha)

Country	Agricultural Area	Arable and Permanent Crops	Available Land for Cultivation	Corrected Figures for Available Land
Cambodia	5,307	3,807	1,500	1,500
PRC[a]	554,851	154,850	400,001	7,300
Lao PDR	1,909	1,031	878	878
Myanmar[b]	11,293	10,981	312	6,000
Thailand	18,487	17,687	800	800
Viet Nam	9,622	8,980	642	642
Total excluding PRC	46,618	42,486	4,132	9,820
Total	**601,469**	**197,336**	**404,133**	**17,120**

ha = hectare, Lao PDR = the Lao People's Democratic Republic, PRC = the People's Republic of China.

[a] Statistics do not show Guangxi Zhuang Autonomous Region and Yunnan Province (the parts of the PRC that fall within the Greater Mekong Subregion) separately. It should be also noted that either the data on agricultural area are overestimated or the area under arable and permanent crops are underestimated. The PRC's National Study Team indicates that the available cultivable area is only about 7,300,000 hectares.

[b] Available cultivable area in Myanmar is about 6,000,000 hectares (Myanmar Country Report).

Source: Food and Agriculture Organization of the United Nations.

Potential for Increasing Yield

There is huge variation in energy crop yields across the subregion (Table 7). The sugarcane yield, for example, is about 19 t/ha in Cambodia and 53 t/ha in Thailand; though this is low when compared with the PRC's 77 t/ha, Indonesia's 75 t/ha, or the Asian region's average of about 65 t/ha. Cassava yields show similar variation, from about 10 t/ha in the Lao PDR to 21 t/ha in Thailand and Cambodia.

These variations show that there is potential for further growth in production without area expansion. They also indicate the potential for lowering production costs, which would benefit both the feedstock and biofuel producers. High-yielding varieties of cassava and sugarcane are available for adoption by farmers, and considerable progress has been made in breeding sweet sorghum lines with higher millable cane and juice yields;[13] some of these have been commercially released in India.[14]

Yields could also be increased by using improved production practices such as irrigation, mechanization, applying the correct amount of fertilizers, and improving harvesting techniques. However, these measures may involve substantial capital investment which may be beyond the capacity of small farmers, especially if done in the less favorable areas. They also bring environmental costs and risks. These factors need to be taken into account in the formulation of a strategy for biofuel development.

Sweet sorghum has a high biomass output of 3,000–6,000 kg/ha of grain and about 45.0–67.5 t/ha of fresh stem yield. The stem of sweet sorghum is rich in sugar, and is crushed and fermented to produce bioethanol. Table 9 compares the ethanol production of three varieties of sweet sorghum with one variety of sugarcane at experimental station in Myanmar located at Pyinmana. Ethanol production from each ton of stalk ranges from 3.22 l to 6.88 l, depending on the variety. By comparison 1 t of sugarcane stalks produces 4.72 l of ethanol. This underlines the considerable productivity gains that can be achieved by selecting higher-yielding crop varieties.

Jatropha is a fast-growing, sturdy tree that can be grown in combination with other crops; however it suffers some technical problems that have given rise to reservations over its economic benefits when grown as a feedstock crop for biodiesel production. For instance, it has been observed that the oil yield varies quite significantly in different locations. Table 10

Table 9: Ethanol Production per Ton of Stalk (liters)

	Sweet sorghum variety			Sugarcane
Item	M 81 E	Della	NTJ-2	Guitang-11
95% ethanol (liters per ton)	3.22	6.88	3.79	4.72

Source: ADB. 2008. Strategies and Options for Integrating Biofuel and Rural Renewable Energy Production into Rural Agriculture for Poverty Reduction: Myanmar. Consultant's report. Manila (TA 6324-REG).

Table 10: Oil Content of Jatropha Seed from Various Locations in Myanmar, 2006–2007 (%)

Location	Oil Content
Kayah	41.3
Shan (south), Banyin	39.6
Mandalay, Pyawbwe	39.5
Kayin (Thai variety)	36.1
Shan (south), Namlatt	35.1
Shan (north)	34.8
Sagaing (Monywa)	34.1
Sagaing	34.0
Magway	33.9
Big-M	32.8
Bago	31.0
Shan (east)	29.9
Ayeyarwady (Kyankhin)	27.1
Yakhine (Myaypon)	27.1
Sagaing (Tamu)	26.1

Source: Department of Agricultural Research, Ministry of Agriculture and Irrigation, Myanmar.

13 Eg., sweet sorghum lines, SSV 84, SSV 74, and the hybrid NSSH 104.

14 International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). 2007. *Pro-Poor Biofuels Outlook For Asia And Africa: ICRISAT's Perspective.* Nairobi, Kenya.

shows Myanmar's experience with jatropha plants in different areas. The oil content of seeds was found to vary from 26% to 41%. Similarly studies by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) report large oil content variations in India (footnote 14).

Profitability

Table 11 shows the cost of production of bioethanol and biodiesel using different feedstocks and currently available technology. The production cost of bioethanol is as low as $40 per barrel (/bbl) in Brazil, and as much as $128/bbl in the EU. Biodiesel production costs range from $48/bbl in the Pacific Islands to $128/bbl in the European Union (EU). These figures show that biofuels can only be competitive when the price of fossil fuel is high. At a crude oil price of $45–$50/bbl only the Brazilian and Thai bioethanol industries remain competitive; however profits would be marginal since storage and distribution costs would need to be taken into account.

Table 11 also shows the relatively lower cost of production in developing countries, as would be expected in agrarian economies with abundant, low-cost, but skilled family labor. This is particularly the case in Brazil and Thailand for bioethanol; and in India, Indonesia, and Malaysia for biodiesel. Yield improvements in the selected energy crops could further reduce biofuel production costs in the GMS, especially given that the cost of feedstock production accounts for 75% of the total production cost.

Environmental Issues Associated with Biofuel Production in the Subregion

The development and expansion of biofuels is indeed alluring. The net surplus of cassava and sugarcane in the subregion reduces the threat of massive area expansion, leading to the displacement of food crops or encroachment into forests and grasslands. The subregion's abundant resources—vast uncultivated arable lands, cheap labor, and a favorable tropical climate—are conducive to the growth of a wide range of crops, including nonfood crops such as jatropha and sweet sorghum, which can grow in marginal areas. But even the use of these marginal areas, though presumed to be environmentally beneficial, has trade-offs that need to be carefully studied.[15]

The marginal, idle lands perform valuable ecosystem services, such as retaining soil nutrients and water,

Table 11: World Bioethanol and Biodiesel Production Costs ($ per barrel)

Bioethanol	$/bbl	Biodiesel	$/bbl
EU (wheat and sugar beet)	82–128	EU (rapeseed)	64–128
Brazil (sugarcane)	40	US (soybean)	64–107
US (maize)	64–80	India (jatropha)	59–85
Australia (sugarcane)	61	Pacific Islands (coconut)	48–96
Thailand (sugarcane)	43	Malaysia (oil palm)	62
PRC (sugarcane)	85	Indonesia (oil palm)	74

$/bbl = US dollars per barrel, EU = European Union, PRC = the People's Republic of China, US = the United States.

Note: 1 barrel equals 160 liters.

Source: Dufey, A., S. Vermeulen, B. Vorley. 2007. *Biofuels: Strategic Choices for Commodity-Dependent Developing Countries*. Common Fund for Commodities. Amsterdam. The Netherlands.

[15] Long-term soil trials to determine whether cassava improves or degrades soil show that poorly managed cassava production can result to massive soil erosion when grown even on slightly sloped terrain (Howeler, R. H. 2008. *Does Cassava Cultivation Degrade or Improve the Soil?* Presentation).

and providing habitats for many species of plants and animals. They are also often used for livestock grazing or as a source of wild products gathered by rural people for subsistence or cash. Such displacement issues are not often well understood, and are frequently undervalued or ignored. [16]

The ability of feedstocks like jatropha and sweet sorghum to grow well in marginal areas is potentially significant if the areas used indeed have degraded soils, since they offer the potential to maintain or increase the carbon stock of a given area, and therefore may enhance the greenhouse gas performance of biofuel production.[17]

The productivity trade-off of growing crops, including jatropha and sweet sorghum, in marginal areas must also be considered. These plants survive by shedding leaves as an adaptive measure to avoid dying due to excessive moisture loss; but growth is slow and fruiting delayed until rainwater becomes available. Plant growth and yield could be improved with the application of fertilizer. However, unless organic fertilizers—such as animal or green manures—are used, the application of chemical fertilizer may create run-off and consequent onsite and downstream impacts.

Water can also be a limiting factor both in feedstock production and biofuel processing. Sugarcane and oil palm grow much faster under irrigation. The yield gains of nonfood feedstocks also greatly depend on water availability. Water consumption during processing is also high: around 4 l of water are used for every 1 l of bioethanol processed in maize biorefineries in the US (footnote 16).

[16] Turner, B.T., R.J. Plevin, M. O'Hare, and A.E. Farrell. 2007. *Creating markets for green biofuels: measuring and improving environmental performance.* Research report UCB-ITS-TSRC-RR-2007-1. Transportation Sustainability Research Centre. University of Berkeley. US.

[17] Börjesson, P. 2009. Good or bad bioethanol from a greenhouse gas perspective – What determines this? *Applied Energy.* 86 (5). pp 589–594.

Projected Impact of Biofuel Development Plans in the Greater Mekong Subregion

Most projection studies so far undertaken on the impact of biofuel production have predicted rising prices for agricultural crops, threats to food security, and greater impoverishment of the poorer developing countries.[18] These trends are also indicated by the projection analysis undertaken as part of this study which used an analytical framework based on the Global Trade Analysis Project platform.[19] The analytical framework[20] was modified to link agriculture with the energy market and enhanced to include a sector for biofuels. In this exercise, the biofuel development plans of the Greater Mekong Subregion (GMS) countries were incorporated to analyze their net impact on the global and domestic markets.

The model developed and analyzed one reference scenario and four alternative scenarios of biofuel development. The reference scenario assumes that world biofuel production will not expand beyond its production level in 2006; scenario 1 incorporates only the biofuel development plans of Brazil, the European Union (EU), and the United States (US); scenario 2 incorporates the biofuel development of these three major producers with those of the five GMS countries (excluding the People's Republic of China [PRC]); and scenario 3 is scenario 2 with the PRC added. The fourth alternative scenario assesses the effects of global biofuel development determined by market mechanisms under the assumption of high biofuel-gasoline substitution elasticity and high oil price—the "H-H" scenario. The key outcomes for projected prices and production levels under different modeling scenarios are now summarized.

Impact on Global Commodity Prices and Production

The percentage rise of world agricultural commodity prices in 2020 compared with the reference scenario is given for the three alternative scenarios in Table 12. Scenario 1 (the three major biofuel producers) results in price rises ranging from a negligible 0.7% for milk, to 28% for other oilseeds. The price increases of the chosen feedstocks are relatively large: 18% for maize, 13% for soybean, 11% for sugar, 8% for other coarse grains, and 6% for cassava. The additional impact on world prices of the biofuel development plans in the five GMS countries (Scenario 2 versus Scenario 1) and that of the PRC (scenario 3 versus scenarios 2 and 1) is minimal, however.

The projected global price movements resulting from the three scenarios subsequently led to huge production expansions of the energy commodities, particularly maize and sugarcane, in scenario 1 compared to the reference scenario. Only small additional increases in production are seen under scenarios 2 and 3 for these two feedstocks. The impact on the production of cassava and other grains is significant, however, in scenarios 2 and 3. The production of crops that compete for land with energy crops is projected to be lower due to reduced cultivation.

---

[18] Food and Agriculture Organization (FAO). 2008. *Soaring food prices: facts, perspective, impacts and actions required.* High-level Conference on World Food Security. FAO. Rome; International Food Policy Research Institute (IFPRI). 2008. *High food prices: the what, who, and how of proposed policy actions.* IFPRI policy brief. IFPRI Washington, DC; Rosegrant, M. W. 2008. *Biofuel and grain prices: impacts and policy responses.* Testimony for the US Senate Committee on Homeland Security and Governmental Affairs. 7 May 2008.

[19] Asian Development Bank 2008. *Development and impacts of global and GMS regional biofuels in agriculture and the rest of the economy with specific focus on the GMS.* Consultant's report. Manila (TA 6324-REG).

[20] Hertel, T.W. 1997. *Global Trade Analysis. Modelling and Applications.* Cambridge University Press. New York.

Table 12: Impacts on World Average Export Price of Agricultural Commodities in 2020 Compared with the Reference Scenario (%)

Commodity	Scenario 1 (3 producers: Brazil, EU and US)	Scenario 2: (3 producers and GMS-5)	Scenario 3: (3 producers, GMS-5, and PRC)
Rice	4.1	4.5	4.6
Wheat	7.5	7.6	7.8
Maize	17.7	17.8	18.2
Other grains	7.9	7.9	14.4
Cassava	5.5	6.6	8.2
Vegetable and fruit	5.5	5.6	5.5
Soybean	13.6	13.8	13.9
Other oilseeds	27.6	27.8	28.0
Sugar	11.3	12.2	12.3
Fibers	7.7	7.8	7.9
Other crops	11.1	11.3	11.5
Cattle and mutton	2.5	2.5	2.5
Pork and poultry	2.6	2.7	2.7
Milk	0.7	0.8	0.8
Processed food	1.2	1.2	1.2

EU = the European Union, GMS-5 = all the countries of the Greater Mekong Subregion except the People's Republic of China, GMS = the Greater Mekong Subregion, PRC = the People's Republic of China, US = the United States.

Note: The reference scenario assumes world biofuel production will not expand beyond its production level in 2006. Scenario 1 incorporates only the biofuel development plans of Brazil, the EU, and the US; Scenario 2 incorporates the biofuel development of the three major producers and those of the five GMS countries (excluding the PRC); Scenario 3 is scenario 2 with the addition of the PRC.

Source: ADB. 2008. *Development and impacts of global and GMS regional biofuels in agriculture and the rest of the economy with specific focus on the GMS*. Consultant's report. Manila (TA 6324-REG).

Impact on Agricultural Prices and Production in the Greater Mekong Subregion

Tables 13 to 16 show the impact of the projected scenarios on the domestic market of the five GMS countries (i.e., excluding Guangxi Zhuang Autonomous Region and Yunnan Province in the PRC) and on the PRC. As can be seen, the impact of the various scenarios on the domestic economy is much more pronounced than their impact on the global markets. It can further be noted that the effects of scenarios 2 and 3 on the production of feedstocks are particularly dramatic. For example, the rise in cassava production in the five GMS countries compared to the reference scenario is 47% under scenario 2 and 55% under scenario 3 (Tables 15 and 16). The equivalent figure for scenario 1 is -0.9%. The price of sugarcane rises by 37% under scenarios 2 and 3, but only 3.2% under scenario 1.

It is clear from these results that as more resources are devoted to the cultivation of biofuel feedstock crops, the output of other agricultural commodities declines slightly. These changes in domestic land use and agricultural production in favor of biofuel feedstocks can indeed reduce the supply of other crops and therefore threaten food security.

Table 13: Impacts on Price of Agricultural Commodities in Five Countries of the Greater Mekong Subregion in 2020 Compared with the Reference Scenario (%)

Commodity	Scenario 1: (3 producers: Brazil, EU and US)	Scenario 2: (3 producers and GMS-5)	Scenario 3: (3 producers, GMS-5, and PRC)
Rice	3.8	6.5	6.5
Wheat	8.9	9.6	9.8
Maize	11.1	12.5	12.7
Other grains	5.1	6.4	13.3
Cassava	4.2	21.7	25.8
Vegetables and fruit	4.0	6.9	6.9
Soybean	10.3	11.1	11.2
Other oilseeds	12.4	14.1	14.2
Sugarcane	4.8	27.6	27.5
Fibers	8.1	9.1	9.1
Other crops	8.6	9.9	10.0
Cattle and sheep	0.6	1.4	1.3
Pork and poultry	1.7	3.0	3.0
Milk	0.2	0.4	0.4
Processed food	1.5	3.1	3.2

EU = the European Union, GMS-5 = all the countries of the Greater Mekong Subregion except the People's Republic of China, GMS = the Greater Mekong Subregion, PRC = the People's Republic of China, US = the United States.

Note: The reference scenario assumes world biofuel production will not expand beyond its production level in 2006. Scenario 1 incorporates only the biofuel development plans of Brazil, the EU, and the US; Scenario 2 incorporates the biofuel development of the three major producers and those of the five GMS countries (excluding the PRC); Scenario 3 is scenario 2 with the addition of the PRC.

Source: ADB. 2008. *Development and impacts of global and GMS regional biofuels in agriculture and the rest of the economy with specific focus on the GMS*. Consultant's report. Manila (TA 6324-REG).

Further Implications of Projection Results

The projection results also suggest that biofuel production can be positive or negative, depending on the comparative advantage of individual countries in the global market for these commodities. Farmers who own their land and are net sellers of crops in the market are likely to benefit from rising agricultural prices and land values. Biofuel development can be expected to be beneficial for this group, as their incomes and food security will be improved. However, biofuels may be detrimental for the poor, particularly those who are net food purchasers. Social safety nets will therefore need to be set up, or existing social security systems enhanced, to support the most vulnerable members of the population.

It is possible that ambitious biofuel production targets may be automatically cushioned by market forces and adjusted depending on the production capacity of agriculture to supply the needed feedstocks such that the market of other commodities, especially those of food, are not affected. Nonetheless, if developing economies are to reap the benefits of the growth

Table 14: Impacts on Price of Agricultural Commodities in the People's Republic of China in 2020, Compared with the Reference Scenario (%)

Commodity	Scenario 1: (3 producers: Brazil, EU and US)	Scenario 2: (3 producers and GMS-5)	Scenario 3: (3 producers, GMS-5, and PRC)
Rice	2.7	2.9	3.7
Wheat	2.7	2.8	3.0
Maize	11.8	11.9	12.4
Other grains	6.3	6.4	56.7
Cassava	2.9	4.7	61.2
Vegetables and fruit	2.2	2.4	2.9
Soybean	10.9	11.1	11.2
Other oilseeds	22.3	22.5	22.8
Sugarcane	6.0	7.3	7.7
Fibers	5.0	5.2	5.8
Other crops	7.1	7.3	7.4
Cattle and sheep	1.5	1.7	1.7
Pork and poultry	2.0	2.2	2.4
Milk	1.2	1.3	1.3
Processed food	1.5	1.6	1.6

EU = the European Union, GMS-5 = all the countries of the Greater Mekong Subregion except the People's Republic of China, GMS = the Greater Mekong Subregion, PRC = the People's Republic of China, US = the United States.

Source: ADB. 2008. *Development and impacts of global and GMS regional biofuels in agriculture and the rest of the economy with specific focus on the GMS*. Consultant's report. Manila (TA 6324-REG).

in biofuel production and still maintain adequate levels of food security, a complementary set of policy measures and investments would need to be made to produce benefits for consumers of both food and energy, while also contributing to the broader growth of national economies and the betterment of human welfare.[21] One such policy measure is the integration of small producers of feedstocks into the biofuel supply chain.

[21] Rosegrant, M. W., S. Msangi, T. Sulser, R. Valmonte-Santos. 2006. Biofuels and the Global Food Balance. In Hazel, P. and R. K. Pachauri, eds. Bioenergy and Agriculture: Promises and Challenges. *2020 Focus*. 14. November 2006. Washington, D.C. IFPRI.

Table 15: Impacts on Agricultural Production in Five Countries of the Greater Mekong Subregion in 2020 Compared with the Reference Scenario (%)

Commodity	Scenario 1: (3 producers: Brazil, EU and US)	Scenario 2: (3 producers and GMS-5)	Scenario 3: (3 producers, GMS-5, and PRC)
Rice	(0.5)	(2.7)	(2.8)
Wheat	(0.8)	(1.9)	(2.2)
Maize	14.3	10.4	10.7
Other grains	(3.0)	(4.6)	12.8
Cassava	(0.9)	47.4	55.1
Vegetables and fruit	(0.5)	(2.6)	(2.7)
Soybean	10.9	6.9	6.1
Other oilseeds	12.1	8.3	8.2
Sugarcane	3.2	30.8	30.7
Fibers	6.0	1.5	1.5
Other crops	6.7	2.8	2.7
Cattle and sheep	(0.2)	(0.5)	(0.5)
Pork and poultry	(0.1)	(1.2)	(1.2)
Milk	(0.5)	(0.7)	(0.7)
Processed food	(0.7)	(3.0)	(3.1)

( ) = negative number, EU = the European Union, GMS-5 = all the countries of the Greater Mekong Subregion except the People's Republic of China, GMS = the Greater Mekong Subregion, PRC = the People's Republic of China, US = the United States.

Source: ADB. 2008. *Development and impacts of global and GMS regional biofuels in agriculture and the rest of the economy with specific focus on the GMS*. Consultant's report. Manila (TA 6324-REG).

Table 16: Impacts on Agricultural Production in the People's Republic of China in 2020 Compared with the Reference Scenario (%)

Commodity	Scenario 1: (3 producers: Brazil, EU and US)	Scenario 2: (3 producers, and GMS-5)	Scenario 3: (3 producers, GMS-5, and PRC)
Rice	(0.2)	(0.2)	(0.5)
Wheat	(0.5)	(0.5)	(0.9)
Maize	18.0	17.9	17.0
Other grains	(5.2)	(5.3)	93.6
Cassava	(3.9)	1.5	632.2
Vegetables and fruit	(0.2)	(0.2)	(0.8)
Soybean	14.3	14.3	13.9
Other oilseeds	71.4	71.3	70.6
Sugarcane	5.4	6.9	3.1
Fibers	4.8	4.8	3.8
Other crops	(6.7)	(6.7)	(10.1)
Cattle and sheep	(0.2)	(0.2)	(1.3)
Pork and poultry	(0.8)	(0.7)	(2.3)
Milk	(0.8)	(0.8)	(1.6)
Processed food	(0.7)	(0.7)	(1.8)

( ) = negative number, EU = the European Union, GMS-5 = all the countries of the Greater Mekong Subregion except the People's Republic of China (Guangxi Zhuang Autonomous Region and Yunnan Province), GMS = the Greater Mekong Subregion, PRC = the People's Republic of China, US = the United States.

Source: ADB. 2008. *Development and impacts of global and GMS regional biofuels in agriculture and the rest of the economy with specific focus on the GMS*. Consultant's report. Manila (TA 6324-REG).

Appropriate Agribusiness Options for Small Farmers

A range of business options that have been employed for other crops in the countries of the Greater Mekong Subregion (GMS)may also be applicable to the production of biofuel feedstocks by small farmers.

Economic Land Concession Model

The economic land concession model, which is used in Cambodia and the Lao People's Democratic Republic (Lao PDR), entails the leasing of government land (up to 1,000 hectares [ha] in Cambodia and 10,000 ha in the Lao PDR) to private citizens in partnership with foreign investors to develop plantations of crops such as rubber, oil palm, cashew, coffee, and energy crops such as sugarcane, cassava, and jatropha. The model triggers rural development in the form of new roads and other infrastructure, promotes agricultural diversification, and ensures a steady supply of feedstock. Its downside is that farmers are involved only as laborers.

Contract Farming

Contract farming is the most widespread model. It can be formal, based on a legally binding contract, or informal, based primarily on mutual trust and relationship. Farmers agree to sell their produce to companies or processors at a mutually agreed price. To make the sale more binding, the company or processor provides credit for the purchase of farm inputs or as advance payment on the produce that farmers can use for other consumption needs. Support may also be in kind, in the form of production inputs such as seeds, fertilizer, and pesticides. In some cases, technical assistance may also be extended to the contract farmers by the company or processor to improve production practices, farm management, and harvesting.

There are many examples of contract farming in the GMS. In Cambodia, Angkor Kasekam Roonroeung has engaged 80,000 local farming households in the contract-growing of rice. In Viet Nam, contract farming ventures have been successfully undertaken for tea leaf cultivation by the Tea Cau Dat, pomelos by Hoang Gia Enterprises, and sugarcane by Lasuco in Than Hoa Province. In the clustered plantation concept in Thailand, which operates in a similar manner, farmers are grouped by 1,000 ha area to facilitate feedstock consolidation and collection.

As contract growers, farmers are indirectly involved in the commodity supply chain via the middlemen or consolidators. They may or may not benefit from this arrangement, depending on whether they receive a price premium for their produce or whether they are being squeezed by either the middlemen or consolidators, or the processing plants.

Community-Based Models

Another popular business model is the community-based model in which farmers are organized into village-level organizations, cooperatives, or associations. In the Lao PDR, community-based associations are known as village development groups. This model is effective because it enables farmers to band together primarily to gain bargaining power against the middlemen or large-scale processors. This has been done for commodities like vegetables, fruit trees, nuts, and other subsidiary crops to coordinate production and consolidate and market the output. Cooperation brings a coherent voice and political influence, leading to better leveraging of government resources (e.g., national research and development institutes) and more productive dealings with private suppliers. If managed well, the extensive, dispersed network of cooperatives also serves as an invaluable channel for flows of information, expertise, and services back to farmers, e.g., for the sourcing of farming inputs bought in bulk at low cost, training in new techniques, farm management advice, and access to microcredit.

Business Models for Biofuel Development in the Greater Mekong Subregion

As an instrument of rural development, small farmers must be integrated into the biofuel supply chain. According to a study by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (footnote 14):

The challenges for pro-poor biofuel development then are two pronged:

1. To find ways that the poor who are connected (or readily connectable) to market economies can contribute and prosper within a large-scale, industrial biofuels paradigm; and

2. For more isolated villages dependent on self-sufficiency rather than connection to the cash economy, to find ways to help them achieve greater energy self-sufficiency through biofuels, as a first step along a development pathway that leads them towards the market economy to escape from poverty.

To date, bioethanol production in the People's Republic of China (PRC) and Thailand is primarily based on the contract farming model to ensure feedstock supply (footnotes 4 and 10). Existing processing plants in the PRC are state-owned, although they are moving toward privatization. They obtain their feedstock supply of either maize or cassava via contractual arrangements with grain traders in the case of maize, and local farmers in the case of cassava. About 70%–80% of the maize is purchased from grain traders at market prices; the remainder is purchased from farm households, typically at a lower price.

In Thailand, bioethanol production is owned and managed by private companies. These are attached to sugar manufacturing plants (as is the case in Brazil) and operate under a buyback arrangement to establish a long-term, stable market for the farmers' produce and an assured supply of feedstock for the processing plant. The pricing of materials is based on negotiation but with a minimum price guarantee. Some sugar mills provide the seedlings, fertilizer, food and cash advances to households. Likewise, the company may send technical staff to introduce new, intensive farming techniques, and to train the contracted farmers. Depending on the location and conditions of households, processing mills may provide transport for the timely collecting of materials. Any expenditure made in advance by the company is automatically deducted from the proceeds of the purchased crops at zero interest. Furthermore, any breaches of contract are penalized.

Although the industry is dominated by large-scale processing plants, there is room for small-scale bioethanol production ventures to coexist. This requires a balance to be found between the dominance enjoyed by the large-scale industries and smaller cooperatives that require thoughtful planning and execution by all parties—farmers, government, and private companies. Some examples of successful coexistence of these two scales of production are the smallholder farms in Malaysia that are able to compete favorably with large-scale feedstock plantations. As long as the large companies continue to use small farmers to provide their supply of feedstocks, the small farmer can stay connected to the market economy and thus prosper alongside large-scale producers.

Since biodiesel cultivation is at an early stage of development in the GMS, it offers an excellent opportunity for small investors to become involved. Owners of small oil palm or jatropha plantations can collaborate in a community-based business venture to collect biodiesel feedstocks and deliver them to the extraction plants for crushing and pressing into crude oil. The extraction plants can be financed and owned by the village communities. Conversion to biodiesel can also take place within villages, and biodiesel could be blended with diesel for sale in the community.

Integration of small farmers in the full business supply chain cannot happen without conscious effort and investment by development agencies working in concert with the private sector and research institutions. These small producers need a lot of support to organize themselves into community enterprises in order to establish, operate, and sustain biofuel business operations. Training may be needed in leadership and management skills, and investment support will need to be provided, alongside access to research and development and new technology. A few cooperatives of this type in Thailand have apparently done quite well. Small oil palm plantations undertake collection and delivery of oil palm fruits to the extraction plants for conversion into crude palm oil. The extraction plants can be financed and owned by the communities themselves and conversion to biofuel may be done within the villages through the support of the local government and the Ministry of Energy. There are other farmers' organizations at the grass-roots level known as cooperative societies.

Cross-Border Trade in Feedstocks and Biofuel

Considering the diverse nature of GMS countries in terms of their resource endowments, availability of infrastructure, and skills and expertise, cross-border trade in both feedstock and biofuel offers another avenue to begin the development of the biofuel subsector. Biofuel crops can be produced in one country for processing in a neighboring country. The processed product can then be exported. An example of such an arrangement is the contract farming agreement in which the Lao PDR grows tomatoes and baby corn for canning in Thailand. Some of the canned products are exported back to the Lao PDR. Crude palm oil can be produced in Cambodia and converted into biodiesel in Thailand for sale in the Lao PDR. Jatropha can be produced in Myanmar and its seeds exported to Thailand or the PRC for large-scale oil extraction and biodiesel production. Large-scale extraction plants offer the advantages of greater efficiency and better oil quality.

The diverse characteristics of the GMS are not sufficient justification for entering into cross-border trade. The ground rules for biofuel development will need to be carefully formulated at the outset in order to assess whether the subsector will cater to the domestic market alone, or to both the domestic and international markets. This will help ensure that the subsector realizes its potential of fueling sustainable growth and progress and preventing impoverishment of the chronically poor and inflicting greater damage on the increasingly fragile environment.

Cross-border contract farming can take place among the GMS countries. One platform that can be used for cross-border trade arrangements is the Ayeyarwady–Chao Phraya–Mekong Economics Cooperation Strategy which involves Cambodia, the Lao PDR, Myanmar, Thailand, and Viet Nam. Other channels could be developed to include the PRC and other countries outside the GMS.

Policy, Regulatory, and Institutional Support for Biofuel Development

Major Policies to Promote Bioethanol in the People's Republic of China

The People's Republic of China (PRC) set up a series of policies to support bioethanol production beginning in the late 1990s. The first Five-Year Plan for bioethanol—the Special Development Plan for Denatured Fuel Ethanol—and the plan for Bioethanol Gasoline for Automobiles in the 10th Five-Year Plan (2001–2005) had the main goal of experimenting with bioethanol production, marketing, and support measures. In the initial years, substantial support was provided in the form of investment in research and development and the development of technology. At the same time, national standards for denatured fuel ethanol and bioethanol gasoline for automobiles were formulated and implemented. The other major support policies include the waiving of consumption taxes, refunding of value added tax on bioethanol production, provision of a production subsidy to ensure a minimum level of profit for the processing plant, and market control in favor of state-owned bioethanol processing plants.

These policies were continued with minor revisions as bioethanol production and use expanded in the PRC. The only major revision was on the fixed profit/loss subsidy that was replaced by a "flexible subsidy for loss" which is linked to the domestic price of gasoline. In addition, a risk fund was set up from which to draw the loss subsidy to smooth shocks due to oil price fluctuations. A new production subsidy was also formulated and approved for firms that develop a new production base using feedstock that is not produced on the existing cultivated land area. This policy is in response to increasing concern regarding the trade-off between food (grain) security and energy security. The government also provides support for the operations of large bioethanol plants that provide demonstration services to other bioethanol plants.

Major Policies to Promote Biofuel in Thailand

The King of Thailand's "Sufficiency Economy Principle" is the cornerstone of agricultural development in Thailand. Its five maxims are (i) know what you are doing;
(ii) be honest and persevere; (iii) take the middle path, avoiding extremes; (iv) be sensible and insightful in making decisions; and (v) build protection against shocks. This principle has guided biofuel development in the country. Progress in biofuel production and use is summarized as follows:

Biofuel Production

(i) Sugarcane, cassava, and oil palm are used as feedstocks, but the extent of their use is guided by the rule "food first before biofuel". Production expansion will be undertaken but primarily through yield improvement.

(ii) Special privileges are provided to biofuel processors in the form of zero taxes for machinery and other equipment, and zero income taxes for the first 8 years of operation.

(iii) A policy of minimal intervention has been adopted for the issuance of permits to establish bioethanol processing plants; and in the case of biodiesel, there is no intervention at all on permit issuance.

(iv) A revolving fund has been established to assist entrepreneurs who invest in projects that replace fossil fuel with alternative fuel sources in their plants (e.g., the production of biogas from wastewater and electricity generation from biomass in palm oil extraction plants).

(v) A directive has been promulgated on proper water discharge by processing plants to reduce the pollution of waterways, and regular checkups on gasohol engines are conducted to reduce possible air pollution.

(vi) A fair pricing structure has been adopted to enable biofuel producers to be competitive. The biodiesel price is dependent largely on the world (Malaysian) price of crude palm oil, whereas the price of ethanol uses the import price parity principle, in which the world (Brazilian) price of ethanol is the major determinant.

Biofuel Use

(i) A plan has been developed for the gradual substitution of gasoline and diesel biofuel blends over time, with an accompanying policy that requires all government vehicles to use the biofuel blends and encourages private car owners to do the same.

(ii) There are policies on grading and product standardization, and strict quality control.

(iii) A regulated lower price has been introduced for biofuel blends compared to conventional gasoline and diesel. Any losses incurred by the imposition of the lower price are compensated from the Oil Fund—a fund from levies paid by oil and natural gas producers and importers.

Biofuel Policies in the Other Countries of the Greater Mekong Subregion

Cambodia, the Lao PDR, Myanmar, and Viet Nam have not yet formulated specific policies to support biofuel production despite having defined production targets. Support for energy crop production is, however, currently embodied in the countries' agricultural development plans, especially when deciding which crops will be cultivated in order to promote farm diversification and to increase farm incomes. Viet Nam is in the process of refining its policy support for biofuels in accordance with Decision No. 177/2007/QD-TTg. This includes the allocation of investments to promote biofuel production on a much larger scale, increased public awareness on the use of biofuels, and the provision of incentives to private companies that engage in biofuel production. Cambodia, the Lao PDR, and Myanmar have expressed broad policy recommendations that are incorporated in the Subregional Strategy for Developing Rural Renewable Energy and Biofuels in the Greater Mekong Subregion.

Subregional Strategy for Developing Rural Renewable Energy and Biofuels in the Greater Mekong Subregion

The great potential for developing biofuels in the Greater Mekong Subregion (GMS) can be better realized if development occurs in a coordinated rather than a piecemeal fashion. A coordinated strategy to develop and implement plans on a subregional level can benefit all the GMS countries given their proximity to one another, the declining importance of borders as transport networks become increasingly integrated, and their diversity in terms of resource endowment and stage of biofuel development. To make progress in this direction, a subregional framework for developing rural renewable energy and biofuels was formulated, endorsed, and accepted by the GMS countries during the 5th Technical Working Group for Agriculture Meeting held in Vientiane, the Lao People's Democratic Republic (Lao PDR), on 22–24 September 2008 (Appendix 5).

Key Thrusts of the Subregional Biofuel Development Framework

The overall goal of the framework is to promote poverty reduction, enhance food security, and improve the welfare of small farmers through greater access to energy, especially in the rural areas. To achieve this goal, specific strategies are identified to support the following key thrusts to ensure a flourishing and sustainable biofuel subsector:

(i) Development of carefully designed biofuel production plans that guide area expansion and yield improvement of selected feedstocks and that strategize biofuel processing plant size and location in order to ensure minimal or zero competition with food crops in terms of resource use and markets. Country biofuel production plans are developed in the context of overall economic development plans and then consolidated into a subregional biofuel production plan (perhaps through a regional workshop). The consolidated plan will guide possible cross-border trade of feedstocks and biofuels.

(ii) Strong research and development, accompanied by strong human resource capacity in feedstock production and biofuel processing technologies that could be gained through training, experience-sharing and knowledge exchange within and outside the subregion. The type and level of training will differ between countries because of their diverse levels of biofuel development. Cambodia, the Lao PDR, Myanmar and Viet Nam can learn from the experiences of the People's Republic of China (PRC) and Thailand in biofuel production. Tapping public–private partnerships for knowledge exchange and experience sharing will be valuable.

(iii) Expanding small-scale biofuel business ventures that involve small farmers from feedstock production to biofuel marketing and could generate employment and promote poverty alleviation in the countryside. These can be initiated through pilot projects, and the small business ventures will eventually be linked to larger-scale biofuel production plants. This involves the promotion of public–private partnerships.

(iv) Promising cross-border trade arrangements based on the countries' relative competitiveness in feedstock and biofuel production, formulation of an effective biofuel pricing structure, establishment of an appropriate system to maintain quality standards, and development of the necessary infrastructure support.

(v) An effective public awareness campaign on the proper production and use of biofuels and other alternative renewable energy resources in the GMS countries, especially with regard to promoting environmental protection.

Policy Recommendations

Biofuel development clearly involves a wide spectrum of strategies and activities, each with corresponding economic, social, and environmental implications. Implementation of the strategies requires robust policies. Some of these policies already exist and need to be strictly enforced and/or enhanced. Other policies have to be formulated, especially those needed to support small farmers. The key policy recommendations are summarized as follows:

(i) National land use policies need to be further enforced, particularly those aspects relating to land allocation and distribution, and strengthening of the property rights and security of tenure of farmers, especially the use of abandoned lands (such as mine lands) for energy crop cultivation.

(ii) Area development and feedstock production policies need to be put in place to guide the selection and use of feedstocks to avoid putting pressure on the food market, competing with food crops for land and water resources, or inducing further degradation of ecologically sensitive areas. These area development and feedstock production plans should be formulated in harmony with the community and national socioeconomic development plans.

(iii) Biofuel production and use policies should be formulated in conjunction with the area development and feedstock production policies, to help regulate the proliferation of biofuel processing plants and strategize their location to gain maximum support from the country's infrastructure development plan. This policy should also encourage biofuel processing plants to be designed to accommodate mixed feedstocks.

(iv) To safeguard the environment from possible negative impacts of the proliferation of biofuel processing plants, policies are needed to require bioethanol plants to submit their wastewater treatment plans preventing the discharge of wastewater into tributaries and to conduct regular air pollution tests on vehicles that use biofuels to check pollution emissions.

(v) An enhanced investment support policy is needed to fund research and technology development and enhancement of human resource capability. Key areas for research are the potential of nonfood feedstocks such as jatropha and sweet sorghum, and the impact of extensive cultivation of marginal areas. Training and extension is needed on technology and management practices to improve production efficiency in the industry. Knowledge exchange among the GMS countries should be encouraged and promoted.

(vi) An investment support policy is needed for productivity-enhancing activities such as soil and land improvement, irrigation expansion and road development, enhancement of breeding, crop management, seed production programs, and the establishment of demonstration projects. Support is also needed for a limited production subsidy to help establish small biofuel production ventures in rural areas.

(vii) A policy is needed to promote closer coordination of public institutions to ensure proper guidance and monitoring of biofuel development plans and programs that are undertaken—often independently—by numerous government offices (e.g., agriculture, forestry and natural resources, energy, and science and technology). One way to achieve this coordination is to establish a national biofuel board or committee.

(viii) Time-bound incentive policies are needed to encourage private sector participation such as tax holidays, tax awards, or tax exemptions, and provision of credit and loans. Other innovative market incentives should be developed to strengthen public–private partnership in biofuel development especially in research and technology development and in knowledge sharing that would benefit the small producers.

(ix) An appropriate pricing policy needs to be formulated for bioethanol and biodiesel blends to encourage fair competition but also to provide protection to both feedstock and biofuel producers in the face of fluctuating commodity prices.

(x) Cross-border trade and investment policies are needed that benefit all GMS countries and include pro-poor contract growing arrangements, appropriate pricing systems, and effective product grading and standards aimed at improving product quality of both feedstock and biofuel.

The Way Forward

Country governments will need to assemble personnel from key public offices and other institutions, such as research centers and relevant private companies, to further discuss translating the framework into action in the light of available information and resources. These discussions should start with a review of national biofuel production targets. This review should bear in mind the findings of the simulation exercise on biofuel trends in the subregion which demonstrate the potential for significant changes in domestic agricultural production, land use, and trade in favor of the chosen energy crops and to the detriment of food crops.

The following additional activities will need to be undertaken to update and enhance existing plans and ensure more effective implementation of the strategic framework.

Development of a Resource Database. A relevant public institution in each country should be identified and tasked with developing, managing and maintaining a resource database to facilitate the monitoring of biofuel production, use, and trade. Capacity-building may need to be undertaken in the selected institution to help it fulfill its responsibilities. A mechanism will need to be established for coordination at the subregional level (possibly to be integrated in the currently operational Agricultural Network Information System) and to monitor and integrate biofuel production and trade among the countries of the GMS.

Market and Research Studies. A more detailed market study needs to be conducted to assess feedstock and biofuel production and trade in the subregion. The study should also include an analysis of the sustainability and economic profitability of biofuel production by small farmers, and should assist in identifying other potential feedstocks that do not compete with food crop cultivation.

Studies are needed to investigate the potential for biofuel production of non-grain energy crops, such as jatropha and sweet sorghum, and to develop more appropriate production technology, including varietal improvement; farm management practices need to be improved, including fertilizer application, and the use of irrigation facilities; and alternative processing technologies need to be evaluated. The potential of marginal land for energy crop cultivation and the associated environmental impacts also need to be investigated.

All the studies identified could be undertaken by independent researchers with funding from development partners.

Technology Transfer. Technology transfer and knowledge exchange on biofuel processing among GMS countries will help accelerate the advancement of biofuels in the subregion. This can be achieved by, for example, establishing pilot demonstration projects based on proven technologies, such as biogas technology which can be applied in remote rural areas with plentiful animal and crop wastes. Another example of a pilot project could be a community-based biofuel processing plant, such as a biodiesel plant based on jatropha oil, which is managed and operated by small farmers in the community.

Financial support for technology transfer can be solicited from the private sector. Pilot projects can be established as a joint activity between the country government and a private company, with additional funding supplied by development partners.

Conclusion

Biofuel will continue to be a part of the solution to energy deficiency, especially in the rural areas of the GMS. Downswings in fossil fuel prices should not be taken as a reason to become complacent and to stall efforts to develop efficient and less costly biofuels and other alternative energy sources. The price of oil can change overnight, but substitutes that reduce the use of fuel oil take time to develop and adopt. Low fuel oil prices should be seen as an opportunity afforded to countries to carefully plan a rational and efficient strategy for the production and use of biofuel and other renewable energy sources that would indeed promote energy security, agricultural development, poverty reduction, and environment protection without threatening food security.

Appendix 1: Terms of Reference of the Study

Regional Technical Assistance Number 6324: Expansion of Subregional Cooperation in Agriculture in the Greater Mekong Subregion

A comprehensive analysis is necessary to take into account the scope of the biofuels market and determine the extent to which economic and societal values weigh upfront the costs and benefits of biofuel development. This analysis can also be a valuable tool in reshaping planned or existing programs to maximize their efficiency and their net benefits to national welfare.

A rigorous economic analysis of a biofuel program aims to examine whether the substitution of a petroleum fuel, for example, with the equivalent quantity of a biofuel (taking into account the differences in the fuel economy of the two fuels) results in a positive net benefit. With this principle in mind, the quantitative analysis should take into account the costs and benefits of biofuel production from the cultivation of feedstocks to the final product of either ethanol or biodiesel. This appendix briefly describes the methodology for undertaking these analyses. It also indicates some of the difficulties, such as the scarcity or absence of relevant information.

Considering the stage of biofuel development in the Greater Mekong Subregion (GMS), it may be premature to undertake a rigorous quantitative socioeconomic assessment to weigh the costs and benefits of the program. The country assessment study proposed will therefore necessarily be more qualitative in nature and will provide a preliminary assessment on the commercial viability of biofuels development in the long run to feed into the development of a firmer national biofuel program or the refinement of existing strategies.

Objectives of the Assessment Study

(i) To undertake a preliminary but comprehensive assessment of the economic and market potential of biofuels to assist in the identification of promising areas for investment to promote rural development;

(ii) to assess the adequacy of current technology for biofuel systems development and identify needs for research and development, training, and human capacity-building; and

(iii) to review current policies to promote biofuel development and identify appropriate policy levers to strengthen public–private partnerships, encourage investment, and promote cross-border trade.

Proposed Areas for Investigation

Market outlook

To analyze trends in energy supply and use and determine prospects for biofuel production and demand:

(i) Energy supply and demand analysis in the country by source;

(ii) analysis of the international fossil fuels market (oil import and export trends and prices);

(iii) description of current greenhouse gas levels and the likely future trend; and

(iv) supply conditions of biofuels substitutes (e.g., solar, hydropower, and wind).

Characterization

Describe the biofuels resource base and identify the biofuels technology—both existing and in the pipeline for:

Feedstock Production

(i) Identify potential feedstock crops: location, production volume, yield and potential for increasing yield (and reducing cost), potential as feedstock (oil or starch content), and technology to increase production;

(ii) estimate cost of production and income;

(iii) describe and analyze the feedstock supply chain and trade, especially their potential for cross-border trade; and

(iv) describe the socioeconomic profile of the feedstock producers or target groups.

Biofuel Production

(i) Describe existing biofuel plants (if any), the type of feedstock, location, capacity (sources of feedstock), and volume of production;

(ii) estimate the cost of production and income;

(iii) identify and describe the current technology and technology in the pipeline for biofuel production, and research and development support to improve production;

(iv) identify and describe by-products of economic value;

(v) describe and analyze the biofuel marketing chain and trade, especially the potential for cross-border trade; and

(vi) describe the socioeconomic profile of the biofuel producers.

Technology Development in Biofuel Production

(i) Describe existing and pipeline technologies for feedstock production improvement;

(ii) describe the research and development support for feedstock production;

(iii) describe existing and pipeline technologies for biofuel production improvement;

(iv) describe the research and development support for biofuel production; and

(v) describe the complementary technical skills necessary to sustain biofuel systems.

Prioritization

Identify options for feedstock and biofuel development based on simple cost–benefit analysis. (Note: the word simple is used to indicate that the analysis will be more qualitative in nature, especially in the absence of unit values for costing and valuation purposes.) Cost–benefit analysis will be based on parameters as indicated.

Evaluate and identify potential feedstocks taking into consideration:

(i) market potential (including for example, implications for livelihood generation, and trade potential);

(ii) implications for food security (competition with food usage);

(iii) economic risks;

(iv) impact on human health and environment (e.g., greenhouse gas emissions); and

(v) land use and land use issues (impact of large-scale monoculture of feedstocks—destruction of cultures and traditions of indigenous people, extensive use of agro-chemical inputs, drought and extreme climatic conditions, land concentration, marginalization of small-scale agriculture, and habitat loss).

Identify and describe alternative options for biofuel production and evaluate these options in terms of:

(i) the availability of selected feedstocks;

(ii) market potential;

(iii) existing plant capacity;

(iv) technology needs and potential;

(v) infrastructure support needs;

(vi) costs and benefits of potential by-products;

(vii) economic risks;

(viii) impact on human health and the environment;

(ix) availability of skilled personnel; and

(x) convergence with the country's agricultural plan.

Biofuels Business Options

Potential agribusiness models need to be identified that will integrate small farmers into the biofuel market chain, promote national and cross-border trade and investment, and strengthen public–private partnership. Some examples are contract farming schemes, and arrangements in which one country is the supplier of feedstock while another is the biofuel producer.

Policy, Regulatory, and Institutional Support

Policy gaps in agricultural planning and legislation for biofuel development should be identified. Appropriate policy levers should be identified and the regulatory and institutional environment improved to implement integrated strategies, market-enabling measures, and institutional frameworks to steer biofuels development towards the long-term well-being of the rural poor (e.g., product and safety standards, regulations for establishing contract farming or other consolidated production ventures, regulations for cross-border trade in energy crops, and technology and skills).

(i) Policies on public–private participation in biofuel development (particularly in supply generation). In the People's Republic of China (PRC) for instance, rural renewable energy programs—such as biogas—are administered directly by the government. Development of private-sector-based supply and finance has yet to be considered, unlike in Cambodia. Thailand continues to adhere to an administered price system for sugar, molasses, and ethanol; an apparent inconsistency between these price policies probably led to some well-publicized shortfalls in domestic supply.

(ii) Outward-looking policies: Current strategies continue to be inwardly focused. An orientation towards domestic markets and energy needs is appropriate but this should not detract from the creation of new possibilities for foreign trade, regional cooperation, and international finance. The potential for cooperation in the GMS is significant. Relatively advanced technologies are available for international dissemination, both in biogas from the PRC and crop fuels in the PRC and Thailand. Another fertile venue for cooperation would be cross-national supply chains, involving cross-border investment in feedstock through contract farming, subsequent trade in feedstocks, and cross-border investments in processing facilities. Biofuel trade and investment would benefit greatly from current initiatives towards GMS trade cooperation and facilitation, especially through the GMS trade corridors.

(iii) Policies to mitigate or eliminate potential economic, environmental, and social risks from the promotion of agribiofuels: The rush for commercial gain should not obscure the potential disadvantages of biofuels. These risks, though not sufficient to warrant a halt to biofuels development, should be at the forefront of strategies, policies, and regulations related to farming for energy.

Methodology of Conducting the Comprehensive Impact Assessment Study

Conduct country workshops prior to the start of the assessment study to undertake the following:

(i) Finalize a concept note on "Biofuel Prospects: An Assessment Study". This concept note will outline the different activities (e.g., data collection, key person interviews, and focus group discussions) that will be needed to assess biofuel development potential based on the areas for investigation.

(ii) Identify the country assessment team, its scope of work, and responsibilities.

(iii) Define a time frame for study implementation, identifying specific milestones.

(iv) Identification of an independent local consultant who will coordinate the activities and provide guidance on data and information collection, analysis, and report-writing.

(v) The study will primarily involve a compilation, review, and synthesis of literature, secondary data, case studies, and information from key person interviews and focus group discussions related to bioenergy development and cooperation in and for the GMS.

(vi) Analysis will be both qualitative and quantitative (to the extent this can be supported by existing information and data).

(vii) Regular meetings will be conducted for updating on work development, discussing problems that may be encountered, and discussing recommendations to overcome such problems to determine possible changes of scope of work and work plans and/or activities.

(viii) A final workshop will be held to present the results of the country assessment study.

Appendix 2: Impact Study Timeline

Activities	Expected Date of Accomplishment	Actual Date of Accomplishment
Final Country Assessment Study proposal	15 December 2007	February 2008
Consolidated Country Assessment Study proposal	January 2008	April 2008
Study implementation	November 2007–July 2008	November 2007–August 2008
Mid-progress report submission	Third week of March 2008	June 2008
First draft of final report	First week of June 2008	July–August 2008
Final draft of initial report	Third week of June 2008	First to Second week August 2008
Final country presentation of study results	From first week of July 2008	
Thailand		12 July 2008
Viet Nam		25 July 2008
Myanmar		08 August 2008
Lao People's Democratic Republic		11 August 2008
Cambodia		18 August 2008
Final report submission (comments from workshops incorporated)	First week August 2008	Fourth week of August 2008
Consolidation of reports and subregional biofuel strategy	August–September 2008	September 2008
Regional Biofuel Workshop, Vientiane, Lao People's Democratic Republic	September 2008	September 2008
Final Report submission	October 2008	December 2008

Appendix 3: Country Workshop Schedules and Comments

Cambodia

Final Workshop Program

Greater Mekong Subregion Economic Cooperation Program Final Consultation Workshop for the Biofuel Assessment Study

Program and Agenda
18 August 2007, Phnom Penh, Cambodia

2:00–2:30	Registration
2:30–2:45	Opening Session
	Welcome Remarks, Dr. Hang Chuon Naron, Secretary General of Ministry of Economic and Finance and Permanent Vice Chairman of Supreme National Economic Council
	Welcome Remarks by Mr. Haruhiko Kuroda, President of the Asian Development Bank (ADB); and Mr. Arjun Goswami, Cambodia Resident Mission Director, ADB.
	Introduction of the project, Mercidita A. Sombilla, Southeast Asian Research Center for Graduate Study and Research in Agriculture

Session I

2:45–3:00	Presentation on the Energy Market Outlook
3:00–3:15	Presentation on Biofuel Characterization and Priorities
3:15–3:30	Presentation on Agribusiness Models in Practice
3:30–3:45	Presentation on Policy, Regulatory, and Institutional Support for Biofuel Development
3:45–4:00	Coffee Break

Session II

4:00–5:30	Questions and Comments

The People's Republic of China

Comments from the Workshop

Introduction and Background

The final policy workshop on "Strategies and Options for Integrating Biofuel and Rural Renewable Energy Production into Rural Agricultural for Poverty Reduction in the People's Republic of China" was organized by the Center for Chinese Agricultural Policy, the Chinese Academy of Sciences, and held on 9 October 2008 in Beijing, the People's Republic of China (PRC).

The objective of the workshop was to discuss the options and potential impacts of the PRC's biofuel and rural renewable energy development program, with the specific objective of evaluating the progress of the project "Strategies and Options for Integrating Biofuel and Rural Renewable Energy Production into Rural Agricultural for Poverty Reduction in the Greater Mekong Subregion: A case Study of the People's Republic of China".

The workshop brought together the project team members from the Chinese Academy of Sciences, the Chinese Academy of Agricultural Engineering, and the Center of International Cooperation, Ministry of Agriculture, as well as the policy advisers of this project from Department of International Cooperation, Ministry of Agriculture. The workshop was organized as part of the ADB-funded project: Strategies and Options for Integrating Biofuel and Rural Renewable Energy Production into Rural Agricultural for Poverty Reduction in the Greater Mekong Subregion: A Case Study of the People's Republic of China.

The Meeting

Dr. Jikun Huang, Director of Center for Chinese Agricultural Policy (CCAP), Chinese Academy of Sciences, and the research team leader of this project, opened the meeting at 8:30 am on 9 October 2008. He outlined the purpose of the meeting. Dr Huanguang Qiu from CCAP presented the background, project activities, progress, and major findings of this study. After this presentation, policy advisers of this project and research team members expressed their comments on the research progress, methodologies and data being used, the results of the studies, and suggestions on how to improve the final report. Mr. Zhang Yahui, Deputy Director of Center of International Cooperation, Ministry of Agriculture, concluded the meeting at 11:45 am. Since most of the contents of Dr. Qiu's presentation were covered in the final report, here only brief the major comments and suggestions of the participants are listed.

Major Comments and Suggestions from the Participants

Wang Jiucheng said that this study has fulfilled all the requirements of the project as required by ADB and has provided very useful insights and policy suggestions for sustainable development of the PRC's biofuel and rural renewable energy subsector in the future. He also highly recommended the quantitative research methods and models had been used in this study, and suggested that the research members of this project should have a closer collaboration in the future with ongoing projects of the Ministry of Agriculture in the field of rural renewable energy. He also invited Dr. Huang to give a presentation at a conference on 30 October 2008, especially to introduce the CHINAGRO model used in this project to other researchers.

After giving a high praise for this study, **Kou Jianping** gave specific suggestions on how to improve the final reports, including (i) to update the data on the development of the PRC's biofuel and rural renewable energy development from 2006 to 2007; (ii) when talking about the production potential of biofuel from marginal lands, it should be mentioned that there are other constraints such as temperature, water resources, and the cost effectiveness of collecting feedstocks from marginal land; (iii) the negative impacts of biofuel development on livestock production should be explained with wariness, because some by-products of biofuel can be used as feeds (for example, if more sweet sorghum were cultivated for biofuel production, it may produce more feed materials from the by-products); (iv) because feedstock production in the PRC is widely distributed, and given the high cost of collection, transportation, and storage of these feedstocks, the future development of rural renewable energy should also be decentralized. Small-scale biofuel plants should be encouraged in the future, which is also very helpful for actively incorporating farmers into the biofuel industry. He suggests to including this as one policy suggestion in the final report.

Tang Shengyao suggested (i) regarding the production potential of biofuel feedstocks on marginal lands, the constraints of water resources, soil quality, and accumulative temperature should also be considered, but given the limited resources and the limited time for this project, it is hard to do all these assessments during the project timeframe (ii) ADB and the Government of the PRC should put more effort and financial resources into investigations in this field; (iii) in the section of policy recommendations, "improving the efficiency of energy use" should be added as it is an important way to improve national energy security.

Zhang Yahui noted that the importance of household biogas development in the future should be emphasized in the summary and policy implications section of the final report.

Lu Xiaoping summarized that this study gives a detailed review of the development of biofuel in the PRC, market potential of biofuel products, production potential based on possible land resource and feedstocks in the country, and analyzed its potential impacts on the PRC's rural and agricultural development. This study has fulfilled all the requirements of this project required by ADB, and provided very useful insights and policy suggestions for sustainable development of biofuel and rural renewable energy, which are important for both the PRC and other GMS countries.

After summarizing the suggestions of other participants, he also emphasized the importance of regional corporations on meeting the challenges of energy security, especially in the field of biofuel and rural renewable energies. He also encouraged Chinese researchers to participate more actively in the studies lead by ADB, and have closer collaboration with the researchers from other countries of the Greater Mekong Subregion (GMS) in the near future.

On behalf of all the researcher members, **Huang Jikun** thanked the policy advisers for their important support for this study. He also said that the comments and suggestions raised by the participants are very helpful, and the research team will revise the final report according to those suggestions.

Places Visited and People Interviewed

The PRC: List of Places Visited during the Country Assessment Study

Department of International Cooperation, Ministry of Agriculture

Department of Science, Education and Rural Environment, Ministry of Agriculture

Department of Rural Science and Technology, Ministry of Science and Technology Department of Industry Management, National Development and Reform Commission

Jilin Fuel Ethanol Company, Jilin Province, the PRC

Household biogas facilities, in Hohhot, Inner Mongolia Province, the PRC

Household biogas facilities, in Tongliao City, Inner Mongolia Province, the PRC

Village station for plant residue gasification, Tongliao City, Inner Mongolia Province, the PRC

Village stations for plant residue gasification, Siping City, Jilin Province, the PRC

People Interviewed during the Country Assessment Study

Wang Mengjie, Professor and expert on sweet sorghum-based bioethanol, Chinese Academy of Agricultural Engineering

Hao Xianrong, Division Director, Department of Science, Education and Rural Environment, Ministry of Agriculture

Jia Jingdun, Deputy Director-General, Department of Rural Science and Technology, Ministry of Science and Technology

Li Nuyun, Director General, Office of Forestry Biofuel Energy, State Forestry Administration

Several officials at Light Industry Division (in charge of biofuel development), Department of Industry, National Development and Reform Commission

Lu Xiaoping, Director-General, International Cooperative Department, Ministry of Agriculture

Tang Shengyao, Division Director, Department of International Cooperation, Ministry of Agriculture

Wang Jiuchen, Division Director, Department of Science, Education and Rural Environment, Ministry of Agriculture

Kou Jianping, Division Director, Department of Science, Education and Rural Environment, Ministry of Agriculture

Zhao Lixin, Director, Institute of Rural Energy and Environmental Protection, Ministry of Agriculture

Fei Wang Deputy Director, Institute of Rural Energy and Environmental Protection, Ministry of Agriculture

Chen Rukai, Professor and specialist in sugarcane ethanol, Academy of Agricultural Sciences of Fujian Province

Song Andong, Professor and specialist in cellulosic ethanol, Henan Agricultural University

Jijun Zhang, Deputy General Manager, Bio-chemical and Bio-energy Division, China National Cereals, Oils and Foodstuffs Import and Export (COFOCO)

Wu Guoqing, Specialist on feedstock processing and biofuel production at Bio-chemical and Bio-energy Division of COFCO

Technical manager, Jilin Fuel Ethanol Company, Jilin Province, the PRC

Farmers with household biogas facilities, in Inner Mongolia and Jilin provinces, the PRC

Village leaders and managers of the village station for plant residue gasification in Inner Mongolia and Jilin provinces, the PRC

The Lao People's Democratic Republic

Final Workshop Program

Country Assessment Study: Strategies and Options for Integrating Biofuel and Rural Renewable Energy Production into Rural Agriculture for Poverty

11 August 2008, Science and Technology Research Institute, Vientiane, Lao People's Democratic Republic

8:00–8:45: Registration

8:45–9:00: Briefly on Project Objective and Overview of Project by

Ms. Keophayvanh Inexiengmay
Deputy Director General of Science and Technology Research Institute

9:00–9:15: Opening speech

Dr. Maidom Chanthanasinh
Vice President of National Authority for Science and Technology

9:15–9:30: Speech by

Mercedita A. Sombilla
ADB Project Coordinator
Philippines

9:30–9:50: Coffee break

9:50–11:00: Report on Current Situation of Biofuel in the Lao People's Democratic Republic (Lao PDR) and suggestion on the strategy and policy for the promotion of Biofuel in the Lao PDR by:

Mr. Bouathep Malaykham
Chief of Electric Power Management Division
Department of Electricity, Ministry of Energy and Mines

11:00–11:30: Discussion

11:30–11:45: Summary of Discussion

11:55–12:00: Closing the meeting by:

Mr. Kham Sanatem
Deputy Director of National Agriculture and Forestry Extension Service, Ministry of Agriculture and Forestry

Myanmar

Final Workshop Program

Final National Workshop on Assessment of Biofuel and Rural Renewable Energy Development in Myanmar

5 September 2008, Royal Kumudra Hotel, Nay Pyi Taw, Myanmar Annotated Provisional Agenda

10:00–10:30	Registration
10:30–11:00	Opening Session
	Opening Remarks by U Tin Htut Oo, Director General, Department of Agricultural Planning
	Remarks by Dr. Mercedita A. Sombilla, Consultant ADB on the Country Assessment Mission's Final Workshop
11:00–11:15	Coffee Break
	Plenary Session: Presentation on Country Assessment Study Chaired by Dr. Aung Kyi, Pro-Rector of Yezin Agriculture University
11:15–11:30	Opening remarks by Dr. Mercedita A. Sombilla, Consultant, ADB
11:30–11:50	Overview of the outcome of the Country Assessment on Biofuel and Rural Renewable Energy Development in Myanmar presented by U Hla Kyaw, Deputy Director General, Team Leader
11:50–12:10	Presentation made by Dr Thanda Kyi, Market Analyst, on the component of Market Outlook in the country assessment study
12:10–12:30	Presentation made by U San Thein, Biofuel Specialist on the Characterization component of the country assessment study
12:30–13:30	Lunch
13:30–13:50	Presentation made by U Aung Hlaing, Agribusiness Specialist on the Biofuels Business Options Component
13:50–14:10	Presentation made by U Tin Maung Shwe, Policy and Institutional Development Specialist, on the Biofuels Policy, Regulatory, and Institutional Support
14:10–14:30	Presentation on bioethanol development update in Myanmar made by U Sein Thaung Oo, Member of Executive Committee, Myanmar Engineering Society
14:30–14:45	Lessons learnt from the development of biofuel in Thailand; policy framework, and mechanism, presented by U Boon Thein, Director (Planning) of the Department of Agricultural Planning
14:45–15:00	Coffee Break
15:00–16:00	General Discussion
16:00–16:20	Outcome of the Final Workshop Summarized by U Boon Thein, Director (Planning) of the Department of Agricultural Planning
16:20–16:30	Closing Remarks by Dr. Aung Kyi, Pro-Rector of Yezin Agricultural University
16:30	Closing of Final Workshop

Thailand

Comments from the Workshop

Comments on the Final Report on Biofuels Country Assessment Study: Thailand

11 July 2008, Bangkok, Thailand

(i) Thailand's energy consumption is much larger than the combined energy consumption of Cambodia, the Lao PDR, and Viet Nam.

(ii) The transport, logistics, markets, businesses, investment, and policies of the member countries of the Association of Southeast Asian Nations (ASEAN) should be linked together to create a mass market and promote the economic expansion of all countries in region.

(iii) Dr. Samai recommended that farmers should gather into cooperatives or community enterprises (especially in the case of oil palm farmers) in order to build enterprises by applying the community rice mill model. Farmers can establish small-scale community palm oil extraction plants with a production capacity of 1 ton per hour (t/hour) or 5 t/hour and require a palm cultivation area around 2,000–5,000 rai (320–800 hectares [ha]). Effective small-scale palm oil extraction plants are suitable for the extraction of cooking oil, animal foods, electricity generation, and biomass management. As for the excess supply of palm oil, the simple solution is to burn it to generate energy.

(iv) Oil palm cultivation should be promoted in abandoned fields or acidic soil areas, such as in central Thailand and Rangsit. Farmers have already initiated oil palm cultivation in Kanchanaburi, Utaithani, and Sra-Kaew.

(v) The increased cultivation area of energy feedstock crops should be achieved without influencing food and energy prices. The extensive development of transport networks linking all regions implies that a study of feedstock management in all regions would be useful and should be undertaken.

(vi) Regarding the conflict between food and fuel both in production and marketing, Thailand uses only surplus fuel crops to produce energy, once consumption needs are taken into account, as can be seen from the biofuel policy. For instance, the compulsory use of B2 was mandated by the government as there was not enough fuel crop surplus to mandate B5. If B5 were introduced, fuel crops would be channeled to the energy sector and food security would be affected.

(vii) Ajarn Bundit Fungthammasan from the School of Graduate Studies, King Mongkut's Institute of Technology noted that the forecast for biodiesel feedstock for 2011, based on the assumption of expansion of the area of oil palm cultivation, is on track. Khun Sudarat explained that the Ministry of Agriculture and Agricultural Cooperatives set a goal for the new oil palm cultivation area of 0.5 million rai (80,000 ha) in the central and northeastern part of the country, and 2.5 million rai (400,000 ha) within 5 years in abandoned fields provided by Land Development Department. Some farmers who grow rubber may switch to oil palm because of the labor shortage. Hence the expansion of the oil palm cultivation area is expected to meet the target. The planting of oil palm outside the promoted area needs to be confirmed by the Ministry of Agriculture and Agricultural Cooperatives to check that the area is appropriate for investment, according to the new constitution which the ministry must carefully carry out.

(viii) The management of the value chain for oil palm from tree to biodiesel still has a lot of problems.

(ix) Khun Pornsil also suggested that additional study on price mechanism impacts should be conducted in addition to biofuel policies and regulations. Also various issues such as port facilities, too much reliance on foreign policy, and free export of ethanol need to be tackled by the Ministry of Energy. Moreover value chain analysis should be employed to study interrelationships of the different factors affecting the different levels of the value chain.

(x) Ajarn Kanit proposed that the title of the report name should be changed from "biofuel" to "ethanol and biodiesel" as biofuel includes liquid fuel and gas which are not emphasized in report as much as ethanol and biodiesel. In relation to yield potential, the area cultivated to oil palm might not need to be raised if more attention were paid to (i) the technology used, including harvesting which produces a huge amount of waste; (ii) the extraction process which returns an average output of only 15% whereas the potential return is 24%–25%; (iii) the terms of the contract, since harvesting is usually done on a fixed payment contract, in which the contractor aims to maximize the kilograms (kg) or tons of palm rather than harvesting the ripened palm fruit, and therefore less output is generated than could be the case; and (iv) other potential products should be considered as it may be more productive to manufacture the feedstock into alternative products rather than biofuel.

(xi) Dr. Samai advised that stock management both for the demand and supply side is also important. In addition, GMS countries should focus on effective management of excess stock. There should be an organization to oversee biofuel waste management.

Viet Nam

Final Workshop Program

Final Workshop Agenda
Strategy and Options for Integrating Biofuel Production into Rural and Agriculture Development of Viet Nam

25 July 2008, Ministry of Agriculture and Rural Development

8:00–8:10	Inauguration and introduction of distinguished guests and presenters Ms Nguyen Thi Tuyet Hoa, Deputy Director General International Cooperation Department, Ministry of Agriculture and Rural Development (MARD)
8:10–8:25	Project Introduction: Assessment of Regional Resources for biofuel development in the Greater Mekong Subregion by Dr. Mercedita A. Sombilla, Project Coordinator and ADB representative
8:25–8:45	Introduction about country assessment study for biofuel development in Viet Nam by Dr. Dang Kim Son, Director Institute of Policy and Strategy for Agriculture and Rural Development, MARD
8:45–9:15	Market Outlook and Assessment of Country Resource Bases for Biofuel production in Viet Nam by MSc Tran The Tuong, Department of Crop Production, MARD
9:15–9:30	Tea break
9:30–10:00	Prioritization of Country Resource Base and Strategy for Integrating Biofuel Production into Agriculture and Rural Development in Viet Nam Dr. Nguyen Anh Phong, Centre for Agricultural Policy, Institute of Policy and Strategy for Agriculture and Rural Development (IPSARD)
10:00–10:30	Questions and Answers
10:30–11:30	Dialogue among policy makers, researchers and enterprises
11:30–11:45	Conclusion and Recommendations of the workshop

Presenter	Content
Dr. Nguyen Do Anh Tuan Director of Southern Centre for Agriculture Policy and Strategy	**Brief presentation of study in Viet Nam** (i) 5 countries participate in the initial project (ii) 4 principal questions: assessment of the potential market; estimate of supply; rank for priority feedstocks for biofuel production; choice of organizing market to promote the greater participation of the poor and small producers. (iii) Team research presided over by IPSARD in close cooperation with the departments of Crops, Livestock, Cooperatives and Rural Development, and Forestry and International Co-operation; under the MARD
Dr. Dang Kim Son General Director IPSARD	**Dr Son declares the opening of the workshop** This is one of the MARD's earliest pieces of research on the future development of biofuel. (i) The world's oil reserves are enough for only another 30 years. In 2007, biofuel production worldwide was still limited (20% of demand). If the oil price is $40 per barrel, biofuel can meet an estimated 10% of demand. If the oil price is $50, 50% of energy demands will be accommodated by biofuel. It is clear that this is a market issue, depending on the scarcity of petroleum and technology. (ii) Developed countries give substantial subsidies to their biofuel industries, for which funding of research is essential. Regarding environmental issues, carbon dioxide emissions put everyone at risk of climate change. Regarding social issues, in the context of subsidies for the cultivation of corn and wheat for biofuel production (corn price increased by 70% recently), some countries began to experience food scarcity. (iii) In November 2007, the government of Viet Nam approved the strategy for biofuel development, elaborating policies related biofuel development and raising public awareness, drawing up the roadmap, focusing on technology development, and training of human resources to 2010. By 2010, biofuel is expected to meet 0.04% of the domestic demand for petroleum; in 2015, 1%; and in 2020, 5%. It is necessary to have solid collaboration among countries of the GMS, which have similar conditions. This is reason for IPSARD's cooperation in this study. Economic and social issues must be balanced. If there is too much emphasis on economic issues, food security and society will be strongly affected. On the other hand, excessive emphasis on social aspects would be detrimental to the economy and energy security.
Dr. Mercedita A. Sombilla	**Presentation on biofuel initiative** (i) Core Agriculture Support Program of ADB (ii) GMS WGA Initiative on Biofuel: workshop, research (iii) Country Assessment Studies on the Prospects of Biofuel in the GMS (iv) 6 countries involved in study: Cambodia, the PRC, the Lao PDR, Myanmar, Thailand, and Viet Nam.
Dr. Nguyen Do Anh Tuan	**Presentation about study and research process in Viet Nam**

continued on next page

Final Workshop: *continued*

Presenter	Content
M.Sc. Tran The Tuong Department of Crop Production,	**Presentation on the prospects for biofuel supply and demand in Viet Nam** Two principal objectives: (i) determine the demand and supply in energy estimate (ii) identify the characteristics of domestic feedstocks would be suitable for developing biofuel The energy deficit could be addressed by developing renewable energy such as biofuel. The following solutions are proposed: (i) renewable energy (wind energy, solar power, biogas, bioenergy [ethanol and biodiesel]) (ii) Use of agricultural crops and forestry plants (sweet sorghum, moringa, and jatropha), of which forestry plants have great potential
Dr. Nguyen Thanh Son Deputy Director of Department of Livestock, MARD	**Comments:** (i) The research is highly appreciated. (ii) World attitudes towards biofuel have changed since food scarcity appeared. The Food and Agriculture Organization is against the use of food crops to produce biofuel. (iii) There are several other potential food crop resources from which to produce biofuel and other renewable energy. (iv) Jatropha has the most potential for the production of plant-based biofuel. (v) In Myanmar, jatropha has been studied extensively but has not yet become a commodity. The plant is easy to use. (vi) Attention must be paid to its effect on the area for other plants and the quality of land. (vii) Fish fat from catfish in Mekong Delta of Viet Nam can also be used to produce biodiesel, and this does not affect food security. A problem with fish fat is that it freezes in cold weather and this gives rise to engine problems. The biofuel production base of jatropha and fish fat need continued study in the Viet Nam context.
	Tea Break
Dr. Nguyen Anh Phong Centre of Agriculture Policy, IPSARD	**Prioritization and option for biofuel development in Viet Nam** (i) Viet Nam has natural advantages for biofuel production. (ii) There is great support for the biofuel industry in other countries. In summary: (i) Viet Nam has sufficient advantages for biofuel production in accordance with the plan associated with Decision 177. (ii) Viet Nam should focus on competitiveness, advantages and disadvantages of biofuel production, and feedstock options (iii) Private enterprise plays a key role in biofuel development and pioneering new varieties for higher yielding feedstocks. (iv) Government support of state-owned farms is optional. They are not run at efficiency, so may be converted to feedstock areas and processing plants for biofuel. (v) Government plays a key role in guaranteeing the output market for biofuel, i.e., compulsory biofuel sales volume in gas stations. There will be four pilot cities (Ha Noi, Hai Phong, Da Nang, Ho Chi Minh) before nationwide implementation.

continued on next page

Final Workshop: *continued*

Presenter	Content
Dr. Nguyen Do Anh Tuan Leading the session	Comments are invited from the participants on what the biofuel production business model will look like.
Dr. Ngo Duc Hiep Director of South centre for Technology development, Southern Institute of Forestry Science	(i) The Binh Tay Trade and Investment Company signed a contract with a German company to develop jatropha in Viet Nam to produce biofuel for export to Germany. The signing of the $100 million contract was witnessed by the Deputy Prime Minister. 100,000 ha of jatropha will be developed in Ninh Thuan and Binh Thuan provinces. (ii) Rubber seed is another potential plant for biofuel production. The area planted to this crop has been expanded to up to 1 million ha, providing an abundant and stable supply for biofuel production. (iii) In the PRC and South Korea, seaweed is also used to produce biofuel. The department of science and technology in Ho Chi Minh City visited South Korea. The plant has a lot of potential in Viet Nam as the long coastline is suited to seaweed production. Issues for further study: (i) The principal problem for the development of jatropha in Viet Nam is its low yield (5t/ha). Jatropha varieties are imported from countries where the annual yield can be 10-15 t/ha. Seed selection and cross-breeding is needed to solve this yield question. (ii) Our center has studied this issue extensively. We collaborated with Dalat Nuclear Research Institute in genetic research to increase productivity. Jatropha does not shed its leaves in the dry season, so the plant grows and produces seeds year-round. This accounts for the high seed yield. The import of new seeds is also a solution for raising the seed yield. We imported four seed varieties from Malaysia (Viet Nam has only three varieties). The planting of these varieties may be expanded to a large scale to reduce costs and raise yields. (iii) Jatropha could have additional cost but a high revenue only after year 3. With the current price of about VIE3,000–4,000/kg and a productivity of 5–7t/ha/year, agriculturalist's revenue from jatropha established on bare land will be VIE20–25 million/ha/yea r. (iv) Another problem is the availability of land for jatropha development. Investors want to produce on an industrial scale, but have difficultly because sufficient land is not available. To run a processing factory effectively, a minimum plantation of 20,000 ha is required. (v) Jatropha will have potential if it is correctly planted. Its by-products can be used for animal food and as a fertilizer. (vi) 3 t of jatropha seed can be processed to produce 1 t of biodiesel and 2 t of waste. If the waste is used as a fertilizer would only yield a few hundred dollars per ton of feed; but if processed again to remove toxins, it can be used as animal feed, and could yield up to $4,000 for each ton of feed. (vii) We must also care about the relationship between investors and farmers to promote both of them. Jobs need to be created for farmers and the land used more effectively. (viii) Contract farming is important.
Dr. Nguyen Do Anh Tuan	(i) We have to discus the selection of alternative crops and technology. (ii) Multiuse of plants leads to a diversified product to avoid risk.

continued on next page

Final Workshop: *continued*

Presenter	Content
Dr. Pham Van Tuan Head of Science Department, Thanh Tay University	(i) It is most important is to demonstrate the economic viability of the crops to persuade farmers to plant feedstock for biofuel production. If farmers perceive the advantages, they will cultivate the crop. (ii) It is better to develop biodiesel rather than bio-ethanol (iii) The four feedstocks mentioned are correct. However, the options for expanding the area of sugarcane are limited. Even inputs and materials needed for sugarcane production have problems in price and supply. Thus, there is a need to further study the bioethanol production and development from sugarcane. (iv) Sweet sorghum stems can be used to produce ethanol. But sweet sorghum must be cultivated in the existing agricultural area; hence its impacts on food security need to be considered. (v) Jatropha needs to be developed on a large scale in order to be profitable for farmers. A yield of 5–6 t/ha/year is sufficient, but few of regions achieve this result. Moreover, the oil ratio of jatropha in Viet Nam is still low. (vi) Moringa has not yet been studied concretely in Viet Nam. (vii) Fish fat, if it is used for biodiesel production, could produce a toxic gas and become frozen during cold weather causing engine damage. (viii) The strong point of jatropha its lack of impact on food security. (ix) Thanh Tay University studied jatropha and sweet sorghum. The result show that the sweet sorghum yield is 90 t/ha (3 harvests a year), the sugar ratio is 10%, and ethanol yield is 9–10 t/ha (lower than other countries). (x) We agree with your feedstocks proposal. Worldwide the three most commonly used feedstocks are rapeseed, oil palm and jatropha. Jatropha is the best choice in for economic and environmental reasons. Some say jatropha is toxic; however, only the waste after processing is toxic, and we are studying how to remove the toxins so it can be used for animal fodder.
Mr. Dam Hong Quang Director of Nui Dau company	(i) Our company strategy is to construct small factories on a local scale to reduce transport costs brought about by the wide distribution of plantation areas in the northern uplands. The by-product is used for animal feed. (ii) The development of biofuel based on state farms would not be effective because of their weak management. Enterprises do not lack land, they lack land ownership as collateral. (iii) Regarding tax policy, enterprises prefer a tax award rather than a tax exemption. The government should not introduce large subsidies into the industry since this would distort the market. The subsidy would be better used if farmers are the beneficiaries, as they ensure the supply of inputs for the processors. (iv) We need a more effective land policy from the government to make it easier for enterprises to rent land, and at the same time for farmers will have additional benefits if they will be engaging in jatropha production.
Dr. Nguyen Do Anh Tuan	Consider feedstock solutions to develop biofuel in the poor northern mountain region. Investment in infrastructure is needed.

continued on next page

Final Workshop: *continued*

Presenter	Content
Dr. Luong Van Tien Deputy Director of Forestry Science Institute	(i) Voices appreciation for this study related food security and environment. (ii) The research team has its own point of view which is not influenced by developed country guidelines. (iii) The northern mountainous region has potential for maize cultivation. This could be used to produce biofuel onsite, rather than transporting the feedstock to the city for processing. Why don't we use maize to produce biofuel? (iv) There are several projects and programs for developing jatropha in Viet Nam. With farmers, the problem is economics. I am in favor of developing jatropha, but a detailed analysis of its economic and environment impacts is needed.
M.Sc. Tran The Tuong Department of Crop Production, MARD	(i) Regarding the question of maize cultivation, the Crops Department and the MARD have clear development strategies and plans. (ii) Maize cannot be planted on land with too steep a gradient; hence the area for maize production is limited. (iii) Currently, the MARD has given the go-ahead for a project to develop maize for animal feed. Up to 2010, the output of maize will be insufficient for processing into animal feed.
Mr. Vu Huy Phuc Institute for Policy and Strategy, Ministry of Industry and Trade	It is better to choose to develop either biodiesel or bioethanol and to concentrate on one or two plants.
Dr Nguyen Anh Phong	As has been stated, biofuel feedstock areas have been developed in regions with remaining unused and bare land. These areas are always faced with poverty, so we hope that biofuel would be an appropriate solution not only for the recovery of the vegetation but also to improve livelihoods in these regions. Ensuring food security is always the first priority to be considered in our plans.
Dr. Pham Van Tuan University Thanh Tay	We don't encourage planting jatropha in the central highland region. It is preferable to plant it in highland and mountainous regions.
Dr. Mercedita A. Sombilla	(i) Biofuel should be developed together with the transport sector. (ii) The technology gap will make us go further, providing additional information and a framework for the application of technology in Viet Nam for the first time. (iii) Develop a manual of potentials to identify two or three factors: technology, alternative crops (focus on 2–3 initial crops), and additional activities needed for each crop. (iv) The contract farming arrangement with neighboring countries Cambodia and the Lao PDR has great potential to help identify the policy direction. (v) Thank you for the comprehensive study.

continued on next page

Final Workshop: *continued*

Presenter	Content
Dr. Nguyen Do Anh Tuan	**Conclusion** Necessary issues for further study: (i) Study alternative land policies to promote partnerships between enterprises and farmers. Initially, pilot projects may be set up for such partnerships in biofuel production, and from these experiences lessons may be derived and effective policies recommended. (ii) The need to conduct quantitative analysis, and undertake economic modeling for competitiveness analysis to estimate the domestic resource cost to prioritize biofuel feedstocks for Viet Nam. (iii) Establish multisectoral economic models for biofuel development to generate options for the planning of biofuel feedstock production. (iv) Conduct value chain analysis for all types of potential biofuel feedstock, with a focus on analyzing how local characteristics determine biofuel production models. (v) Further study to identify appropriate processing technology based on collaboration with other institutes and related departments (e.g., the Institute of Development Strategy [MOIT], Institute of Forestry Science [MARD] and universities, e.g., Thanh Tay, Agriculture No1). (vi) Upgrade the study of the biofuel subsector from the national to the regional and inter-regional scales. (vii) Conduct a baseline survey for all biofuel feedstock areas, for use in impact assessments. **END OF WORKSHOP**

Appendix 4: Members of the National Biofuel Study Team

Cambodia

Lead Coordinator:	Luyna Ung Supreme National Economic Council
Market Outlook:	Hay Sovuthea Supreme National Economic Council
Characterization of Resource Base:	Sar Chetra Ministry of Agriculture
Prioritization:	Luyna Ung and Hay Sovuthea Supreme National Economic Council
Business Options:	Luyna Ung Supreme National Economic Council
Policy and Institutional Issues:	Sopheak Siek Supreme National Economic Council

The People's Republic Of China

Lead coordinator:	Jikun Huang Center for Chinese Agricultural Policy (CCAP), Chinese Academy of Science (CAS)
Market Outlook:	Jun Yang CCAP, CAS
Characterization of Resources Base:	Yuhua Zhang Institute of Rural Energy and Environmental Protection, Chinese Academy of Agricultural Engineering
Prioritization:	Huanguang Qui CCAP, CAS
Business Options:	Yahui Zhang Center of International Cooperation Services Ministry of Agriculture Jikun Huang CCAP, CAS
Policy and Institutional Issues:	Jikun Huang CCAP, CAS

Lao People's Democratic Republic

Lead Coordinator:	Kham Sanatem National Agriculture and Forestry Extension
Market Outlook:	Phouvong Phommabout Trade Promotion Center Ministry of Industry and Commerce
Characterization of Resource Base and Prioritization:	Keophayvanh Insixienmay Science and Technology Agency
Business Options:	Sounthone Ketphanh Forestry Research Institute
Policy and Institutional Issues:	Boutheap Malaykham Electrification Division Department of Energy

Myanmar

Lead Coordinator:	U Hla Kyaw Department of Agriculture and Planning, Ministry of Agriculture and Irrigation
Market Outlook:	Thandar Kyi Yezin Agricultural University
Characterization of Resource Base and Prioritization:	San Thein Myanma Industrial Crop Development Enterprise, Ministry of Agriculture and Irrigation
Business Options:	U Aung Hlaing Department of Agricultural Planning
Policy and Institutional Issues:	U Tin Maung Shwe Myanma Academy of Agriculture, Forestry, Livestock and Fishery Sciences

Thailand

Lead Coordinator:	Suthiporn Chirapanda, Retired Government Employee
Market Outlook:	Ms. Sudarat Techasriprasert Office of Agricultural Economics
Characterization of Resource Base:	Somjate Pratummin Ministry of Agriculture & Cooperatives
Business Options:	Samai Jain-In Ministry of Science and Technology
Policy and Institutional Issues:	Prapon Wongtarua Ministry of Energy
Project Coordinator:	Ms. Vannapha Yongchareon Office of Agricultural Economic Ministry of Agriculture and Cooperatives
Assistant Project Coordinator:	Pornprome Chairidchai Office of the Permanent Secretary Ministry of Agriculture and Cooperatives
Assistant Project Coordinator:	Pornchata Bussuvanno Office of Agricultural Economics Ministry of Agriculture and Cooperatives

Viet Nam

Lead Coordinator:	Nguyen Do Anh Tuan Institute of Policy and Strategic Agricultural and Rural Development, Ministry of Agriculture and Rural Development (IPSARD-MARD)
Market Outlook:	Nguyen Do Anh Tuan IPSARD-MARD
Characterization of Resource Base:	Cuc Trong Trot Department of Crop Production, MARD
Prioritization:	Phan Dang Hung Department of Forestry, MARD
Business Options:	Vi Viet Hoang Department of Cooperation and Rural Development
Policy and Institutional Issues:	Tran The Tuong Department of Crop Production, MARD

Appendix 5: Framework for Biofuel Development in the Greater Mekong Subregion

Framework for Biofuel Development in the Greater Mekong Subregion

Goal: To further reduce poverty, enhance food security, and improve welfare through greater access to energy especially in the rural areas.

Mission: To develop rural renewable energy resources, including biofuels, in a judicious and sustainable manner to increase the supply of energy, promote environmental protection, and facilitate rural development by enhancing livelihood opportunities, employment, and incomes, especially among small farmers.

Objectives:

(i) to reduce dependence on fossil fuel importation,

(ii) to promote agribusiness models that ensure the strong and continued participation of small producers, and

(iii) to promote an integrated biofuel market in the Greater Mekong Subregion (GMS) for both feedstocks and biofuels through cross-border trade.

Selected feedstocks for biofuel production: For bioethanol: sugarcane, cassava, and sweet sorghum; for biodiesel: palm oil, *Jatropha curcas*, *Moringa oleifeira*, and fish oil. The last two are being strongly considered in Viet Nam.

Short-term development strategies (1–5 years)

Collect and analyze more data and information to estimate relative production surpluses and deficits of energy crops, particularly the selected potential crops, across the GMS countries.

(i) Identify areas for feedstock cultivation that will not compete with or encroach on food crop areas in each country.

(ii) Estimate potential production and demand for each food crop.

(iii) Formulate an area development plan for the establishment and cultivation of both food crops and selected energy crops that would match biofuel production capacity of the region but at the same time ensure food security.

(iv) Promote knowledge exchange through the exchange of improved and new varieties and technology exchange, country visits, and educational tours.

(v) Enhance managerial skills for running cooperatives, and small and medium-sized enterprises (SMEs).

(vi) Advance research and development into second- and even third-generation biofuel production.

(vii) Enhance public awareness on the use of biofuels and other alternative renewable energy resources.

Medium-term development strategies (6–10 years)

(i) Continue development initiatives and expand those that show great potential for sustaining growth and development.

 (a) Expand village production areas and coverage of crude ethanol and biodiesel.

continued on next page

Appendix 5: *continued*

(b) Upgrade community biofuel ventures to SMEs (crude oil and refined oil production) and expand scope of marketing coverage.

(c) Expand pilot testing areas of biofuel processing plants using a mixture of feedstocks.

(d) Expand pro-small-farmer contract growing arrangements within the country and between GMS countries.

(e) Expand implementation of biogas technology.

(f) Expand cross-border trade.

(g) Strengthen public awareness campaigns on the use of biofuels and other alternative renewable energy resources.

(h) Continue with research and development and human resource development-strengthening activities.

(ii) Monitor relative changes in production, demand, trade, and prices of food crops and energy crops.

(iii) Initiate assessment work to determine the likely impact of efforts to promote and develop biofuel production and use.

Long-term development strategies (beyond 10 years)

(i) Continue development initiatives and expand those that show great potential for sustaining growth and development (as indicated in the medium-term strategies), including monitoring and assessment work.

(ii) Promote pilot testing of feasible and appropriate second- and third-generation biofuel technologies.

Enabling Policy Instruments for Long-term Development of Rural Renewable Energy and biofuels in the Greater Mekong Subregion

Existing Policies to be better enforced

(i) Food security policy versus energy development policy (primarily in Thailand and the People's Republic of China)

(ii) Energy security and conservation policy

(iii) Environmental protection policy

Policies to be enhanced

(i) Formulation of development and implementation plans of feasible rural renewable energy sources and technologies (such as biofuels and biogas).

(ii) Land use and management policy to encourage private sector participation.

(iii) Policy support to strengthen cooperatives and SMEs, primarily those that cater to biofuel production activities.

(iv) Technical support for production and other extension services (e.g., efficient input use, management practices, and the dissemination of technical information).

(v) Infrastructure and other support (e.g., road networks, credit, and communications).

(vi) Investment support for research and development (e.g., varietal development, improved farming practices, and advanced-generation biofuel technology).

(vii) Investment support for enhanced human resource development (technical and business management skills).

continued on next page

Appendix 5: *continued*

New policies to be put in place

(i) Incentives and market mechanisms that encourage private sector participation to support the development, use, and marketing of bioenergy and other forms of rural renewable energy to achieve the strategic goals of food and energy security

(ii) Policy support for the establishment of village biodiesel processing plants based on jatropha, oil palm, and fish fat

(iii) Market expansion through cross-border trade

(iv) Creation of national biofuel board or committee to coordinate activities of various public offices related to biofuels development

(v) Creation of a subregional coordinating mechanism to monitor and integrate biofuel production and trade so that the scale of the enterprise operation matches scale of feedstock supply in the GMS

(vi) Enabling cross-border trade and investment policies for feedstocks and biofuels, contract farming regulations, product standardization and quality control, and an effective pricing structure. Creation of an institution for research and development into non-food feedstocks such as jatropha and sweet sorghum

Action Plan: Follow-up Activities

Analytical studies

(i) Database development to enable cross-country comparison of biofuel potential within and outside the GMS, cost–benefit analysis of potential feedstocks and products, and identification of country market portfolios of feedstock and biofuel capacities

(ii) Market and supply chain analysis of domestic and cross-border trade

(iii) Economic and market analysis of the potential of non-food feedstocks such as jatropha, sweet sorghum, and moringa

(iv) Environmental impact assessment on the use of marginal areas for biofuel production

(v) Environmental impact assessment of biofuel processing plants

(vi) Evaluating how biofuels can help small farmers promote the clean development mechanism.

(vii) Comprehensive impact assessment study of biofuel development initiatives in the GMS through analytical modeling; institutionalization of such models in the GMS countries

Pilot demonstration projects

(i) Pilot demonstration projects for biofuel production, especially in Cambodia, the Lao People's Democratic Republic, and Myanmar

(ii) Establishment of small-scale biodiesel processing plants for village-level use and/or crude oil processing plants for export

(iii) Setting up cooperatives or SMEs for biofuel production and marketing

(iv) Setting up small-scale biogas and/or other rural renewable energy projects, especially in areas where biofuel development is not very feasible

Research and development

(i) Varietal improvement, improved farm practices to increase yield, and more efficient biofuel processing technology

continued on next page

Appendix 5: *continued*

(ii) Improved feedstock and biofuel production technology for non-food feedstocks such as jatropha and sweet sorghum.

(iii) Second- and third-generation biofuel technology based on crop residues, algae, and other materials

Capacity-building and training

(i) Skills enhancement on impact assessment, cost–benefit analysis, economic and market evaluation, strategic planning (based on use of models), monitoring, and evaluation

(ii) Human capacity-building on technical aspects of biofuel production and management of small business enterprises

Source: the authors, based on recommendations of the country reports.

Integrating Biofuel and Rural Renewable Energy Production in Agriculture for Poverty Reduction in the Greater Mekong Subregion: An Overview And Strategic Framework For Biofuel Development

This report contains the Greater Mekong Subregion Regional Strategic Framework for Biofuel Development. It also presents the executive summaries of this report, the individual biofuel study reports for the six member countries, and the biofuel modeling study. The findings were endorsed at the Fifth Meeting of the Greater Mekong Subregion Working Group on Agriculture on 22-24 September 2008 in Vientiane, the Lao People's Democratic Republic."

About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries substantially reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to two-thirds of the world's poor: 1.8 billion people who live on less than $2 a day, with 903 million struggling on less than $1.25 a day. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

Asian Development Bank
6 ADB Avenue, Mandaluyong City
1550 Metro Manila, Philippines
www.adb.org
ISBN 978-971-561-845-8
Publication Stock No. RPT090356

ISBN 978-971-561-845-8
9 789715 618458

Printed in the Philippines