For a Living Planet

Developing Sustainable Pro-poor Biofuels in the Mekong Region and Nepal

A holistic approach looking at smallholder benefits from an economic, social and environmental point of view

2009

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List of the main abbreviations and acronyms used

ADB	Asian Development Bank
Bbl	Barrel
BMP	Better Management Practices
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CJO	Crude Jatropha Oil
CLV&N	Cambodia, Laos, Vietnam and Nepal
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GMS	Greater Mekong Sub-region
GoL	Government of Lao PDR
GoN	Government of Nepal
GTZ	German Technical Cooperation
Ha	Hectares
HVC	High Value Conservation
IFPRI	International Food Policy Research Institute
INGO	International Non-Government Organization
JICA	Japanese International Cooperation Agency
LIRE	Lao Institute for Renewable Energy
MAF	Ministry of Agriculture and Forestry
MEM	Ministry of Industry Mines and Energy (Lao PDR)
MOI	Ministry of Industry (Vietnam)
NAFRI	National Agriculture and Forestry Research Institute (Lao PDR)
NGO	Non-Government Organization
PDR	People’s Democratic Republic
PMO	Prime Minister’s Office (Lao PDR)

REE	Rural Electricity Enterprises
RGC	Royal Government of Cambodia
RSB	Roundtable on Sustainable Biofuels
RSPO	Roundtable of Sustainable Palm Oil
SIDA	Swedish International Development Cooperation Agency
SME	Small and Medium Enterprise
SNV	Netherlands Development Organisation
STEA	Science, Technology and Environment Agency (Lao PDR)
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
VBARD	Vietnam Bank for Agriculture and Rural Development
WB	World Bank
WWF	World Wide Fund for Nature

Foreword and Acknowledgments

WWF and SNV commissioned this study as part of their global partnership on bioenergy which is described later. The study was conducted by a lead international consultant, Mr. Steven Shepley, with a team of consultants in each of the target countries:

- Ms Odarac Souksavat in the Lao PDR;
- Mr. Prom Tola in Cambodia;
- Mr. Thong Le Quang in Vietnam; and
- Dr. Subarna Lal Bajracharya, Mr. Shusil Sharma and Dr Mick Boswell in Nepal.

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The consultants conducted most of the research in early 2008. This consisted of desk studies of existing information, plus field work to verify the current situation and compile case studies on relevant activities in each country. This study is not intended to be a detailed in-depth analysis of all the issues, but rather it applies a holistic view to the situation in each of the four countries.

Readers should note the extreme economic environment that has developed during the period of this study. When it started energy prices were at record high levels, but by the time it has being edited and finalized energy prices had fallen dramatically and the world was in a deepening financial crisis. Consequently, some of the assumptions about energy prices and feasibility of biofuel may not be accurate in the current context, however they have been kept in this report as the duration and impacts of the current financial climate are unknown.

SNV and WWF hope that this document contributes to a better understanding of the potential for biofuels to contribute to the development of the region studied.

Executive summary

Biofuels have attracted strong interest in developed countries as a potential solution to the problems of fluctuating fossil fuel prices, desired energy security and the need to mitigate greenhouse gas emissions. Developing countries are initiating biofuel programs for the same reasons, plus the potential export earnings that could be achieved by using marginal land not available in developed countries. In theory, a thriving biofuel industry could deliver a range of economic, environmental and social benefits.

However, the public media and industry journals around the world have been portraying biofuel developments as not necessarily environmentally friendly or beneficial for poor communities. Much of this has been based on the experiences in specific countries and economies, e.g.: North America (corn-based ethanol), Brazil (sugar cane based ethanol) and Malaysia (oil palm based biodiesel).

This study explored the issues of biofuel development specific to Cambodia, the Lao PDR, Vietnam and Nepal. The study aimed to assess the potential for biofuels to improve the situation of poor smallholders in the target countries, without compromising food security and sustainable environmental management. The study evaluated existing initiatives as well as the potential for a biofuels sector in each of the four countries. In particular, case studies were produced of biofuel projects involving smallholders in each of the target countries. The potential role that SNV and WWF could play was then analyzed based on the benefits and risks identified.

This report consists of the following sections:

Chapter 1 describes the background and aims of the study.

Chapter 2 gives an overview of the region, current government policies related to the biofuels sector, present initiatives and stakeholders involved and a brief introduction to smallholder farmers in the region.

Chapter 3 presents case studies from Cambodia, Laos, Vietnam and Nepal and an analysis of the different biofuel feedstocks which are being grown or could be grown in the target countries.

Chapter 4 analyzes the “hot topics” or the controversial issues considered to be highly relevant to the biofuels sector in the region: Food versus Fuel, Local versus export markets; the local government context; social and environmental impacts.

Chapter 5 suggests possible intervention points for SNV and WWF including development of an institutional framework for the biofuels sector, environmentally and sociably sustainable biofuel markets, and knowledge and capacity development.

One of the main findings of this study is that developers of large-scale agricultural crops face a number of common factors in each of the target countries, including issues of low governance and the difficulty of enforcing supply contracts with many individual farmers. The study presents an alternative model, based on community-level feedstock cultivation, fuel oil production and consumption. This model potentially solves some of the problems of large scale contract farming and could offer greater poverty reduction. This should lead to improvements in household incomes and livelihood opportunities by promoting energy self-sufficiency for participating smallholder farmers. The study proposes intervention options for the development of sustainable biofuel markets based on this community model.

The study did not aim to promote specific biofuel feedstocks from the large number of biofuel crops being used around the world. However, some elements of the analysis and discussion relied on characteristics of a specific crop. For example, Jatropha is particularly well-suited to a community production model because it is already grown in each of the countries for other reasons (e.g.; fencing), and small-scale processing for on-site use is quite feasible. However, readers should also note that a common criticism of Jatropha is that relatively little is known about the scientific and agronomic details of the plant. Detailed and lengthy research is needed to develop any wild species into a reliable commercial crop. Cassava and sugarcane, when produced sustainably, also show good potential as smallholder feedstocks for biofuel processing. It is foreseen that these feedstocks production are more feasible in countries with more advanced biofuel sectors such as Vietnam.

The study proposes a number of interventions that SNV and / or WWF could make in order to increase the poverty-reduction and environmental benefits of biofuel production in the region. These are presented in this report for further discussion and development. The recommendations include developing a community-based model of feedstock production, trialing an ‘inclusive business’ approach, and that any biofuel production in the region should be guided by sustainability guidelines such as those developed by the Roundtable on Sustainable Biofuels (RSB).

1. Introduction

1.1 The SNV and WWF partnership on biofuels

SNV Netherlands Development Organisation (SNV) and the World Wide Fund for Nature (WWF), both non-governmental organizations (NGOs), are working to promote sustainable social and environmental development in developing countries. The organizations are complementary as WWF focuses on environmental aspects and SNV on poverty reduction. In December 2006 WWF and SNV signed a Memorandum of Cooperation to develop income and employment generation opportunities through sustainable resource management and biodiversity conservation.

Global interest in biofuels has grown rapidly in recent years. Biofuel production has doubled over the last five years and will likely double again in the next four years. A recently published report by the United Nations (UN) predicts that over the next 15 to 20 years, biofuels may be providing 25 % of the world's energy needs (UN-energy, 2007). There are various drivers for biofuel expansion. These include energy supply security, increasing energy prices, rural development, farmers' incomes in industrialized countries and greenhouse gas (GHG) emission reductions. Global energy demand is expected to rise by 53% from 2005 to 2030, with developing countries contributing 70% of this increase (Asian Development Bank (ADB), 2007). While these drivers do not always concur with the objectives of SNV or WWF, biofuel development might impact positively and/or negatively on some of the organizations' aims and missions and more importantly on the well being of poor communities and their environment. Yet, the experiences of some other countries would suggest that the development of biofuels is not necessarily environmentally friendly or beneficial for poor communities. Therefore both organizations are motivated to clarify the situation and determine if the potential benefits of biofuel can be obtained in this region without the negative side effects reported in some other regions.

The mission of WWF[1] is to stop the degradation of the planet's natural environment and build a future in which humans live in harmony with nature, by:

- conserving the world's biological diversity;
- ensuring that the use of renewable natural resources is sustainable;
- promoting the reduction of pollution and wasteful consumption.

Within this mission WWF is naturally concerned with climate change and environmentally and sociably sustainable solutions. In developing countries, WWF is seeking ways to significantly reduce GHG emissions while pursuing local development goals - providing clean energy to those

[1] http://www.panda.org/about_wwf/who_we_are/index.cfm

without any energy services. WWF is helping communities and conservation areas adapt to a changing climate. Actions such as restoring damaged forests, wetlands, and other habitats increase their resilience, help protect nature, and generate income for local people. Without such work, climate change could well be the final blow to already stressed ecosystems and the human populations that depend on them. The Energy Vision of WWF states that sustainable bioenergy is one of the key means to cut GHG emissions and provide sustainable energy globally, next to energy efficiency and other options.

The complementary role of SNV operates synergistically with WWF in finding strategies and solutions to pro-poor development. SNV is dedicated to a society where all people enjoy the freedom to pursue their own sustainable development. They contribute to this by strengthening the capacity of local organizations. Within their objectives, SNV aims to improve smallholder livelihood by improving food security and reducing poverty while developing capacity from a value chain perspective. SNV believes that appropriately designed cash crops have the potential to significantly improve income generation and household production in developing countries. SNV is also recognized as a world leader in the application of renewable energy technology for rural communities, particularly in the establishment of domestic biogas programs. Although renewable energy is sometimes seen as a luxury in developing countries, SNV believes that it can contribute to long-term solutions for pro-poor development in rural communities. By reducing dependence on fuel wood and the associated issues such as ill-health, the time used to collect fuel and income expenditure, more resources are made available for education, health and sanitation.

Within the WWF-SNV partnership, an Activity Agreement on Bioenergy for Sustainable Rural Development was implemented in 2008. The objective of this joint activity was:

> “to develop strategies and options for the development of environmentally sustainable and socially equitable bio-energy production as a contribution towards both poverty reduction in rural communities, and to climate change mitigation”

At the ninth meeting of the Conference of the Parties (COP9) to the Convention on Biological Diversity (CBD), WWF and SNV (2008) urged member states to adopt the following principles in developing strategies to ensure sustainable development of biofuels:

- Biofuels should deliver large positive energy and GHG balances over fossil fuels;
- Biofuel feedstocks should be selected on the basis of the most efficient GHG balance, from production through to processing and use;
- Biofuel policies and programs should address displacement effects that influence GHG balance, poverty and the environment;
- Biofuel strategies should contribute to the livelihood and wellbeing of indigenous populations;

- Biofuel production areas should not be established through indiscriminant conversion of natural ecosystems (natural and semi-natural forests, natural flood plains, wet and peat lands) that have high conservation values and/or critical carbon storage functions;
- Biofuel feedstocks should be produced using Better Management Practices (BMPs);
- There should be an equitable playing field for small producers;
- Governments should implement complementary measures: including land-use planning, food security measures, improvement of law enforcement and governance;
- Implementation of biofuel policies must take into account food security and must not threaten the realization of the right to food;
- Public subsidies and other financial instruments should be directed towards additional measures to help ensure sustainable and pro poor biofuel production;
- Biodiversity concerns should be incorporated in the broader energy policies.

It is in pursuit of this vision that SNV and WWF commissioned this study specifically concerned with biofuels in four developing countries in the Asian Region: Cambodia, Lao PDR, Vietnam and Nepal[2]. Other activities under the WWF-SNV partnership on Bioenergy are taking place in Honduras and Peru.

1.2 Study's objectives and scope

The biofuel market is already well established and growing fast around the world. In the Mekong Region and Nepal, the private sector, governments, and international organizations are paying increasing attention to biofuels. SNV and WWF decided to jointly investigate the situation of biofuels specifically in the Mekong region and Nepal with the general objective:

> "To develop sustainable strategies and options for the development of biofuels in Vietnam, Laos, Cambodia and Nepal for reducing poverty among rural households within an environmentally sustainable framework."

Sustainability means that smallholders will be able to improve their livelihood positions in an environmentally friendly manner, which does not compromise biodiversity and natural ecosystems, through participation in various emerging and on-going biofuel initiatives within the Asian Region. Biofuel sustainability depends on the interaction of three factors: economic viability, social suitability and environmental durability. The key to viable biofuel development depends also on the livelihood choices and

[2] These countries were selected because of the current or future presence of SNV and WWF activities.

behavioral patterns of smallholder households. However, it is often recognized that poor households are limited in their choices since they need to respond to immediate needs and short term priorities.

The specific objectives of the study are:

Identification of options: to identify main opportunities, threats, options and trade offs for smallholder farmers to participate in biofuel development in a sustainable way maximizing long term social, environmental and economic benefits.
Knowledge exchange and development: to develop awareness and cooperation among stakeholders from government, private sector, international organizations, NGOs, community based organizations and farmers on the sustainable development of biofuels, and to seek their input on priorities for market development, policies and programs.
Recommendations and program concept development: to select priorities and make recommendations for the development of the sector at various levels (farmers, private sector & investors, government and coordination); to develop a concept for interventions/initiatives for sustainable pro-poor biofuels in Vietnam, Laos, Cambodia and Nepal; and to identify the strategic positions open to SNV and WWF to have the most appropriate impact in the sector.

The term biofuels can be used to refer to a large number of different things. **The scope** of this project was limited to liquid biofuels that can be used as a substitute for some conventional fossil fuels (gasoline, diesel etc.) for transport and/or stationary applications. In particular, the project focused on biodiesel and ethanol, with relevant feedstocks, that currently appear to be the most interesting for smallholder farmers in the selected countries. The market for biofuels, including stakeholders and government policies in the four target countries, was examined as well as the end-use of the products. Case studies of current projects and/or businesses in the sector were developed for each country. Based on these studies and background data a set of issues was analyzed which included: Product feasibility; food vs. fuel; local markets vs. export; government policies; impacts on smallholders; poverty alleviation and social sustainability; climate change, carbon financing and environmental sustainability. This analysis was used to design specific intervention strategies for WWF and SNV including policy development.

This study considers the controversy surrounding the debate over the potential social, economic and environmental impact of the increase in biofuel production. It also recognizes that each of these controversial issues is country and region specific, so generalizations are dangerous. Developing countries have their own set of biofuel issues, which can be different from those of the industrialized countries.

1.3 Introduction to Biofuels

To address climate change effectively and with the sense of urgency required to stop the 2^{o}C increase in temperature and meet the goals set by the Kyoto protocol, a major switch from greenhouse-polluting fuels to cleaner fuels is needed. Record oil prices (USD150/bbl in July 2008[3]), fears of unaffordable and rapidly depleting sources of fossil fuel, the desire to achieve energy security (especially for countries depending on imports) and to mitigate climate change have combined to heighten interest in biofuel production as a possible cost-effective, alternative source of energy.

Bioethanol is a high-octane fuel which is used primarily as a gasoline additive and extender. It can be produced from carbohydrates such as sugar, starch, and cellulose by fermentation using yeast or other organisms and is made primarily from high sugar crops such as sugarcane, cassava and maize. World production of ethanol (all grades) in 2007 was about 13.5 billion gallons (Renewable Fuels Association[4], 2008). Brazil, as an emerging economy, remains one of the major world leaders in fuel ethanol production, with 5 billion gallons (after the USA with 6.5 billion gallons). In Asia, ethanol production and use are led by China, India and Thailand (620 million gallons for the three countries).

Biodiesel is produced from the oily seeds of plants such as oil palm, coconut, rapeseed or Jatropha. It contains no petroleum, but can be blended at any level (up to 20%, without engine modification) with petroleum diesel to create a biodiesel blend. Biodiesel is made through a chemical process called transesterification whereby glycerin is separated from fat or vegetable oil. The process leaves behind two products 1) methyl esters (the chemical name for biodiesel) and 2) glycerin (a valuable byproduct usually sold to be used in soaps and other products). Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics. Global biodiesel production is rising and had reached 5-6 million tons in 2006. Approximately 85% of biodiesel production came from the European Union (EU) where Germany is the world's biggest producer of biodiesel. In Asia, Malaysia and Indonesia are the largest producers of palm-based biodiesel, but the production remains insignificant compared to the targets of government policies in the region.

Domestic biofuel production offers significant benefits for developing countries that are net importers of fossil fuels. The main benefits include improved energy security and reduced pressure on foreign exchange reserves. This is a new industry that is well-matched to many developing countries because it is based on agricultural production and should create jobs, income and new opportunities in rural areas.

[3] Down to a lowest in December 2008 of USD 30/BBL
[4] http://www.ethanolrfa.org/industry/statistics/#E

Some governments are providing substantial support for biofuel development (and research) to enable it to compete with conventional gasoline petrol and diesel. These measures include consumption incentives (fuel tax reductions), production incentives (reduced taxes and direct subsidies) and mandatory blending standards. Critical factors in assessing the viability of a crop for ethanol or biodiesel production, and the sustained attractiveness of biofuels as alternative fuels, are the reliability of feedstock availability and feedstock prices *vs*. oil prices. Institutional preparedness also points to achievements in aspects of research and development to produce higher yielding varieties of crops, promote sustainable cropping systems to avoid land degradation and improve farm productivity, and smallholder livelihood development among other considerations.

Although assessments of the global economic potential of biofuels have just begun, current biofuel policies may, according to some rough estimates, lead to a significant increase in the share of biofuels used in global transport energy consumption – from just over 1 % today to 5 to 6 % by 2020 (World Bank (WB), 2008). With increasing demand for biofuels, considerable land may be diverted from food to feedstock production. The FAO estimates that the amount of land that would be used for the development of biofuels – at present about 1 % of the world's arable land – could increase up to 3 % by 2030 and as much as 20 % by 2050 (UN-energy, 2007)

Alarms have been raised over fears that the resulting increased demand for fuel crops might contribute to increased commodity prices with adverse effects on consumers and environmentally sensitive land. The incursion of palm oil plantations on sensitive land has already occurred in Malaysia and Indonesia. The palm oil industry has recognized concerns that it is having significant negative affects on the environment and, in conjunction with the WWF and other stakeholders, has formed the Roundtable on Sustainable Palm Oil (RSPO) which endeavors to ensure that palm oil is produced in a sustainable manner. Most palm oil is used in food production but demand from the biofuel industry is growing. This raised concerns about the impact of biofuel production on local environments, livelihoods of displaced people and GHG emissions.

The Roundtable on Sustainable Biofuels (RSB) has set the international standard for assessing the risks, challenges and opportunities of the biofuel sector, of which a preliminary version is summarized and linked in table 1. Based on this international standard it is hoped that sustainable production schemes may be developed.

TABLE 1: DRAFT SCORECARD CONCEPT FROM THE ROUNDTABLE ON SUSTAINABLE BIOFUELS

	Overall energy and GHG efficiency	**Conservation of natural resources**				**Social concerns**	
	Total score for product life-cycle (well-to-wheel)	Biodiversity	Soil health	Air quality	Water use	Food security	Working conditions
1.Considerable reduction of ecological footprint	Low GHG emissions, maximize carbon sequestration (eg., low-till)	Biodiversity corridors, using degraded land	Restore degraded land	No sig. impact on air quality on farm or at processing factory	Use of non-thirsty crops	Use of degraded or idle land	Best-practice wages and working conditions
2. Small or medium reduction in ecological footprint	10-90% GHG emissions as compared to fossil fuel	Buffer zones	Erosion protection	Moderate impact on air quality	Moderate impact on water quality		
3. No or negative impact on ecological footprint	High N_2O emissions from fertilizers; conversion of high carbon-stock land	Deforestation; Habitat encroachment			Water pollution; Significant reduction in water availability		Hazardous or illegal working conditions

Source: The Roundtable on Sustainable Biofuels: “Ensuring that biofuels deliver on their promise of sustainability”, Energy Center, Ecole Polytechnique Federale de Lausanne, Switzerland, June 2007.

1.4 Hot topics

The following list summarizes the main controversial biofuel issues that have been proposed and debated in recent years, and require serious consideration by any development agency working in this area:

- **Food versus fuel**: can the agriculture sector meet biofuel demand without compromising food security? Farmers might benefit from high commodity prices but what about net purchasers of food?
- **Government policies**: what is the current policy environment in the region concerning biofuels specifically and sustainable agricultural development in general?
- **Climate change and environment**: how effective are biofuels in mitigating climate change? Are we using the right yardstick to determine the amount of energy required to produce biofuels in developing countries where farmers are less likely to use inputs (e.g. nitrogen fertilizers) or practice mechanized farming?
- **Impact on poverty alleviation**: how does biofuel development affect the energy needs, savings & income generation for households and employment opportunities of the rural poor?

Summary of chapter 1

Global energy demand is expected to rise by 53% from 2005 to 2030, with developing countries contributing 70% of this increase. Rising costs of fossil fuels, and their other disadvantages such the associated carbon emissions, have prompted a search for alternative renewable energy sources, such as bioenergy, including biofuels, which can be supplied by agriculture. The market demand and usage of biofuels, namely bioethanol and biodiesel, is gaining prominence. Spurred by many of the same considerations as the industrialized countries, many developing countries are now initiating biofuel programs based on agricultural feedstocks. SNV and WWF have formed a partnership to develop sustainable strategies and options for the development of biofuels in Vietnam, Laos, Cambodia and Nepal for reducing poverty among rural households within an environmentally sustainable framework. Based on case studies and other considerations, the program aims to examine biofuel sustainability in the region depending on the interaction of three main factors: economic viability, social suitability and environmental durability. The study findings will be used to guide SNV and WWF potential interventions.

2. Biofuels in the Mekong and Nepal

The rapidly emerging interest in first generation biofuels (i.e., biofuels made from sugar, starch, vegetable oil, or animal fats using conventional technology (UN-energy, 2007)) has identified biofuel production as an innovative measure to reduce smallholder poverty, generate employment and improve livelihood systems. Biofuels in Asia have received a lot of negative press due partly to palm oil plantations in Malaysia and Indonesia and the presumed effect of other feedstocks on food prices. However, most studies were carried out in North & South America and Europe (for e.g. Steenblick, 2006; Doornbosch and Steenblick, 2007), with very little reported about the current status or potential of biofuels in Asia. By focusing this study on Vietnam, Laos, Cambodia and Nepal, SNV-WWF aims to address the right issues and to ensure that interventions in the region are based on sound knowledge.

2.1 An introduction to the region

The four target countries **Cambodia, Laos, Vietnam and Nepal (henceforth CLV&N),** encompass approximately 132 million people, with per capita GDPs ranging from approximately USD270 (Nepal) to 630 (Vietnam) (table 2). The economies rely heavily on **agriculture** (table 2), which is limited or adapted to certain geographical areas and strongly influenced by local climates. In Vietnam, for instance the fertile river deltas are some of the most densely-populated parts of the world, and most of the nation’s food is grown in there, in paddy fields, relying on two distinct monsoon seasons. Lao production systems, in a variety of agro-ecological zones, are diverse, ranging from rain-fed and irrigated rice-based farming systems in the Mekong River valley plains to shifting cultivation in upland areas and cash-crop and livestock production in upland plateau areas. **Rice**, the staple crop in the region, is produced with varying degrees of productivity due to variations in the technologies and inputs available. The amount of arable land, available per capita, shows that most farmers are **smallholders** with plots ranging below one hectare (table 2).

TABLE 2: GENERAL BACKGROUND INFORMATION ON THE FOUR TARGET COUNTRIES

	Cambodia	**Lao PDR**	**Nepal**	**Vietnam**
Population (approximate in million, 2005[5])	14	6	27	85
Population growth (%) 1995-2005[5])	2.3	2.2	2.3	1.9
Per capita GDP (USD, 2005[5])	440	485	272	631
Agriculture- value added (% of GDP[6])	30	42	34	20
Work force in Agriculture (% of total employment, 1996-2005[5])	70	85	79	58
Arable land/capita (ha)	0.25	0.3	0.1	0.75
Agricultural land (% of land area[6])	30.3	8.5	29.5	31
Rice (% of cropped land)	90	73	44	85
Forested area (% of total land[5])	59.2	69.9	25.4	39.7
Protected areas (number of)	23	20	17	107
CO2 emissions (annual in thousands of tons, 2004)/% of total world emission[7])	535/<0.1	1,280/<0.1	3,043/<0.1	98,66/0.4
Fossil fuel[8] imports (bbl/day)	3,585	2,941	11,550	271,100
Fossil fuel domestic production (bbl/day)	None	None	None	324,000[9]
Official biofuel policy	No	Draft	Draft	Yes (decree)

Apart from Vietnam, all four countries currently rely entirely on **imports of fossil fuels** (table 2). Reliance on expensive fuel imports or inefficient and polluting traditional energy sources increases the hardships faced by the rural poor. Overall, GHG emissions are relatively minimal (table 2) but are rapidly increasing with agriculture mechanization and urban development. In most countries, petroleum products are the largest contributor to the total combined emission of all pollutants, while fuel wood and coal are also major contributors.

[5] Source UNDP development report 2007/2008: http://hdrstats.undp.org/countries/
[6] Source WB World Development Indicators database, Sep 2008; data are from 2005-2007 depending on country.
[7] Source: http://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions
[8] Source CIA World fact book, 2008, data for Cambodia and Laos are from 2004, for Nepal, 2006 estimate and Vietnam, 2007.
[9] Source CIA World fact book, 2008, figures are the 2007 estimate.

Another important characteristic of the region is the large and rapidly growing economies of **India and China, and Thailand** to a lesser extent. High population density and pressures on natural resources, coupled with rapidly increasing industrialization are propelling resource shifts away from agriculture to other sectors in these countries. Due to the raw material constraints now faced by these bigger economies there is a growing need to outsource primary and intermediate products as well as cropping land from the targeted countries.

CLV&N have **rich biodiversity** and many different ecosystems. In Nepal for example, there are eight bioclimatic zones, ranging from sub-tropical to cold desert areas, and 35 vegetation types, which are included in protected areas such as national parks, conservation areas, wildlife reserves, and hunting areas. In Laos also, large tracts of forest which are rich in wildlife and biodiversity have been preserved and Cambodia possesses environmentally significant wetlands (table 2). WWF has identified three major eco-regions in the greater Mekong region: The greater Annamites, Dry forests and Mekong river regions[10]. These environments are under considerable threat from rapid economic growth, urbanization and rising human pressure on relatively scarce natural resources. **Deforestation** due to firewood collection and agricultural practices (either shifting cultivation or large-scale land clearing) is a major issue in the region. Agriculture and human pressure are also seriously affecting water resources in the four countries. Preservation of the environment is not only important from an ecological point of view but affects agriculture and those depending on it for their livelihoods by leading to soil erosion, landslides, floods etc. which may result in a downward spiral into further poverty.

2.2 The region's dependence on fossil fuels and government responses

Within the Greater Mekong Sub-region (GMS with Cambodia, Laos, Myanmar, Thailand, Vietnam, and Yunnan province of the Peoples' Republic of China), energy demand is projected to increase between 7% and 16% per annum – faster than the expected rate of economic growth – placing great stress on existing energy systems. However, these energy demands mask great disparities in energy usage. The Asian Development Bank (ADB, 2007[11]) estimated that 50 million out of 300 million people in the GMS are not reached by electricity and must rely on traditional fuels.

In Nepal, more than 90% of the energy supply originates from traditional sources (fuel wood, agricultural residue and animal waste). Less than one third of the population has access to electricity and in the rural areas, where most people live, access is even lower. The commercial sources of energy - petroleum, coal and electricity - are used mainly for industrial, transport and domestic sectors with negligible use in the agricultural

[10]http://www.panda.org/about_wwf/where_we_work/asia_pacific/our_solutions/greatermekong/area/ecoregions/index.cfm
[11] figure is from 2003

sector. This is because agriculture in Nepal is still highly labor intensive with little mechanization. Heavy use of energy is thus concentrated in large industrial establishments such as cement, iron and steel, plastic, and metal industries.

Collection of firewood has been the main cause of deforestation. Air pollution is a serious concern in urban areas due to the dust generated by vehicles, increasing use of fossil fuels for transportation, and concentration of industries. The transport sector is the largest contributor to total emissions of pollutants in Kathmandu Valley followed by household, industrial, and commercial sectors. Although this study is focused essentially on biofuels, it is worth mentioning that there is an ambitious biogas program in Nepal to address some of the above issues.

In January 2004, the Nepalese cabinet decided to blend 10 % ethanol in petrol being used in the country. However, this decision has not yet materialized because of unsettled disputes over ethanol prices between the government and sugar factories. To date no firm policy decisions have been made on using biodiesel as a substitute for fossil diesel, the dominating fossil fuel in the country.

The Lao PDR imports all of its (fossil) fuels through Thailand and Vietnam (approximately 323,000 bbl of petrol and 754,000 bbl of diesel in total for 2007) and consumption is increasing by 5%/annum[12]. Fuel is mainly used for transportation and commercial energy requirements but most of the population relies on fuel wood for heating and cooking. Only a small proportion of fuel imports is used for electricity (97% of electricity is produced by hydropower). Given that Lao PDR is landlocked, it is particularly vulnerable to dependence on external energy sources. In this context, the need to explore new and environmentally-friendly alternatives to external energy sources needs to be seriously addressed by the government.

At present, while many ministries and regulations indirectly govern the biofuels sector, a cohesive national policy, specific decrees or regulations on biofuels do not exist. Recently, the Prime Minister requested that the Lao National Council of Sciences draft a biofuels policy for the consideration of the Government of Laos (GoL) (Lao Institute for Renewable Energy (LIRE), 2008). Other relevant policy drafts with regards to biofuel development are the following:

• Resolution of the VIII General Congress of the Lao Revolutionary Party, 2006 - Section 5.1. : Development Plan for Industrial Sectors (pp 114-116 Lao language). The plan encourages investments in feedstock crops for biodiesel and ethanol production. Relevant sectors should integrate this objective in their industrial development strategies; public organizations, ministries and provincial authorities also need to define their own strategy focusing on biodiesel and ethanol promotion.

• Decree of the Prime Minister’s Office (PMO) on Fuel Saving No. 09/PMO, 25 May 2006 (English translation). Article 1 stated that both the public

[12] Lao PDR State Fuel Company

and private sectors should reduce fossil fuel consumption and improve fuel efficiency use through adequate awareness media campaigns. Article 2 urged the Ministry of Energy and Mines (MEM), Ministry of Transportation and Construction, and the Science Technology and Environment Agency (STEA) to create specific policies and development plans on fuel alternatives based on renewable energies. The agencies were requested to actively participate, support and further cooperate with research and development organizations that are engaged in alternative fuels, biodiesel and ethanol production. The Ministry of Agriculture and forestry (MAF), the MEM, the Ministry of Planning and Investment and banks must also endorse measures to support oil crop planting.

• MEM Policy on Fuel Saving and Promotion of Biofuel Production in Lao PDR, Non official draft, 20 October 2006 (English translation). This document is the first draft paper developed by the MEM on the promotion of biofuels; it is not official yet. It addressed issues, goals, targets and strategic objectives that aim to promote the use and development of biofuel production in the Lao PDR. The MEM draft document targets are a 5% biofuel production share in total fuel consumption by 2015 and a 5% reduction in fossil fuel consumption from 2010 forward. The document states that information centers in rural areas should be given support to provide instruction in cultivating and producing biofuels. It also mentions that initiatives should concentrate on cultivating oil plants for family use and at the village group level and then up-scaling for national and export markets at a later stage.

Although exploitable oil and gas deposits have been found within **Cambodia**'s territorial water, exploitation of the resources has yet to commence. Cambodia today relies almost entirely on imported diesel fuel and heavy fuel oil for power generation throughout the country. There is no national grid, but over 500 private entrepreneurs have established small Rural Electricity Enterprises (REEs) in villages and towns across the country. These REEs provide an important service, but rely on (sometimes old) diesel generators, sub-standard infrastructure and limited technical knowledge. Consequently, most of Cambodia's rural communities are 100% dependent on imported diesel fuel for electricity, and they face some of the highest electricity costs in the world at an average of USD0.51 per kWh in 2003 (WB, 2003)[13]. Electricity costs are five times higher in Cambodia than in neighboring Laos and twice as high as in Vietnam. The highest agricultural demand for diesel fuel consumption is associated with commodity transport, rice milling, water pumping activities and pedestrian tractors.

[13] There are actually three categories or pricing systems for official government power systems. The first group is the consumer in the capital, Phnom Penh, which accounts for 80% of the total consumption of electricity in Cambodia with an average price of USD0.17/Kw/h. The second category is for the provincial cities where electricity costs USD0.25/Kw/h. Finally there is the third category comprising all the rural areas outside the cities, in this case the price fluctuates between USD0.4 and 1/Kw/h. Small private rural power producers often charge higher prices than these in order to cover costs.

The impacts (which are also true for the other countries) of high energy costs are three-fold: 1) Households find it harder to break the poverty cycle because a high proportion of household income goes to paying for battery charging or local mini-grid power, instead of basic health, nutrition and education; 2) Rural development is curtailed because high energy costs make new productive value-adding industries unfeasible and uncompetitive; and 3) Rural communities are fully exposed to the fluctuating availability and price of diesel fuel.

The Royal Government of Cambodia (RGC) formulated a national energy sector policy in October 1994, its objectives being to provide a secure, reliable, environmentally safe, and sustainable energy supply from various forms, at reasonable and affordable prices, in order to address the needs of the population as well as economic development of the Kingdom. In this respect, it encourages the exploration and development of all national resources, which are socially and environmentally acceptable to the national communities, and the efficient use of energy and energy conservation. The current policy statement on rural renewable electricity is a reaffirmation of an earlier policy, and an extension of the commitment by the RGC. A new draft policy document is now under review.

Vietnam imports 271,100 bbl/day, of which 65% is diesel fuel and 35% is gasoline; the mean daily consumption of fossil fuels is 21 liters/capita/day. Although Vietnam's energy consumption per capita is one of the lowest figures in the world, a 6 fold increase is predicted by 2025. The level of daily consumption is growing at 5%/year, as in Laos, due to increasing industrialization. With proven reserves of crude oil of 615 to 900 million tons, coal reserves of 3.8 billion tons and natural gas reserves of 600 million m^3, Vietnam could be energy sufficient for the next 25 to 30 years.

In November 2007, the Prime Minister of Vietnam approved a program[14] to focus on the development of biofuels. The program outlined the roadmap to the year 2015 and a vision till the year 2025. The approval was made by a decree which further detailed "development of biofuels, a new and renewable energy, to partially replace fossil fuels in order to achieve energy security and environment protection". The goals of the program are for production of biofuels to reach 0.4% of total energy demand by 2010, 1% by 2015 and 5% by 2025.

The Electricity Law states that "Renewable energy generation projects will get investment incentives, favorable tariff and tax reduction/exemption, according to Guidelines of Ministry of Finance"[15]. In particular Vietnam supports the development of renewable energy for improving rural livelihoods and to reduce poverty[16].

At present, a number or projects/programs/studies on the development of renewable energy in Vietnam includes:

[14] Supported by Brazil with a technology sharing pact on ethanol production
[15] Vietnam Law of Electricity, 1 July 2005, sub-article 13.1.c
[16] Vietnam Law of Electricity, 1 July 2005, sub-article 60.4

- National Master Plan on Renewable Energy, implemented by the Ministry of Industry (MOI), 2006-2007 feedstock like Jatropha and Cassava are considered;
- Strategy and Policy for Vietnam Bio-fuel Development, implemented by MOI, 2007-2008;
- Biogas Program for Husbandry Sector in Vietnam, financed by SNV, 2003-2010;
- Vietnam Sweden Rural Energy Program, financed by SIDA, 2005-2008;
- Remote Area Renewable Energy financed by WB, 2002-2009;
- Strengthening Regulation, Planning and Implementation Capacity for Renewable energy, financed by WB, 2002-2009;
- National Master Plan on Renewable Energy, financed by JICA, 2001-2002.

2.3 Biofuel potential and initiatives in the Region

The collective transport energy demand of the region's largest economies Thailand, India and China amounts to ***6.2 million barrels/day***. With rapidly emerging biofuel strategies and programs and robustly increasing renewable energy resource demands, the need for outsourcing biofuel feedstocks from the targeted countries is rapidly increasing. Thailand is outsourcing biofuel feedstock from Laos and Cambodia to meet its entrenched biofuel production targets[17]. China is aggressively outsourcing biofuel feedstocks from Cambodia, Laos and to a lesser extent Vietnam. To meet its demand, India is boosting the domestic production of biofuel feedstocks and outsourcing feedstocks such as sugarcane from Nepal. Japan and Korea are also investing or showing interest in investing in feedstock production in the target countries. Yet, in all four countries, increased rice production is needed to feed growing populations. The shortage of remaining arable land and the demand from Thailand, China and Vietnam to outsource food and biofuel crops will likely restrict capacity for further expansion of production of these commodities for domestic purposes and there is little likelihood that the targeted countries will be able to supply biofuel markets beyond the Asian region. **Consequently, based on domestic demand and assuming that biofuel is a commodity that supplements conventional fuels, it is unlikely that the four countries will ever supply biofuel markets in Europe and North America.** Nevertheless this assumption is debatable since biofuel could be considered as a "high-priced luxury product" because it offers a service (carbon-neutrality) that is more highly valued in industrialized countries than in most developing countries. In this situation it may become feasible for a developing country to export some/all of its biofuel to Europe/Japan for a very high price while continuing to import fossil fuels for their own use at a lower price.

[17] Thailand, Ministry of Agriculture and Cooperatives and Ministry of Commerce, 2007.

There is a great potential for commercial development of biofuels **in Nepal**. It has been estimated that 30% of the land area is climatically favorable for the cultivation of Jatropha (locally called Sajiwan although there are 200 other local names)[18]. Apart from Jatropha, there are many other non-edible oilseed-bearing plants that can be cultivated on the wastelands of the country to reduce dependency on imported fossil fuels[19]. It has been estimated that, even if only 10% of the climatically favorable area is used for Jatropha cultivation, sufficient biodiesel can be produced to replace fossil diesel used in the country.

In some areas, such as the Terai area[20] of the country, there is potential for sugarcane cultivation. At present, it is estimated that 70% of the country's sugarcane is grown under rain-fed conditions. Sugarcane production can be encouraged by using it for ethanol production. This could contribute to increase its value and eventually make it a major cash crop. Even the limited sugarcane being cultivated in the country at present could be sufficient to produce enough ethanol to replace 20% of the petrol being used in the country, if all sugarcane was processed for that purpose. Although there are no visible commercial applications of biodiesel or bioethanol in Nepal of any significance, credible adaptive research and development and pilot/demonstration activities have been carried out since the 1980s.

Currently there are 20 or so small-scale Jatropha projects including some feed crop sales to India. Pioneering work has been conducted primarily by the Nepal/UK Oil Seed Project[21] seeking to implement a national program of plant oil extension and is described in the case study in Chapter 3. The People Energy and Environment Development Association is also promoting a rural livelihood initiative through the harvesting of wild Jatropha seeds and the cultivation of high yielding hybrid varieties on marginal land and community forests. A co-operative business model is employed for collection, processing and marketing of oil to fuel diesel generators in a local hospital. The Biovillage Foundation Nepal is proposing to plant 2.5 m trees on 1000 ha including carbon trading. The Nepalese National Agriculture and Environmental forum is also initiating a biodiesel project[22]. Finally, the proposal "Community Based Jatropha Biodiesel for Rural Economic Growth in Nepal" was submitted by the Clean Energy/Environment Unit in Nepal and selected as one of the four 2008 Internal Grants awardees under the Innovation Investment Program of

[18] Boswell, M. J. [1998] Exploration and Utilisation of the Indigenous Renewable Oil Resource in Nepal: *Jatropha curcas* a Low Altitude Species, Proceedings of International Conference on the Role of Renewable Energy Technology for Rural Development. 98-106.

[19] Boswell, M. J. [2003] Plant Oils: Wealth, Health, Energy and Environment, Proceedings of International Conference on the Role of Renewable Energy Technology for Rural Development. 37-45.

[20] The Terai area of Nepal is a narrow flat plain stretching from the lesser Himalayas to the Indian border. It makes up to 17% of total area, has a subtropical climate and relatively fertile soils (source: Wikipedia.org)

[21] A collaboration between The Research Centre for Applied Science and Technology Tribhuvan University Kathmandu Nepal, University of Northampton UK and Oxford Brookes University UK with finance from the British Embassy to Nepal, UK Department for International Development/British Council, University and private sources.

[22] http://www.naef-nepal.org/rural_energy.htm

Winrock International. The project targets the use of Jatropha growing in community waste lands and as hedges in the private lands to produce biodiesel locally for rural applications, mainly for operating irrigation pumps.

As mentioned above, while a formal policy **in Laos** on biodiesel has yet to be developed, to help offset the rising cost of fuel imports and as part of its poverty eradication strategy (GoL, 2004), the GoL is promoting the commercial production of appropriate crops and import substitutions to strengthen Lao PDR's trade position. There has been considerable attention given to the potential of Jatropha as a crop to provide energy sufficiency and to build an integrated approach to rural development. This includes proposals to designate approximately two million hectares of land for the development of biofuel feedstock plantations (GoL, 2004) and feedstock production targets of 24,000 ha for Jatropha and 10,000 ha for sugarcane production[23]. In the initial phases, demand for biofuels is likely to be driven by government policies.

A growing number of actors in Laos are involved or showing an interest in the promotion and development of biofuels. These include: government authorities (the PMO, STEA, MAF and MEM); non-profit organizations and private research institutes such as the Lao Institute for Renewable Energy (LIRE); the private sector such as Sunlabob Renewable Energy and Kolao; and International NGOs (INGOs) such as Triangle Génération Humanitaire, International Cooperation for Development and Solidarity, VECO as well as SNV and WWF who are getting more involved in the sector with plans under internal discussion. More information can be found in the LIRE report on Biofuels in the Lao PDR (LIRE, 2008).

In Cambodia, there has been a sharp increase in the production of biofuel feedstock over the past few years. For example, between 2001 and 2006 the production of cassava increased from 142,000 tons to 2,200,000 tons, although it should be noted that a large proportion of this was used for edible starch products. The main driver of demand for Cambodian agricultural commodities has been the demand pull from Thailand, China and Vietnam for biofuel feedstocks (cassava, but also sugarcane).

Although, not shown in the official agricultural statistics, perhaps the most important biofuel feedstock in Cambodia is Jatropha Curcas. The importance of Jatropha derives from the interest of foreign investors and NGOs in developing sustainable biofuel production enterprises for both private companies and for smallholder households. The prevalence and extent of rice cultivation suggests a robust potential market for Crude Jatropha Oil (CJO) to power tractors and small-scale rice mills. Another potential demand for CJO is in the production of electricity. There are already some isolated examples of electricity generation using CJO. In some provinces REE uses CJO to replace 7.5% of the diesel used for its electricity production.

[23] From the draft Biofuel policy by the Lao Ministry of Energy and Mines.

Although **Cambodia,** as with Laos, is just beginning to develop its biofuel sector, there are a number of major players that are helping to drive it. These include both public (Ministry of Industry, Mines and Energy, Dept. of Hydropower, Dept. of energy development, MAF and three universities) and private sector organizations (SODECO, Biodiesel Cambodia, Bagani, FACT). INGOs are also involved including agencies such as GERES, JICA, the WB, the UNDP, and GTZ.

Vietnam's liquid biofuel made from biomass is attracting increasing interest from local and international investors and from politicians and decision makers. The government sees biofuels providing possibilities to stimulate rural development, to create jobs, to save foreign exchange, to reduce GHGs and to increase national energy security.

In the past, biofuels produced from feedstocks and by-products were not price-competitive in Vietnam. However, with oil prices exceeding on average $100/bbl in 2008, biofuel competitiveness has strengthened. To date, biodiesel from Basa fish and waste oil from the food and beverage sector and bioethanol from sugar molasses has been produced economically in Vietnam in limited quantities. With Vietnam biofuel production targets of 50 million liters of biodiesel by 2020 (to blend 500 million liters of biodiesel) and 500 million liters of bioethanol by 2020 (to blend 5 billion liters of gasohol)[24], the potential domestic market for biofuels appears far more robust than in the other targeted countries.

At present, there are a number of private and government biofuel activities **in Vietnam**, which can be classified into: (i) biodiesel production for export; (ii) R&D activities; (iii) pilot projects; (iv) biodiesel production for self-consumption and commercial trade. Key examples of stakeholders in the sector are:

a) **Green Energy Ltd.**, Vietnam (GEV), a Vietnamese for-profit corporation engaged in two vertically integrated aspects of the biofuel industry in cooperation with SNV;

b) **Biopact Co, Ltd**. Vietnam which is set to advance its bioenergy program through the construction of two large ethanol production plants;

c) **Itochu Corp. and Petrosetco** (PetroVietnam subsidiary) have a Cassava Bioethanol Plant in Tay Ninh (see case study in Chapter 3);

d) **Viet Duc sausage company** (Hung Yen Province) which harvests Jatropha plants in Hung Yen Provinces for export to Germany;

e) **Agrifish JS company** (An Giang Province) produces biodiesel by blending fat of cat-fish with diesel to run diesel-engines; and

f) **Centre for Petrochemical Technology** (Ho Chi Minh City) is running a two-year pilot project to mix waste cooking oil with diesel to make a cheaper diesel fuel.

[24] Strategy and Policy for Vietnam Bio-fuel Development, implemented by MOI, 2007-2008

2.4 Meet the smallholders

In order to understand the potential for smallholders to be involved in and benefit from biofuel development, we should first understand their situation, characteristics, drivers and constraints.

The large majority of smallholders in the studied countries operate primarily as subsistence agricultural households who farm less than one hectare to no more than 2 ha of land with limited land use and tenure rights. The smallholder family ranges in size from 5 to 7 persons. The average rice yields are between 1.5 to 3.5 tons/ha. A large number of smallholders without access to irrigation (some 70 to 80% of the total) are restricted to one rice crop per year and live at the margin of food security[25]. The majority of smallholder producers still practice traditional or low intensity production. They encounter difficulties in adopting new production technologies that demand higher investment and higher production costs, given their limited financial resources, skills and knowledge base.

In all four countries, farmers receive low farm gate prices for their produce to protect the profits and incomes of operatives higher up on the supply chain. Some 60 to 70% of biofuel processing costs comprise the cost of feedstock acquisition. With the heavy dependence of financial sustainability on low feedstock prices, actors along the supply chain squeeze the profits of smallholder farmers to maintain the competitiveness of biofuel products with fossil fuel alternatives. At present, therefore, the smallholder producer pays the real cost of risk protection for key players up the feedstock supply chain. The disadvantage of smallholders is that they add little value to the biofuel supply chain by trading raw materials instead of selling finished or semi-finished produce.

The linkage between producers and market actors is also weak, thereby raising risks in production and marketing. Lack of access to markets has resulted in high input costs, high transaction costs, and low output prices. Inadequate market access is largely exacerbated by the limited bargaining power of smallholder producers in commodity and produce value chain. All these factors mean that smallholders are reticent to (and financially unable to, without some form of assistance) make precipitous farming system changes in response to emerging market opportunities. **Thus the target countries appear to have restricted potential for significant expansion of their smallholder agricultural production bases without government or external assistance**.

Summary of chapter 2

[25] Source: Field interviews with smallholders and literature review of multiple references.

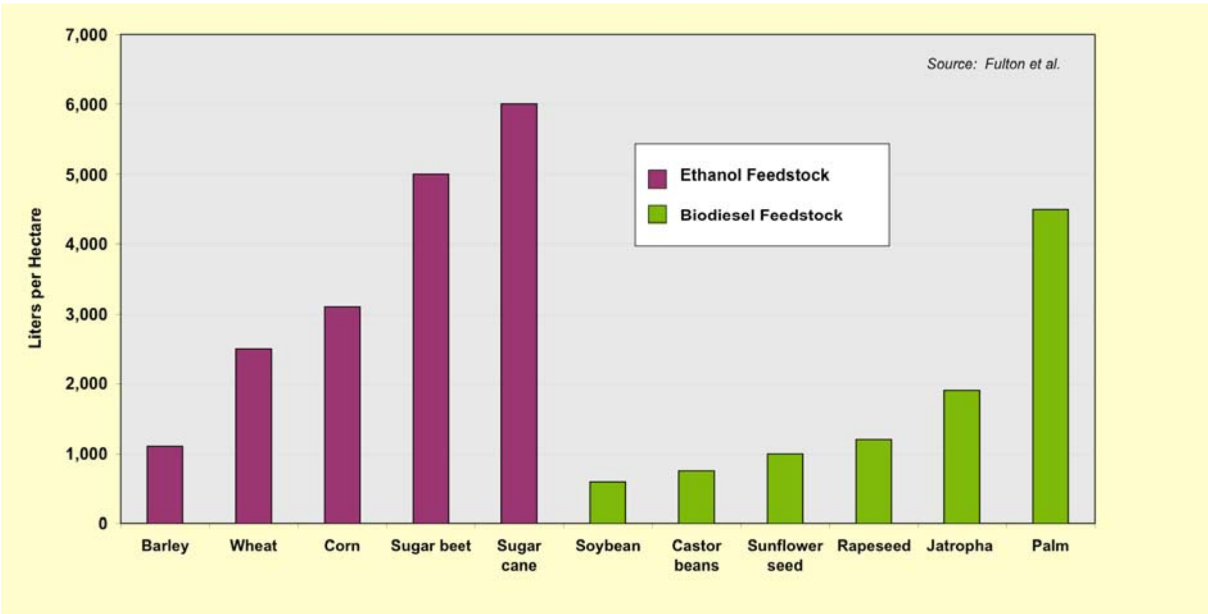
- The four target countries are characterized by low GDP economies based largely on smallholder agricultural systems and are increasingly affected by rising population densities and industrialization especially in the main regional drivers, China, India and Thailand;
- The four target countries have rich and diverse ecosystems which are under threat;
- Reliance on fossil fuels and/or traditional energy sources is increasing the hardships of the rural poor and is a major contributor to GHG emissions;
- Apart from Vietnam, biofuel policies and biofuel production initiatives are only in the development stage;
- A range of actors from the public and private sectors, as well as development agencies are initiating activities in the biofuel sector in each of the countries.
- Low intensity subsistence farming systems, weak value chains and inadequate market linkages are presently restricting the capacity of smallholders to participate successfully in large projects with economies of scale and continue to constraint the development of commercial agriculture;
- Overall, although biofuel stakeholders are beginning to appear and to launch biofuel initiatives, the absence of environmental governance and detailed biofuel sector planning may create dangers for unsustainable development.

3. Biofuel Options for smallholders in the Mekong Region and Nepal

The rationale for increasing the production and usage of biofuels is based on the premise that it will have potentially positive environmental and social impacts. These include the mitigation of climate change through GHG abatement and conservation of fossil fuels, but also energy supply security and the maintenance of employment in the agricultural sector. The environmental impacts of diverting land to biofuel crops depend on several factors, including yield, water consumption, chemical inputs, watershed and soil management, as well as biodiversity conservation. The social impacts depend on whether biofuel crops will compete with food crops needed for subsistence and improve local energy independence.

The various biomass feedstocks used for producing biofuels can be grouped into two basic categories, those for bioethanol production (in red in figure 1) and those for biodiesel (in green in figure 1). These are the currently available "first-generation" feedstocks, which comprise various grain and vegetable crops. These are harvested for their sugar, starch, or oil content and can be converted into liquid fuels using conventional technology. The yields from the feedstock vary considerably, with sugar cane and palm oil currently producing the most liters of fuel per hectare.

Figure 1: Biofuel yields of selected ethanol and biodiesel feedstocks



Source: Fulton et al., extracted from the German cooperation BMZ report, June 7, 2006

The possible biofuel feedstocks in the targeted region of the GMS and Nepal are maize, cassava, sugarcane, soybean, and Jatropha curcas. Oil palm is a key biofuel crop in Malaysia and Indonesia. It is highly productive with high extraction rates and profits. However, this crop was not included in this study because its positive economic benefits are much reduced for latitudes above 7-8 degrees north and southern latitudes. Moreover there is very little oil palm grown within the targeted countries.

The included feedstocks are considered to be potential options because they are already produced to some extent in the targeted areas, are included in some existing farming systems and are compatible with the prevailing conditions. Table 3 gives an overview of feedstock production and usage in the four countries.

Within regional auto-subsistence farming systems, production choices are governed by the following considerations by order of priority: (1) the overriding need to secure household food safety nets[26]; (2) financial and market risk management through diversification (supplementary crops, livestock and fisheries); and 3) cash income development from high value cropping to the extent that productive resources and access to irrigated land and markets are available. These relative priorities and constraints determine smallholder willingness and capacity to participate in the biofuel/ feedstock sectors.

[26] Household food safety net protection has become considerably more critical with the doubling of cereal grain prices in 2007-2008 and the growing inability of smallholders to purchase basic food staples in open markets, sharpening the critical focus on the household safety net an even more urgent priority. Rice price escalation is being driven by reduced production from poor harvests and reduced productivity from climate change, rising costs of production and marketing from escalating fuel prices, rising demand from population growth, commodity speculation etc.

TABLE 3: BIOFUEL FEEDSTOCK PRODUCTION AND STATUS FOR EACH TARGET COUNTRY

Biofuel feedstock/country	Cambodia	Laos	Nepal	Vietnam
Cassava (ha)	145,500	6,770	-	370,000
Commercial Jatropha (ha)	500 (estimate)	1,500 (estimate)	500	1,000 (estimate)
Maize (ha)	75,400	86,000	223,700	12,416
Soybean (ha)	65,530	9,535	4,865	6,780
Sugarcane (ha)	7,090	10,000	49,310	280,000
In country processing of biofuels	On-farm processing of Jatropha for local use is being piloted	On-farm processing of Jatropha for local use is being piloted	Not yet due to very early development of industry	Ethanol production for domestic consumption expected in 2009. Jatropha processed on small-scale for local consumption in development
Status of Biofuel feedstocks	Export of cassava, Soybean and maize, sugarcane to Thailand, Vietnam and China	Export Jatropha seed, maize, soybean, sugarcane, cassava to Thailand/China	Export Jatropha seeds and sugarcane to India	Domestic use expected in near future; Exports of dry cassava chips to China.

In order to gain further insight into biofuel and biofuel feedstock production in the region, case studies in Cambodia (3 studies), Laos (3 studies), Vietnam (1 study) and Nepal (1 study) were conducted. The main approaches employed in the studies were field visits, structured interviews and focal group discussions with key stakeholders involved in the cases, including smallholders, Small and Medium Enterprises (SMEs), traders and processors. Where required, secondary source data were used to round out the discussions of the case study issues and findings. Here, we present only one case study from Cambodia concerned with community farming of Jatropha, two cases from Laos as examples of contract farming and outsourcing arrangements, an example of large scale cassava farming for local processing in Vietnam and one case study from Nepal concerned with community farming of Jatropha. Feedstock options were then analyzed based on findings from case studies and a number of criteria: productivity, oil and ethanol extraction rates, gross and net smallholder margins, ease of production, and environmental and social impacts (table 4).

3.1 Case studies

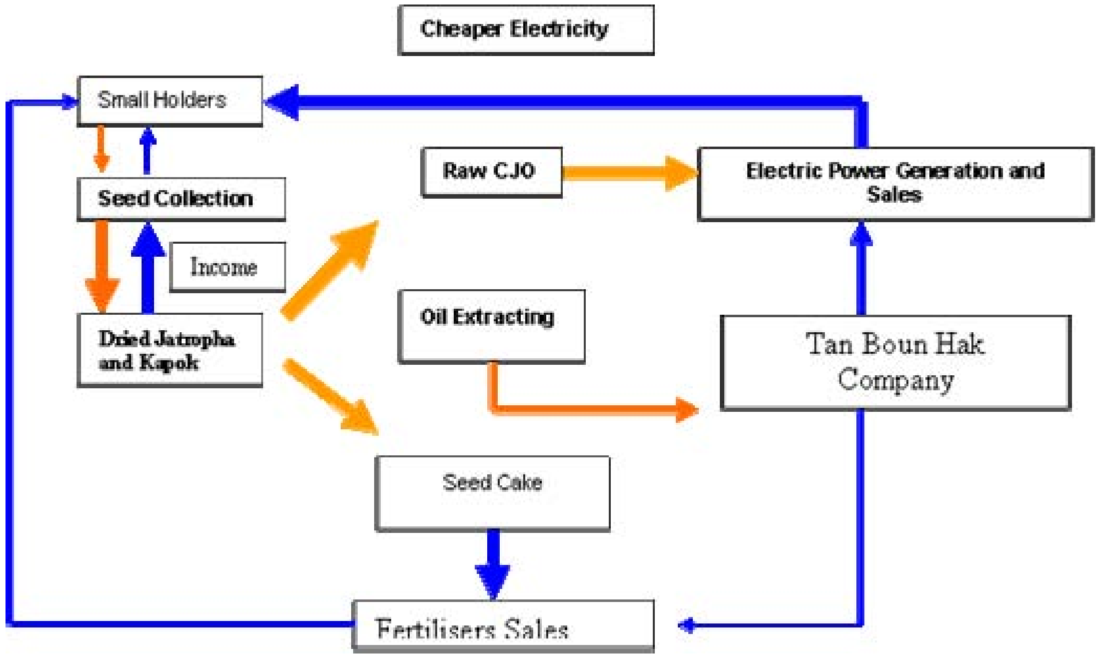
3.1.1 Mr Hak's Biodiesel operated Rural Electrification Enterprise in Cambodia

In Cambodia, Mr Tan Bun Hak has set up a REE using biodiesel made from Jatropha and Kapok seed oil. He invested in Jatropha in 2004 after attending a meeting on the use of CJO instead of fossil diesel to run electrical generators. The source of the Jatropha feedstock is from his own plantation and seeds obtained from contract farming agreements with his neighbors. He also obtains Kapok seeds from his neighbors but only in small quantities so this study focused on the Jatropha. At present, the oil produced is used in a diesel generator to supply electricity to 83 households in the village. Plans are currently underway to expand the production to 800 families in five villages. Mr. Hak expects to produce enough electricity for those families to use pumps to irrigate their paddy fields, mulberry plantations and vegetable gardens, power mechanical looms for silk weaving and sewing machines for garment manufacturing. This electricity could also power guesthouses for ecotourism. The five villages are located near a crane and bird sanctuary around a 9th century reservoir. Mr. Hak sometimes sells excess oil to Thailand.

Mr. Hak has been able to cut the price he charges for his electricity by 40%, to an average of USD0.62/KWH compared with electricity generated from fossil fuel diesel of USD0.92/KWH. In 2008, the German company Elsbett with support from GTZ, provided Mr. Hak with a modern biodiesel engine with a modified filter suitable for use with CJO. This biodiesel engine can be run for 3 hours/day. Thus, the villagers' reliance on GHG producing fossil diesel has been completely replaced assuming that the supply of Jatropha oil is sufficient. However it not clear if the tariff charged by Mr. Hak represents the true long-run economic cost of the electricity, considering that he received some donor support for the capital cost of the generator.

Mr. Hak planted four hectares of Jatropha trees on converted rice land, starting from branches he cut from hedges in neighboring villages. In the fields the trees are planted 3 m apart and with a 3 m row spacing to give 1,300 plants/ha. The yield of seeds averages 1.3 kg/plant. Improved practices such as pruning, fertilization or dry season watering are not used by Mr Hak. Other Jatropha seeds are collected from live fences around the homes in local and sometimes even distant communities. The seed cake resulting after oil pressing is used by the local farmers as a fertilizer, which they also buy from Mr. Hak (figure 2). The press cake is stored in pits and applied when needed. Large amounts are needed to obtain good crop responses.

Figure 2: Relationships between smallholders and the local REE in the case study



The contract farmers derive benefit not only from cheaper electricity but also from supplemental income from collecting seeds. Assuming a harvest rate of 3 kg per hour and a market price of USD0.075-0.1/kg, the profit per hour of work is about USD0.2-0.3, which is more than the basic wage of about USD0.15 for agricultural workers.

The seed oil content is a maximum of 30 to 35%. With mechanical oil expellers up to 75%-80% of the oil can be extracted but in general the yield obtained is only about 67% of its maximum. Hence, 4-5 kg of Jatropha seed can be converted to 1 liter of CJO. At the time of study, the oil was sold in Cambodia for USD1.5/L. This gives a valorization of a working hour of USD0.4 (without calculating the depreciation of the press).

Summary

Smallholders benefit from seed collection and cheaper electricity. Because they collect seeds from natural fences (as well as from wild Kapok) their financial inputs are minimal and their labor results in higher profits than the basic wage. Mr. Hak's plantation of Jatropha is not as productive or as profitable as it could be due to land and production-use practices. Since all fuel used in the REE is locally produced it can be assumed that GHG emissions are being reduced compared to the baseline case of using diesel fuel.

3.1.2 Contract farming arrangements in Laos for feedstock supply to Thailand

Two case studies are included for Laos to provide examples of contract farming comprising two different feedstocks: sugarcane and Jatropha, for outsourcing to Thailand.

Case 1- Sugarcane farming for Mitr Phol

Thailand's biggest sugar producer, Mitr Phol Co. Ltd operates under contract to the Thai Government to deliver 4 million tons of sugar per year for bioethanol production. However, the company is only able to deliver 2 million tons from its land holdings in Thailand and is now investing in sugar and molasses production from sugarcane in the southern Lao province Savannakhet, through its subsidiary Mitr Lao. Mitr Lao supplies seed cane and technology to contract farmers and guarantees farm gate prices. The semi-processed molasses is then transported to Thailand. The GoL approved the investment and granted a land concession of 10,000 ha in 2005 for a fee of USD6/ha/year. The GoL also authorized Mitr Lao to establish contract farming arrangements in the province for another 15,000 ha with smallholders.

In practice, the operation began with a 100 ha trial and the present concession area is only suitable for 6,000 ha of sugarcane, leaving 4,000 ha idle from projected investment. The company has signed written agreements with 660 contract farmers and provided 100% of the investment costs without collateral. The company applied the following criteria to select the farmers:

- The farmer must have documents showing (a tax receipt) legal rights to occupy the land;
- A minimum of one hectare of cane must be cultivated;
- The land should have access to water for irrigation;
- The land can be no further than 20 km from the processing factory;
- The farmer must demonstrate a commitment to producing a quality product.

Using the standard approach for contract farming, where farmers contribute land and labor, and investors provide capital and agriculture inputs, technical know-how and marketing services, the company provided about USD120/ha of credit to each farmer for:

- Support for land preparation;
- Chemical fertilizer;
- Irrigation;
- Cost of extra hired labor for weeding or other activities.

The company provided training in sugar cane cropping and market access. It also loaned equipment to some farmers, which they can purchase on an installment basis, for planting and harvesting in areas with labor shortages.

The best performing farmers are producing 40 tons/ha compared to others who are only producing 20-30 tons/ha. This is still low compared to average yields in Thailand (50 tons/ha) and Australia (90 tons/ha). Significant production losses, estimated at around USD300,000 worth of cane for 2007, were made due to buffalo and cattle grazing. An additional loss of 50 ha was made due to accidental fires. Yields are also low due to insufficient weeding, which the farmers refuse to do without increased payments. Part of this problem lies in the chronic shortage of agricultural labor due to migration to Thailand for better wages. Other problems were caused by the use of unsuitable land for cropping because good land is being kept for rice growing, as a directive of the Savannakhet Provincial Agriculture and Forestry Office. Sugarcane has high water requirements (250-270 L/ha/season) and requires irrigation for good productivity however irrigation leads to higher costs and lower profits for the farmer. The ratio cost to income is therefore crucial for farmers if they have to benefit from this crop.

In 2007-2008 the company achieved only 45% of its cane production through contract farmers. It is now considering taking over the management of plantations in an arrangement where farmers would rent out their land and be paid as daily laborers for a bit more than USD2/day. To date, the company has signed contracts to rent 128 ha of land in Xayboury district, for a period of 10 to 12 years at a fee of USD6/ha/year. The company also wants to organize the farmers into farmer production groups or cooperatives based on models that work in Thailand. However the company also recognizes that they need to revise their approaches based on local realities rather than applying systems used in Thailand.

Sugarcane has many negative environmental impacts. The environmental damage due to the project may include potential biodiversity loss and land degradation due to conversion of habitat in Mekong corridor wetlands. Soil erosion, nutrient runoff and pesticide usage could also cause siltation, eutrophication and contamination of Mekong or other freshwater ecosystems. Effluents can also be produced from sugarcane processing. At present, however, this has not been investigated in the field and environmental impact assessments could be required.

Summary

Mitr Lao’s first attempt to produce sugarcane for Thailand by contract farming in Laos had been relatively unsuccessful for both the company and farmers. This case study highlights the need for locally adapted biofuel initiatives.

Case 2- Jatropha plantations for CJO production by EQUITECH

The second Lao case study concerns contract farming of Jatropha in plantations by a SME called EQUITECH Lao (A subsidiary of the Thai EQUITECH company). EQUITECH Lao aimed to acquire Jatropha feedstock from smallholder farmers in Savannakhet province, which it would then convert to CJO in Laos and to biodiesel through transesterification in Thailand. EQUITECH contracted about 2,650 farmers, through the Lao Organic Product Promotion Association, for 12 months, to provide seed from 16,000 ha.

EQUITECH did not provide farmers with demonstrations or training in growing Jatropha but distributed leaflets with limited information about estimated yields (4 kg/tree), tree densities (2,500/ha) and costs and returns (for e.g. a gross margin of USD1,114/ha). However no information about the requirement inputs (labor or otherwise) or optimum cultivation techniques was given. Farmers were provided with mature Jatropha saplings averaging 2 years old. EQUITECH's contract price for seeds is approximately USD0.1/kg.

From field visits and discussions with EQUITECH farmers, the most probable yields from the current plantation will not exceed 200 to 300 g/plant, with a planting density of 1,200 trees/ha hence 240 to 360 kg/ ha. At EQUITECH's contract price, average smallholder margins could not exceed USD25-38/ha and with an estimated cost of production, including household labor, of about USD57/ha, it appears that farmers could make losses. The main cause of this low productivity is poor cultivation and land-use management techniques due to a lack of knowledge by the contracted farmers.

Other issues associated with the scheme are:

- An incapacity in the Lao legal system to enforce contracts which means that farmers sell seed contracted to EQUITECH to other buyers from Thailand or China if they offer higher prices;
- Encroachment on forests using shifting (slash-and-burn) practices by the contract farmers to clear land for the Jatropha plantations rather than using land that is usually used for rice production or even degraded areas where Jatropha is supposed to be suitable;
- Jatropha production requires 2 or 3 years of development and careful pruning to reach commercially viable productivity levels so that smallholders relying on Jatropha plantations will have little or no income without intercropping;
- Jatropha plantations require high labor intensity which means that farmers are often forced to hire labor and incur extra costs.

Summary

In response to some of these problems and first experiences, EQUITECH wanted to revise its business plan to a cooperative model where organized farmers produce feedstock and expel oil with company provided expellers. Farm-produced oil could have been used by local communities to power farm machinery, including pumps and tractors and then surplus oil sold to EQUITECH at the prevailing CJO price. It was believed that this new business model would result in higher gross margins for smallholders and increase both productivity and profits for the company. Land availability without further forest clearing was not addressed. Nevertheless, the company has now departed from Laos and farmers are left with their own Jatropha plantation, which should be of great potential for rural energy if a new scheme is organized and the supply chain developed (as in the model from Mr. Hak in Cambodia)

3.1.3 Jatropha in Nepal - Nepal/UK Oil Seed Project

The Nepal/UK Oil Seed Project was implemented by Dr Mick Boswell in 1995 and was featured in television documentaries and some 30 or so radio and newspaper articles. Dissemination activities embraced local and national interests with briefings to the then Prime Minister, Deputy Prime Minister and Ministerial officials in the policy and planning executive with a view to implementing a national program of plant oil support (see below).

Initial work in the project focused on testing diesel engines fuelled with a range of indigenous plant oils. A related oil expeller study produced the fuel oil from indigenous seeds collected from various districts in Nepal. The data obtained suggested that CJO is a suitable fuel. An endurance program was subsequently implemented in a purpose-built test facility at Tribhuvan University using a diesel engine operating in simulated field conditions fuelled with indigenous CJO. Some 700 trouble-free hours were achieved with engine performances comparable to those with conventional fuel.

In a pioneering scheme some 160,000 Jatropha trees were intercropped at two sites as a low canopy under a higher storey of existing stands of mature tropical hardwood. The soil quality was marginal - meaning unsuitable for agricultural crops - patchy and in some areas stony. Some 70,000 trees were propagated by seedlings from local seeds, around 80,000 were local cuttings and about 10,000 were local seeds sown directly.

‘Hands-on action training’ was provided to Women Development Groups in the establishment and cultivation of the trees. Related training in seed harvesting and post-harvest processing was also provided along with training in oil expelling and end uses for oil and process by-products. The scheme provided contractual agreements to the Groups for access to land for cultivation, maintenance, agro-processing and seed collection as well as 50% ownership of the seed yield.

Mill houses were constructed on-site for agro-processing machinery including an oil expeller, rice hullers and polishers, maize grinding and electricity generation - all machinery driven through a series of belts and pulleys by a diesel engine operating on CJO in the conventional layout utilized in rural areas.

A co-operative business model embraced collection and processing of seeds for fuel oil, the processing of rice and maize and the generation of electricity at the mills to meet local needs for agro-processing, household energy and fertilizer. Novel, simple and low cost cooking stoves and lamps fuelled on CJO were developed and tested for the household environment. A three month field trial of lamps operating on CJO was successfully conducted in 10 local households. A common local rice variety was cultivated using local techniques and various concentrations of Jatropha oil cake as fertilizer. Seed yields revealed that oil cake concentrations of around 5 t/ha lead to higher productivity than chemical alternatives.

The Nepal/UK Oil Seed Project has been working to implement a national program of plant oil extension[27]. A simple and robust model was proposed for economic analysis and extension which is rooted at the household level, consistent with traditional farming practices and utilises the low cost, proven and familiar technology the Nepal/UK Oil Seed Project has adapted for CJO fuel[28]. The project found that in a non-monetised rural household with only 250 small trees planted around the perimeter as a living fence, given the negligible work involved in establishment, cultivation and harvesting of the trees, enough CJO would be produced each year to meet processing costs and [for illustration only] to fuel at least one clean-burning lamp continuously day and night for the whole year. Furthermore, the oil cake, fruit pods and leaves would be available as manure providing nutrients to cultivate about 200 kg of rice.

In the monetized household with a similar number of trees, the model showed that about 68 liters of fuel can be produced at no cost each year provided that the oil cake can be sold for about 0.05-0.07USD/kg. If the oil cake is retained by the household for cultivation, the fuel cost is competitive with fossil kerosene or diesel. If the fences are used to protect crops grown on quality agricultural land then irrigation and fertilisation of these adjacent crops should impact positively on Jatropha seed yield. The model could be applied to more than a million households in the country resulting in significant positive impacts on the national economy from fossil fuel substitution and employment opportunities in manufacture of oil expellers, cooking stoves and lamps etc. Stationary diesel engines, cooking stoves and lamps that operate on CJO are cleaner than chemically processed biodiesel fuel with no energy, water or chemical inputs required in fuel processing - and a local focus links smallholders interest in cultivation to end use in the household and small-holding.

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[27] Boswell, M. J. [2004] Status and Extension. Nepal/UK Oil Seed Project Concept Briefing to GoN, and other agencies.

[28] According to the Gulf Times [14/02/08] this concept model seems to have been implemented recently in Myanmar, with the Government supplying certified seeds to farmers with a view to cultivating around 200 plants per household throughout the nation.

Several problems were encountered by the project. Firstly, the implementation and operation of the plantation sites occurred against a backdrop of growing Maoist insurgency which ultimately and sadly completely restricted work and commercial activity was not achieved. Political stability is thus a pre-requisite for extension. Commercialisation was also constrained by a lack of established markets, training programs and support from resource agencies and government offices. This has not been an area of priority for resource agencies or indeed for the Government of Nepal (GoN).

The project also found that marginal land may have historical and informal functions within the local communities. If this land is already accessed for fodder and fuel, biofuel plantations can impact negatively on local community needs and if access for fodder and fuel continues there can be negative impacts on the biofuel crop. Land titles may also be unclear or disputed.

Lastly, seeds should be certified and supplied from a registered source because the yield from wild seeds is unknown. It is crucial too to assess the quality of land and any prospects for easy irrigation otherwise significant variations in seed yield will be experienced. Seedlings require protection from snails and seed pods from unidentified boring beetles. The lead time from seed to yield is very difficult for farmers to manage.

Summary

The Nepal/UK seed project developed stationary diesel engines, cooking stoves and lamps that operate on CJO. More than a million households throughout Nepal could benefit from cultivating Jatropha fencing to protect crops from browsing animals and producing CJO. The project set-up was consonant with traditional farming practices, supplied oil cake fertilizers which increased rice yield and clean household energy using proven and familiar technology adapted for CJO. Simple end-uses such as lamps are of much interest to the farmers. These can be produced at low cost and a subsistence farmer could easily grow the small number of trees as fencing that would be required to produce the fuel. Unfortunately, political instability hampered progress. Plantations of Jatropha on marginal lands were also trialled in another community based program involving women. The project identified an important issue concerning so-called marginal land which may in fact already play a significant role in the livelihoods of local communities.

3.1.5 Cassava cropping for ethanol production in southern Vietnam

The Vietnam case study concerns ethanol production from cassava in Tay Ninh province, which is in southern part of Vietnam, west of Ho Chi Mihn city, on the border with Cambodia. Foreign investors (a firm from Singapore and the Japanese Itochu cooperation) are joint venturing in large scale projects with Vietnamese companies (Bien Hao sugar company and Petroleum Services and Tourism company (Petrosetco)) to build factories to produce ethanol from molasses obtained from processing sugar cane and cassava. It is expected that upon full operation, the combined output of ethanol, to be blended with petrol at 90% (so that the resulting fuel is known as E-90), will supply 10% of Vietnam's national consumption of E-90 by the end of 2009. The case study is mainly concerned with the cassava feedstock.

Tay Ninh province is the biggest producer of cassava in Vietnam. Approximately 10,000 ha are planted with cassava on average sized land holdings of 0.85 ha with slopes of 0-15%. The average yield is 8 to 10 tons/ha. Although varietal selection has greatly improved yield, the yield in the production area is still considered very low (demonstration plots can produce 30 tons/ha). Nearly all tillage and weeding is done by hand or with buffalo (for plough tillage), however in a few areas tractors are used. Weeding must be done up to four times per season. Herbicides are not used. Generally Tay Ninh farmers plant at the beginning (May) or end of the rainy season (October). Planting is done with cassava stakes, horizontally, at a high density of up to 20,000-25,000 plants/ha. Cassava grows relatively well on poor soils but requires a large amount of inputs to produce high yields. 0- 50 kg of Nitrogen (N) /ha, 30-100 kg of Potassium (K_2O)/ha and 15- 30kg of Phosphorous (P)/ha are applied to the fields in the province. If the cassava price fluctuates and farmers can not afford such large inputs, animal manure and legume intercropping are used instead to maintain soil fertility. In some farms in Tay Ninh, fertilizer inputs are very low and soil fertility is decreasing. The majority of cassava for ethanol production is harvested after 10-12 months to ensure high starch content.

The total variable cost of cassava cultivation in Vietnam in 2007 was about USD150/ha, at an average root yield of 12.5 tons/ha**.** The resulting gross income is about USD330/ha and net income is around USD180/ha. On average, labor accounts for 40-70% of cassava production costs. The average labor requirement is 65-80 man-days/ha. Gross returns on labor are from about USD0.85-1.45/day. If we assume that the average (rural) daily wage is approximately 1 USD, then cassava cultivation compares favorably. The second largest cost item is fertilizer, constituting a bit more than 15% of total production cost.

In Tay Ninh, smallholders procure cassava to collectors and middlemen. In turn, the collectors and traders sell cassava roots to chip processors. These intermediate processors then sell chips as semi-processed raw material to the ethanol producers. Although the cassava grown in Tay Nihn area produces 72,000L of ethanol it is not enough to fully supply the factories, thus the factories have started outsourcing feedstocks from Cambodia.

Smallholders in Tay Nihn are faced with large price variations and imports from Cambodia are expected to lead to further decreases in the prices paid for cassava in Vietnam. Competition for land is also becoming a problem with other cash crops such as sugarcane, rubber, coffee, and cashew nuts receiving large investments from the Government.

Most cassava in Tay Ninh is grown on small plots and patches of land which are not suitable for rice or other crops. However cassava plants do not provide much soil cover and in sloping areas (more than 10% slope) this leads to soil losses via erosion. Depending on the amount of chemical fertilizer used, this could also lead to contamination of water resources. At the processing end, factories do not have adequate effluent mitigation facilities and untreated effluents are discharged into streams and onto surrounding land.

Summary of all case studies

- Smallholders benefited from community-based biofuel initiatives; especially when they captured and controlled the highest value addition from biofuel enterprises and achieved farm energy security at the household and community levels;
- Smallholder benefits from plantation scale biofuel contracts depend on a number of factors including productivity, labor and agricultural inputs as well as land management practices;
- Biofuel processing enterprises that relied solely on feedstock supply from unorganized smallholder farm enterprises experienced raw material constraints, under capacity utilization with downstream profit constraints;
- Smallholders require extension services and training for optimal production;
- Smallholder-based biofuel feedstock production appears difficult to organize for successful enterprise profitability and requires other than standard contract farming business models to succeed;
- Foreign biofuel enterprises tended to apply business models and approaches from their own countries, which are often unworkable in countries where feedstock outsourcing is practiced;
- There were many potential negative environmental impacts associated with all the approaches used, except perhaps Jatropha grown by the community in hedges, including soil erosion, water resources contamination, and land and habitat degradation due to forest encroachment.
- Although land availability appears to be an issue, farmers often chose or were directed to use new land or otherwise unsuitable land for biofuel feedstock cropping rather than land usually planted with rice.

3.2 Analysis of Suitable Biofuel Feedstock alternatives

Biofuel cropping alternatives in the region were compared based on results from case studies and other findings in the literature. The economic, environmental, social impacts of the biofuel feedstocks for cropping by smallholder farmers in the region were examined and summarized in table 4 below:

	Economic impact					**Environmental impact**			**Social impact**	
Crop/criteria	Income (UDS/ton)	Yield (ton/ha)	Biofuel production (L/ha)	Labor input (Man/days/ha)	By product marker/usage	GHG reduction	Soil degradation	Water contamination	Competition with food	Use for own biofuel production
Cassava	77-125	8-10	3000-3800	65-80	Leaves for fodder/stems for biogas	-10 to -50%	Yes soil erosion	No or little	No or little	no
Jatropha	92-115	0.8-2.5	220-700	60-100	Seed cake for fertilizer/after transesterification glycerin for soap or other uses	-40 to -80%	Land clearing for plantations	no	no	yes
Maize	48-77	0.3-0.8	117-234	75-80	Cobs/stalks for other bioenergy production	-10 to -50%	yes	yes	yes	no
Soybean	520-610	0.2-8	130-350	30-80	Soy meal for animal feed	-40 to -80%	Yes due to inputs and erosion. But benefit of nitrogen fixation	yes	yes	no
sugarcane	82-100	40-60	3210-3900	80-90	Can be used for animal feed, to make paper or burned for bioenergy	-10 to -50%	yes	yes	no	no

TABLE 4: INDICATIONS OF THE ECONOMIC, ENVIRONMENTAL AND SOCIAL IMPACT OF BIOFUEL FEEDSTOCKS GROWN IN THE REGION

With rising oil prices and rapidly increasing **cassava** ex-factory prices for feedstock, cassava has become a major biofuel crop profitable for farmers and processors. It is a major crop in northeastern Thailand and is the major feedstock grown in Vietnam (see case study in the first part of this chapter). As a feedstock, cassava has the advantage that it is already known in the area and is easy to produce and technically suitable for smallholders without significant extension inputs. Furthermore, in general, cassava requires few agrochemical inputs (it is relatively insect tolerant but losses can increase to 50% if a virus such as the cassava mosaic virus appears in the growing area). Cassava has low fertilizer requirements so most cassava is grown on small plots and patches of land which are not suitable for rice and other main crops. Cassava yields are improving due to the introduction of new varieties thereby reducing unit costs and increasing revenue and income. However weeding and harvesting are currently done by hand which leads to high labor requirements. Although cassava is often used for animal feed (dried chips) and for human consumption (roots), its production does not appear to be competing significantly with food feed stocks in this region. Cassava leaves, when treated to remove cyanide, provide excellent fodder for livestock, although it is rather expensive and time consuming, and the woody stem could also have potential for energy production via biomass gasification (LIRE, 2008). A major disadvantage of cassava is that the plant does not produce enough vegetation for adequate soil coverage which can result in erosion especially if grown in hilly areas. It is also important to note that the production of bioethanol is a complex process and it cannot be made locally without expensive equipment.

Jatropha is a hardy shrub which is grown traditionally in Asia as hedges to protect garden plots. Jatropha oil, from its non-edible seeds, is being promoted as an easily grown biofuel crop in hundreds of projects throughout India and other developing countries. However, because it was only recently identified as a biofuel crop, research is lacking concerning best cropping practices and related impacts on productivity and soil fertility. Thus although the plant can grow well on marginal soils with limited water resources, seed productivity can vary between 800 kg to 3,000 kg/ha/year (or can be even lower, see case study for Laos above) and hence oil yield can vary wildly. For example, on average, one hectare of plantation on normal soil will provide approximately 850 liters of oil whereas plantations on poorer soils will give only about 230 liters of oil/ha. In large scale plantations there is also very high labor requirements for seed harvesting. Nevertheless Jatropha is a potentially very profitable smallholder crop, if grown in compound and field hedges and farmers receive full market prices. Smallholder profit margins increase substantially when they add more value by extracting their own oil, which can be pressed and strained by the household using simple equipment costing from as little as about USD60, for use in their farm machinery in place of fossil diesel. Under these circumstances, there is minimal and easily mitigated possible soil and land degradation and water pollution, and the tree has been shown to increase soil stability. Although Jatropha plant material, seeds and oil are toxic[29] *(curcin),* the by-products (press or oil cake) can be used with care as fertilizer.

Maize is widely cultivated throughout the world, and a greater weight of maize is produced each year than any other grain. Maize is used to produce bioethanol particularly in North America. Currently Nepal grows the most maize in the study area (table 3). At present, maize is profitable for smallholder producers in the region as a food crop but would be less profitable for producers of bioethanol and not a suitable transport biofuel feedstock in the region because under most circumstances it is only viable with heavy government subsides. Furthermore although maize is seasonal, and so does not compete with rice production, its use as feedstock could compete robustly with its use as human and animal feed crop. Finally, Maize mono-cropping in the region is causing land degradation, soil erosion and water pollution from agrochemicals. An alternative for maize is the use of maize cobs and stalks, after harvesting the grain, for other bioenergy production (biogas or heat).

The **soybean** is a species of legume native to East Asia that is currently grown in all four countries in the target region. Soybeans are an important global crop, providing oil and protein. The bulk of the crop is solvent-extracted for vegetable oil and then the soy meal is used for animal feed. A small proportion of the crop is consumed directly by humans. Soybean can grow up to 3,000 m above sea level making an interesting crop for the mountainous regions of the study area such as in Nepal and northern Laos. As with other bio-oils, Soy biodiesel can be an environmentally friendly fuel as it is renewable, nontoxic and biodegradable. However, as with other biofuel crops this depends on the way the feedstock is produced. As in the case of palm oil, soy has been the subject of many environmental campaigns, as large scale development especially in South America has resulted in conversion of forests and caused environmental degradation. Smallholder soybean production shows high revenue to cost ratios so the crop is profitable. For biofuel production, the oil content is only 15%, compared with 30% for Jatropha. However, proponents of soy-based biodiesel emphasize that oil for biofuel is only a by-product of the edible meal and therefore soybean farmers are not reliant on only one market. Soybean is a nitrogen fixer and improves productivity of subsequent crops by 10% to 15% (e.g. rice, maize, etc.) but can also lead to soil erosion and pollution due to agrochemical use depending on land-use practices.

Sugarcane cultivation requires a tropical or subtropical climate, with a minimum of 600 mm of annual moisture. It is one of the most efficient photo synthesizers in the plant kingdom, able to convert up to 2% of incident solar

[29] It is reported that five children were killed in Uttar Pradesh's (India) after eating Jatropha seeds, mistaking them for cashew nuts; Re: http://www.newkerala.com/topstory-fullnews-40221.html

energy into biomass. Thus when extracted sugar is used to make ethanol it is highly productive and the major bioethanol crop worldwide. Sugarcane is grown in all the four countries and extensively in Vietnam and Nepal (table 3; also see Lao case study above). Sugarcane is a perennial crop, which precludes other cropping alternatives. It is also labor intensive, unless mechanized. Sugarcane is highly water intensive and so productivity depends on irrigation. Without irrigation, the yield averages some 40 tons/ha. With irrigation, sugarcane yields double to over 80tons/ha. As a water intensive crop, sugarcane, grown on commercial scales, generates high irrigation costs and reduces profits and net income for farmers.

Other biofuel crops, such as **tropical sugar beet**, are as efficient as sugarcane in producing bioethanol but require far less water and, most importantly, can grow in alkaline or sodic soils that are basically unsuitable for food crop production. Sweet sorghum is also showing some promise as it is simpler to process than sugarcane. The crop has 2-3 cropping periods a year, and can be grown in fallow sugarcane land. It also yields fiber that can be burned as fuel, which is similar to that of bagasse produced from sugarcane. Furthermore, the **"next-generation"** of biofuel feedstock comprises cellulose-rich organic material, which is harvested for its total biomass. These fibers can be converted into liquid biofuels only by advanced technical processes, many of which are still under development. Cellulosic biomass such as wood, tall grasses and crop residues is much more abundant than food crops and can be harvested with less interference to the food economy and potentially less strain on land, air, and water resources. Promising energy crops include fast-growing woody crops such as willow, hybrid poplar, and eucalyptus, as well as tall perennial grasses such as switchgrass and miscanthus. Another potential "next-generation" feedstock is the organic portion of municipal solid waste. Nevertheless the benefits of next generation feedstocks are yet to be proven.

Summary of feedstocks analyses

- All of the feedstocks have high labor requirements if grown as plantations, which can lead to difficulties for smallholders if extra labor must be hired.
- Only maize and soybean can be grown exclusively in the dry season so as not to compete with rice growing in the wet season. However they are also both cropped as food for humans or animals.
- Without conservation land management practices all of the crops have the potential to lead to land degradation and contamination or over usage of water resources;
- No actual analyses of GHG reductions were carried out during the study. However from the literature, there are no striking differences among the crops for biodiesel or among feedstocks for ethanol production, respectively. Any differences would be due to the extent of land conversion and fertilizer used to grow the different crops;

- Based on the analysis, Jatropha (particularly when grown in hedges for local use) appears to be an interesting option for biodiesel production as cassava shows promise for bioethanol.

4. Analysis of Issues affecting pro-poor and environmentally sustainable biofuels

This part of the study focuses on the main issues concerning the sustainable development of pro-poor biofuels in the target countries based on findings from case studies and other analyses. In particular issues raised by the Roundtable on Sustainable Biofuels, which launched version zero of the global principles and criteria for sustainable biofuels (RSB, 2008)[30] in August 2008, and the guidelines established by SNV-WWF (see introduction) are discussed in light of the regional situation. Moreover, this chapter addresses the hot topics mentioned in chapter 1 such as:

- **Food *versus* fuel;**
- **Government policies;**
- **Climate change and environment;**
- **Impact on poverty alleviation;**

4.1 Food *versus* fuel

"Implementation of biofuel policies must take into account food security and must not threaten the realization of the right to food."[31]

An important issue with biofuels, and which has been widely publicized is their supposed affect on food prices in general, and in the studied region, where arable land is relatively scarce, competition between land for growing food and feedstocks is a potentially serious problem, especially to the rural poor and subsistence farmers.

In some countries, biofuel production may have affected the prices of food crops on the world market. For example the price of maize increased by some 60% during the past two years (WB, 2008). The U.S. is the world's largest maize exporter and when its biofuel expansion contributed to a decline in grain stocks, it may have also, inadvertently, contributed to an increase in some world cereal prices. Similar price increases have occurred

[30] http://cgse.epfl.ch/Jahia/site/cgse/op/edit/lang/en/pid/70341
[31] The following quotes are from the RSB Version Zero document

for oil crops such as palm, soybean and rapeseed, possibly partly because of biodiesel production.

However, although price increases are often blamed on biofuel production, issues such as stock levels, exchange movements and climate change, as well as intangible factors such as commodity demand pull from economic growth and preference shifts among consumers, commodity speculation and land conversion and release to non-agricultural sectors also play a major role in affecting commodity price increase. **Thus, the blame leveled on biofuel production as the sole cause of food price escalation is overly simplistic and misleading** (WB, 2008). Some food price increases are anticipated but, as with most aspects of biofuels, estimates vary. The International Food Policy Research Institute (IFPRI) projects maize prices to increase by 20% by 2010 and 41% by 2020, with similar increases for oilseeds (26% by 2010, and 76% by 2020), and wheat (11% by 2010 and 30% by 2020) (IFPRI , 2008). The FAO, on the other hand, projects that prices of coarse grains will increase by only 15% by 2016, whereas the price of wheat would remain unchanged (FAO, 2007).

Findings from case studies in Cambodia, Laos and Vietnam suggest that **so far in the majority of cases, land used to crop biofuel feedstock is not being competing with food crop production**. This is due to the predominance of subsistence smallholder farming systems anchored on household food safety nets, as well as incomes derived form rice cropping still being competitive with those from biofuel feedstocks. Both smallholder farmers and the government have given highest priority to sustaining and expanding rice production to meet rising consumption needs in the face of rapid population growth. At the present time, the in-country market demand for feedstocks which can also serve as human or animal food, such as maize, soybean and cassava is not sufficient (for the moment) to cause a threat to food security. The emerging threats are not to food but more oriented to sensitive environmental resources, which will be discussed later.

In the future if markets and prices for biofuel feedstocks continue to increase, there may be more competition for land. In that case, feedstocks which are seasonal do not require large inputs of water and can grow on marginal or degraded land (e.g. cassava and Jatropha) will be the preferred option. New crops are undergoing evaluation including alternative or complementary crops to the traditional feedstocks cited above. Thus, there are other options to growing biofuel crops (other than food crops) and the issue in many developing countries, especially, those that are both net importers of food and fossil fuel, is not food *versus* fuel***,*** **instead, the issue is managing limited water and land resources to promote both food and fuel production.**

4.2 Local *versus* export markets

The analysis of the four targeted countries clearly demonstrates that the state of biofuel development in these countries remains in its infancy although the interest and concern certainly exist. At present only Vietnam has a coherent national biofuel policy and the biofuel sector in all four countries is just beginning to evolve.

Biofuel sector development is a long-term process[32] requiring many years for private sector and smallholders to respond to emerging markets through paradigm shifts in farming systems, investment mobilization, and infrastructural improvement to processing and distribution to support a vertically integrated value chain for commercial biofuel development Although the pace of biofuel development is increasing as biofuels become more competitive with fossil fuels, it is unrealistic, however, to assume that the targeted countries will be able to develop sophisticated and viable commercial biofuel sectors in the short to intermediate time frame.

All four countries are constrained by a number of limiting factors, some of which have been discussed in other sections. In summary, these include[33]:

- Small parcel holdings of smallholder households;
- Prevalence of smallholder farming systems targeting the food safety net (rice and other grains) over commercial agriculture;
- Inability to cultivate perennial crops by the majority of smallholders on small holdings because of the need to grow rice and other grains for auto-consumption in the wet season; as well as land tenure scheme;
- Greatly restricted access by smallholders to irrigated land, which would allow them to produce biofuel feedstocks in the dry season after having secured their food safety nets in the wet season;
- Labor market shortages caused by out-migration from rural areas and restricted capacity of household labor to supply labor for concurrent auto-consumption farming and biofuel feedstock farming;
- Land release and conversion to non-agricultural sectors;
- Rising fossil fuel prices which increase the costs of diesel fuel for hand tractors, water pumps, fertilizers and pesticides, thereby reducing profit margins and restricting investment potential and other cropping alternatives;
- With the possible exception of Vietnam, all of the targeted countries lack the investment capital, technical know how and business

[32] Five of the most advanced biofuel sectors in the world are the USA, Brazil, Thailand, China and India. In those countries, it has taken 30 to 35 years for the biofuel sectors to attain the present stage of development.

[33] In all four countries, there are grandiose and unrealistic schemes and plans launched by foreign companies for biofuel development on large scales of thousands of hectares. All of these schemes investigated appear to be either fronts for land speculation or unrealistic as they lack investment capital and knowledge of smallholder farming systems and the constraints under which these systems operate.

friendly policy environments to develop modern biofuel feedstock, processing and distribution systems for both domestic and export markets;

- Smallholders in the studied countries are risk averse (like most smallholders all over the world) and reluctant to adopt new technologies and crops without agricultural credit, extensive trial demonstrations and robust value chains and market linkages. For e.g., it has taken ten years to develop commercial maize production in the Lao PDR;
- Extension mechanisms in the targeted countries are still developing, limiting smallholders' access to inputs, technology and markets;
- The targeted countries (except for Vietnam[34]) lack effective rural finance mechanisms;
- The levels of feedstock production in the target countries are presently inadequate to supply commercial biofuel production on a viable economic scale.

Thus, the findings of this study suggest that the present constraints faced by smallholders practicing auto-subsistence agriculture will restrict biofuel feedstock production capacity to low level raw material production for domestic biofuel production and/or outsourcing by regional markets. This statement might change if production increase and thus open export market potential.

The governments of the targeted countries have set or drafted policy goals to substitute 5% of fossil fuels with biofuels within the medium timeframe up to 2020. Although broad policy statements speak of export markets, a significant increase in investment in the sector appears to be needed to reach these internal targets before large scale exports become feasible.

4.3 Current policy environments in the region

"Biofuel production shall follow all applicable laws of the country in which they occur, and shall endeavor to follow all international treaties relevant to biofuels' production to which the relevant country is a party." [35]

[34] The Vietnam Bank for Agriculture and Rural Development (VBARD) lends to rural households on the basis of collateral posting, group liability and project worth criteria for households that do not belong to groups or are unable to post collateral. VBARD utilizes three different credit methodologies. First, it provides individual loans to rural farmers and entrepreneurs, with collateral requirement such as a land use certificate. Second, VBARD lends to individuals through joint liability groups. Third, VBARD uses brokerage services of mass organizations, which targets borrowers unable to provide collateral.

[35] Same as reference 26 : Source RSB

All countries surveyed have signed the Kyoto agreement and thus engaged in supporting sustainable resource management, developing clean energy mechanisms and supporting climate change policies.

Traditionally, the market for biofuels has been largely policy-driven. Taking the example of biofuel leaders like Brazil and Germany, the market has been sustained through government interventions such as mandates and subsidies by way of tax credits, among others. Asian countries continue to examine the model of Brazil, wherein governments mandate biodiesel and ethanol blending targets for national diesel and gasoline stock piles. Blending mandates are creating growing markets for biofuels in India, Thailand, Japan, China, and the Philippines; Malaysia and Indonesia are preparing policies for compulsory biodiesel blending. It is recognized that this process might help to buffer over production that depresses prices as observed recently. More challenging will be the determination of governments to maintain pro-biofuel policies in the long-term. Droughts and lack of land affecting supply, stabilization of oil prices affecting economics, and a host of other possible scenarios may cause governments to withdraw support under changing conditions. Table 5, below, presents an overview of the policy environment in the four targeted countries as assessed by the study team, where weaknesses and gaps need to be addressed if the biofuel sector aims to account for a major share in energy consumption.

TABLE 5: COMPARATIVE GOVERNMENT POLICIES AND OTHER FACTORS INFLUENCING BIOFUELS

Policies/Indicators	**Nepal**	**Laos**	**Cambodia**	**Vietnam**
Environmental Policies	Yes	Yes	Yes	Yes
Market Friendly Policy Directives	Yes	Yes	Yes	Yes
Environmental Governance	Poor	Very Poor	Poor	Very Poor
General Policy Enforcement	Weak	Extremely Weak	Weak	Moderate
Pro-Poor Policy directives	Yes	Yes	Yes	Yes
Extension Mechanisms	Under development	Under development	Under development	Exist but need further support
Strength of Value Chains	Very Weak	Very Weak	Weak	Moderately strong
Ease of Doing Business[36]	121/181	165/181	135/181	92/181

[36] Source: http://www.doingbusiness.org/economyrankings/?direction=Desc&sort=1

Economic Freedom Index[37]	112/157	137/157	100/157	135/157

Beside the policies elaborated by government, it is important that all actors involved in the biofuel chain become owners of the development process in order to create an efficient and dynamic sector beneficial for all.

"Biofuel projects shall be designed and operated under appropriate, comprehensive, transparent, consultative, and participatory processes that involve all relevant stakeholders."

And ***"Biofuel production shall not violate human or labor rights, and shall ensure decent work and well-being of workers; there should be an equitable playing field for small producers."***

Vietnam appears to be the most progressive of the four countries. The other three countries are mired in contradictions between policy instruments and practices. The underlying weaknesses facing these countries are the prevalence of market distorting practices, including monopoly and oligopoly practices and collusion among government officials, traders and other operatives within existing supply chains. Other market distorting practices include the practice of kick backs and payoffs for business licensing, taxation, export and import licensing, land concessions, inter-provincial trade taxes and other collusive and inhibiting practices. The political instability that has plagued Nepal for the last 14 years has also played a role. Agencies have found it difficult to address environmental problems comprehensively because of frequent changes in senior staff and political interference in program implementation.

4.5 Pro-poor biofuel perspectives

4.5.1 Impacts on smallholder farmers

"*Biofuel development shall contribute to the social and economic development of local, rural and indigenous peoples and communities."*

Biofuel feedstocks, when produced on a large scale, could represent a paradigm shift in agricultural development. As with all shifts, there would be both winners and losers. However, there could be considerable offsetting benefits from biofuel development. From the point of view of poor farmers who have dealt with declining commodity prices for more than 40 years, developing biofuels could provide an opportunity for diversifying benefits and intensifying production which could lead to increased household income.

[37] Source: http://www.heritage.org/research/features/index/countries.cfm

Moreover, some biofuels might also contribute to alleviating poverty through employment and rural wealth creation. Because biofuel production is labor intensive (especially for harvesting), there could be significant employment creation in some countries[38] and especially in the selected countries of this study. If mechanisms are introduced to ensure that much of the increase in prices accrues to the farmers, both biofuel and increased food prices can stimulate rural economic growth through additional capital inflows, create demand for goods and services that provide employment, reduce rural-urban migration, and create linkages and multipliers. This has been observed in Brazil where biofuel production in sugarcane-producing regions stimulated rather than competed with the other food crops and the income generated through agro-industrial activities related to sugarcane helped “capitalize” agriculture and improve conditions for producing other crops.

From the case studies in the preceding section, the picture on the sustainability of biofuels is mixed.

In the Lao PDR, smallholders benefited little from sugarcane or Jatropha plantation schemes. This was due to a number of reasons including inappropriate business models, lack of training and extension services, poor land-use practices and low farm gate prices. Smallholders participating in the plantation schemes were forced by economic circumstances to sell their labor at less than the labor opportunity cost and their net return to labor was less than they make from rice. In addition contracted smallholders, who only grew and harvested the crop, could not benefit from value adding to the crop by biofuel production, as in some neighboring countries[39].

In Cambodia, the case study showed a very positive example of socially sustainable biofuel production that is benefiting smallholders and other villages. Farmers who collected and/or cultivate Jatropha seeds and sold then to the REE, gained more than the basic agricultural wage, paid less for electricity and have access to Jatropha seeds cake for fertilizer. It is interesting to compare the incomes that can be derived from different models of Jatropha farming. For smallholder families, who produce their own feedstock on small plots (a double row 400m fence, 1,600 m2), and consume their own oil in tractors and water pumps the profit is USD440. The same farmer who only sells seeds makes a net profit of USD102 on the same living fence.

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[38] Biofuel production could add an estimated 9 million jobs in China, one million jobs in Venezuela by 2012 and up to 1.1 million jobs in Sub-Saharan Africa (De Keyser and Hongo, 2005)

[39] In Thailand, farmers have better access to marketing information and technology than their Lao counterparts. Thai farmers have discovered that they can produce their own oil from simple presses, manufactured in local blacksmith shops for about USD 60 to USD1,700. A community-based oil extruder and filter, copied in Thailand from a German model, retails for USD14 000. This equipment can produce 500 liters of clean CJO per day.

Cambodia benefits economically from its strategic location between major biofuel markets in Thailand and Vietnam and the relatively short transport distances from feedstock producing areas to these robust regional markets. In the past three years, there has been a dynamic expansion of smallholder production of cassava in Khampong Thom, Khampong Cham and Bantay Meanchay Provinces. Thai and Vietnamese bioethanol processing enterprises send collectors in their own trucks to buy cassava tubers directly from farmers at the farm gate. Cambodian cassava producers presently capture robust net returns of USD350 per hectare. The net margins from Cambodian Cassava are equivalent to rice and add a major dimension to smallholder livelihood systems.

In Vietnam, the principal biofuel feedstocks are cassava and sugarcane produced by smallholders as feedstock for local ethanol factories. From the case study on cassava (see chapter 3), the average return to labor is slightly higher than the rural wage rate of USD1/day. The major constraint to farmers who produce raw material for conversion to ethanol is limited land area availability and the need to produce rice for auto-consumption. In addition the higher profits and returns to labor from rice cultivation (the net margin from commercial rice is USD250/ha with a daily return to labor of USD2.5) is another disincentive to biofuel production.

Biofuel cassava feedstock production in Vietnam appears not to be as profitable for smallholders as producing commercial rice for domestic sales and export. The lack of cassava profitability for Vietnamese smallholders is the major reason why Vietnamese processing plants run at below capacity and the main driver for outsourcing cassava feedstock from Cambodia.

In Nepal sugarcane is presently sold as raw materials to India. The returns to smallholders from producing sugarcane are USD280/ha or USD1.4/worker-day. Thus, compared with returns from producing grains such as rice and wheat, which are USD2.5/work-day per season, the smallholder receives only almost half the returns from producing ethanol biofuel feedstocks under present conditions.

If Jatropha productivity in Nepal was equivalent to productivities in Laos and Cambodia, smallholder gross margins would amount to 800 x USD0.23= USD184/ha for contract farmers. This magnitude of profit margins for contract farmers would be less than the profits from planting grain crops.

As described in the case study in Chapter 3, a simple and robust model demonstrates that with just 250 small trees planted around the perimeter as a living fence enough CJO would be produced each year to significantly benefit householders by saving on other energy costs and providing fertilizer.

From the case studies and the analysis of costs and returns to smallholders in the four target countries, it would appear that **the most viable economic alternatives for smallholder production of biofuels is the planting of Jatropha** in compound and field hedges with household extraction and use of CJO in place of fossil fuel diesel for pedestrian tractors, water pumps, generators and household interior energy requirements. Other biofuel options from the studies would generate net margins less than those received from the production and sale of commercial rice and other grains. The exception is the economic viability for Cambodian farmers of producing cassava on converted forest and eco-system land for sale to processing plants in Thailand and Vietnam as noted in the previous discussion.

Thus, although not presently the overall case in the region, the study suggests that there is the potential for smallholder farmers to benefit from the production of biofuels, especially from crops that do not compete with production of food crops (such as Jatropha) or multiple-use, low water-usage crops (such as sweet sorghum and cassava) that can meet the varied needs of small producers for food, cash income and animal feed. However, as new second-generation technologies are developed, although these will probably remain expensive for extended periods, there is still the possibility that first-generation technologies may become noncompetitive. This is a normal business risk and, as with any other product, measures should be considered to ensure that value chains have the means and resources to adapt to emerging opportunities. There is also some risk that the price of fossil fuels could decline (as now with USD50 per barrel in December 2008), rendering biofuels noncompetitive, although many experts generally agree that with rising demand and depleting reserves, there is little probability of this occurring in the future.

4.5.2 Social sustainability

In reality, biofuels are not different from other cash crops but high demand and rapid expansion of biofuel production, such as in Cambodia, could increase conflict over **land rights** and utilization. If land tenure systems are weak, there is a risk of land appropriation by large private entities interested in the lucrative biofuel markets. The poor, who often farm under difficult conditions in remote and fragile areas and generally have little negotiating power, may be tempted to sell their land at low prices or where land is legally owned by the state (typical in many Asian countries), find their land allocated to large, outside investors. Minority ethnic groups and women are most at risk of becoming “biofuel refugees”. Furthermore, smallholder farmers and rural people engaged in supplying private companies with raw materials for biofuel processing **often lack legal recourse in the event of reneged contracts and inequitable benefit sharing** when most of the value adding accrues to business and not to farmers. Farmers involved in biofuel production are also subject to the effects of extreme weather situations such as droughts or floods. These are natural risks and, as with all other crops, measures need to be considered to mitigate their effects through possible insurance mechanisms. As biofuel development is taking place rapidly, this issue needs to be addressed as a matter of urgency – to move beyond debate and advice farmers and governments of the opportunities and risks associated with biofuel production.

4.5.3 Biofuels can contribute to national incomes

Poverty alleviation and energy security are linked: availability of local energy is fundamental to intensifying agriculture and agricultural development is essential to poverty alleviation.

CLV&N use much of their available funds to import oil with little left to invest in alternatives to support economic growth. Oil-importing countries have been hit hardest by soaring oil prices that are worsening their balance of payments. Biofuel development can improve foreign exchange reserves of most of these countries, either by substituting for imports of oil or by possibly generating revenues through biofuel exports[40]. For example if farmers in Laos produced their own fuel for running tractors the savings would amount to approximately USD14 million per year (calculated from an estimate of 55,000 tractors using 200 liters of fuel per year) or approximately USD260/year extra income for smallholders.

4.5.4 Biofuels and poverty alleviation

Biofuel production can be especially beneficial to poor producers, particularly in remote areas that are far from consumption centers, where inputs are more expensive and prices lower, making food production, by and large, noncompetitive. In addition, agro-climatic conditions in these areas do not usually favor increased cropping intensity. The challenge of providing poor rural people with meaningful income-generating opportunities remains largely unaddressed. Seeking solutions, projects often support niche products (apiculture, medicinal and aromatic plants, etc.), but these products usually have limited demand, long marketing chains and low producer prices.

Amid concerns that biofuel cultivation, refining, combustion and transport can result in significant environmental problems that are likely to become more acute as biofuels production and trade expand, there is also belief that biofuel cultivation can have positive impacts in rural areas where poor people have limited options to meet their energy needs. In Nepal for example, the rapidly deteriorating environmental and natural resource base has contributed to poverty, as people find it more and more difficult to meet their basic resource needs in a sustainable manner. Fuel wood is usually their primary household energy source, but its harvesting is usually unsustainable and can contribute to deforestation. Burning animal dung – another important energy source – can cause serious health problems. Substituting biofuels for fuel wood and dung can increase energy efficiency and decrease health risks. At the same time, biofuel cultivation, if combined with appropriate technologies, can open the door to sustainable, low-cost, off-grid electricity generation, with the added benefits of reducing women's domestic

[40] Brazil initiated its biofuel program when oil prices increased in the late 1970s, primarily because it could not afford the high cost. The initial program cost about USD4 billion and required sustained government subsidies, but they have since been removed. Today, the program has resulted in savings of more than USD100 billion and made Brazil the world's largest exporter of bioethanol.

chores and increasing opportunity for rural industry and employment.

4.6 Biofuels and the environment

4.6.1 Climate change

"Biofuels should deliver large positive energy and GHG balances over fossil fuels and should be selected on the basis of the most efficient GHG balance, from production through to processing and* use*."

One of the big selling, but most debated, points of biofuel is its carbon neutrality. Growing plants absorb carbon and, when harvested, release only the amount of carbon they absorb and there is little doubt that most biofuels emit fewer greenhouse gasses than fossil fuels when used for energy, thus mitigating the effect on climate change. The debate is over the *net* carbon savings which means factoring in all the GHGs emitted throughout the entire production cycle.

The results will vary, depending on the type of feedstock, cultivation methods, conversion technologies and energy efficiency (Hazell, 2007). Sugarcane-based bioethanol can potentially save between 80 and 90% of GHG emissions per 1.6 km (or 1 mile) while biodiesel from soybeans and oil palm can save 40%. In general, biofuels from grains have lower performance, reducing carbon emissions by 10 to 30% per 1.6 km or, in some cases, even producing higher emissions than fossil fuels when nitrogen fertilizer inputs are too great (Zarilli, 2006).

The literature shows that energy parameters have been well researched for carbon savings based on agricultural practices in developed countries, but would it be correct to apply these analyses to developing countries without further study? Clearly, less use of fertilizer and labor-intensive farming feedstock production in developing countries appears to be relatively more environmentally friendly than large-scale, commercial, mono-cropping operations in the developed world. Partly due to low commodity prices, poor farmers of the developing world have had no funds and few incentives to buy fertilizers that emit GHGs, and they rarely use mechanized farm equipment that consumes polluting fossil fuels. On the other hand, if deforestation takes place to grow the feedstocks then this could turn most of the biofuels into net emitters. The degree of advantage would therefore need to be substantiated through further analysis.

GHG and energy balances in Nepal, Laos, Cambodia and Vietnam remain to be determined. There have been no life cycle analyses and quantitative studies conducted in these countries. Jatropha grown by smallholder households in perimeter hedges and processed into CJO to produce on-farm energy supplies may offer the highest GHG reduction impact because of the absence of land conversion, lack of chemical fertilizer use, minimal fossil fuel use through substitution of diesel for CJO. It is estimated that the potential for GHG reduction lies between 40% and 80%.

Except for Vietnam, there are no biofuel feedstocks produced for commercial plant processing into biofuels in the studied countries. Larger scale biofuel operations in Laos, Cambodia and Nepal consist of feedstock production to support processing industries across national borders. The total GHG balance in the biofuel life cycle is affected by feedstock production, transport from farm to processing plants, fossil fuels consumed by processing, transport to retail outlets and the use of biofuels to power cars and trucks. Because the targeted countries are mainly suppliers of feedstocks for external processing, the local GHG balances do not provide the complete picture of GHG balance impact without comprehensive life cycle analysis of the total value chain from field to retail. In the absence of quantitative assessments of GHG impacts of biofuel enterprises in the targeted countries, it is difficult to assess whether the selection of feedstocks for commercial enterprises have the most efficient GHG balances. Further investigations are needed to produce reliable and refined assessments of environmental and social impacts of larger scale biofuel projects on key environmental and socio-economic indicators.

4.6.2 Land use

In all four of the targeted countries, agricultural environmental standards, while promulgated into law, are rarely enforced. There are no mitigation and enforcement mechanisms in place to promote environmental sustainability of the agricultural sector. While this omission has little impact on smallholder production of feedstocks and biofuels for household and community consumption, the lack of enforcement mechanisms could be quite problematic in the presence of an expanded biofuel feedstock and processing program under future mono-cropping scenarios and large plantations.

So far, these plans and projects have not taken off, except for Cambodia, mainly because they lack investment capital and because of the low participation rate of smallholder farmers who find the rewards to their labor to be below prevailing labor opportunity costs. Many of the projects may also not materialize because land speculation may be a hidden agenda behind the project designs. However, should the projects on the drawing board develop as planned in public documents, there is significant downstream risk of major adverse environmental impacts for mono-crop farming and biofuel processing that may be associated with some of these projects in the future.

"Bioenergy feedstocks must be produced using better management practices (BMPs)."

There are also no official recorded BMPs or Good Agricultural Practices currently being practiced in any of the four targeted countries or in Thailand, India or China with respect to biofuel feedstock and other agricultural production. These are a collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while taking into account economical, social and environmental sustainability.

"Biofuel production areas should not be established through indiscriminant conversion of natural ecosystems (natural and semi-natural forests, natural flood plains, wet and peat lands) that have high conservation values and/or critical carbon storage functions".

When land is cleared for planting biofuel crops, the effect can be harmful to the environment, because expansion of biofuel crops can displace other crops or threaten ecosystem integrity by shifting from biodiverse ecosystems and farming systems to industrial monocultures. In Brazil, it is feared that future sugarcane expansion might involve fragile areas. In Indonesia and Malaysia, 14 to 15 million ha of land have been cleared for the development of oil palm plantations. According to the new EU Renewable Energy Directive (2008), a change in land use such as cutting forests or draining peat land can cancel GHG emissions savings "for decades".

Measures to control indiscriminate land-use changes are underway. The EU has developed a policy to ban imports of biofuels derived from crops grown on certain forestlands, wetlands or grasslands. The targeted countries have formulated policies (not enforced) to control the granting of concessions and improved management of national land resources. The risk is that concessions and biofuel feedstock mono-cropping may result in significant land conversion and only focus on economic returns. Moreover subsistence farming systems are encroaching into more environmentally sensitive land as farmers must look elsewhere to engage in non-food crop production while protecting their own household safety nets. This was seen in Cambodia with the rapidly increasing production of cassava on environmentally sensitive areas to supply feedstock to Thai and Vietnamese bioethanol processing plants.

A quick analysis of fossil diesel fuel import substitution targets (assumed to be 5%) suggests that these targets can be achieved, in the majority of countries, through the community-based approach to biofuel development. Table 6 suggests that fossil diesel fuel import substitution targets can be reached through community based production and consumption of CJO for farm machinery in Nepal, Laos and Cambodia. It is yet unclear whether the 5% diesel fuel substitution targets can be reached with community based CJO production in Vietnam. The total land area required to reach 5% fossil diesel substitution in that country would come to about 333,000 ha. To achieve the diesel fuel substitution targets in that country, there may be a need for some plantation Jatropha production and larger scale CJO and biodiesel processing.

TABLE 6: COUNTRY FOSSIL FUEL SUBSTITUTION GOALS[41]

Fossil fuel substitution targets	Cambodia	Laos	Nepal	Vietnam
Fossil fuel imports (bbl/day)	3,700	2,941	11,550	271,100
Fossil fuel reduction target (5%) (diesel fuel, litres/year)	7,550,000	6,000,000	23,500,000	551,000,000
Number of pedestrian tractors	93,000	57,000	80,000	128,000
Number of smallholder households involved	58,000	36,000	47,000	278,000
Number of hectares	4,550	3,550	50,000	333,000

Because smallholder livelihood and farming systems target the use of household land holdings for food safety net purposes, there is an inherent risk of sensitive ecosystem conversion should plantation biofuel feedstock production evolve more aggressively in the future.

In the **Lao PDR**, for example, there is risk of large planned biofuel plantations taking root. Although the estimated area requirements are somewhat nebulous, the plans call for the development of some 665,000 ha of plantation concession land for the planting of Jatropha and cassava, which would almost equal the total rice land area of the country (720,000ha).

In Laos, the major rice production areas lie within Dry Forest Eco-region along the Mekong corridor. This is also the region with the highest concentration of arable land. In the event of major biofuel feedstock production development, there could be significant conversion of

[41] Calculated from data obtained from the CIA Country Fact Book for 2008 and from conservative estimates of Jatropha yields from the case studies.

"marginal"[42] and forest land within the Dry Forest and Anamite Eco-regions or other High Value Conservation (HCV) Areas[43].

With limited smallholder rice land holdings, larger scale biofuel development would need to expand into non-rice areas. At present human activities are already putting pressures on the National Biodiversity Conservation Areas. The 47 ultra poor districts of the Lao PDR lie astride the protected areas and human encroachment is invasive and pervasive. Although the GoL has guidelines and regulations for the management of protected areas, local officials and residents ignore the official regulations and encroachment, deforestation and land conversion is extensive. There is also extensive pressure on Lao PDR's protected areas along the Vietnamese border for Vietnamese loggers, traders and human encroachment. **In the event of major expansion of biofuel feedstock production in the Lao PDR, both eco-regions and protected areas will likely come under severe environmental pressure.**

In **Cambodia**, the major rice growing areas currently lie within the country's economic corridor between Thailand and Vietnam. Major expansion of biofuel feedstocks or other agricultural production would impact adversely on the country's Dry Forest eco-region that lies beyond the rice production areas in the Thailand-Vietnam economic corridor. Much of the impact is occurring here already (with cassava plantings for Thailand and Vietnam bio-ethanol processing plants) and is expected to also affect Cambodia's HCVs in the future. Protected areas in Cambodia are also under threat and are not being effectively managed. This situation results from the weak institutional capacity of the Ministry of Environment to plan and carry out protected area programs, lack of sustained financial resources, outdated information bases, security concerns, overlaps with forest sector issues (especially illegal logging), large scale land allocations for commercial agriculture, and uncontrolled wildlife trade.

Expansion of biofuel feedstock development in **Vietnam** could have equally adverse environmental impacts. The major Vietnam rice growing areas lie within the economic corridor lying astride the Mekong Delta and in the northern corridor along the Red River Delta. Biofuel feedstock and other agricultural expansion would impact significantly on the Anamite Eco-Region linking the two river corridors. **Vietnam** suffers from weak environmental governance problems as Laos and Cambodia. Today, Vietnam's breakneck economic growth has taken a heavy toll on its natural forests. Between 1990

[42] The term "marginal land" when applied to the three targeted countries of the former French Indochina region is a misnomer. Marginal land in that region is actually arable land that has not been cleared for agricultural use because of the high investment costs of land clearing and the unavailability of rural finance and other constraints to bring such land under cultivation. Such land should not be called "marginal" but rather "undeveloped land"

[43] For definition see 'The HCVF Toolkit' – available from www.hcvnetwork.org

and 2005, the country lost a staggering 78% of its primary forests, leaving it with only 85,000 ha of old-growth forest (0.66% of its forest cover or 0.26% of its total land cover). Although deforestation appears to be slowing in Vietnam, much of the forest clearing results from commercial agriculture and subsistence activities, notably small-scale agriculture and fuel wood collection.

The major challenge facing **Nepal** in agricultural development, food security and rural development on the way to 2025 is growing food deficits, both nationally and locally, which have pushed the incidence of food insecurity to dangerous levels. Other possible consequences include rapidly rising and unsustainable food import bills and further environmental degradation, as farming moves onto marginal areas, sloping lands and forests. Nepal had a total of 6.4 million ha of forest in 1964, reduced to 3.9 million ha by 2000. The nation's forest coverage has declined from 37% in the late 1970s to 29% in the early 1990s. With the absence of other means of energy sources, fuel wood is the main source of energy for cooking and heating. In this regard, biodiesel produced from carefully managed crops such as Jatropha have the potential to positively contribute to protecting Nepal's rich biodiversity by replacing fuel wood in rural areas.

In all four countries, the challenges facing protected areas managers go deeper than inadequate funds – often there has been no improvement in habitats and species conservation even where resources have been allocated to specific nature reserves and national parks. Protected areas, even those supported by costly donor-funded projects, continue to suffer from high levels of consumptive uses of biodiversity, particularly through hunting of wildlife for local consumption and trade, Non Timber Forest Product collection and timber extraction. The implications of these trends for biodiversity, and for people and cultures that have long-depended on these resources are of growing concern. The major threat to protected areas is their close proximity to zones of high poverty. Human invasive intrusion is a major problem and the lack of environmental governance will likely accelerate human impacts on protected areas from contiguous villages and from expanding agricultural activity.

4.6.3 Water and soil conservation

"Biofuel production shall promote practices that seek to improve soil health and minimize degradation; Biofuel production shall optimize surface and groundwater resource use, including minimizing contamination or depletion of these resources, and shall not violate existing formal and customary water rights."

Some feedstocks, such as sugarcane, require considerable quantities of water while others such as Jatropha require less. In dry areas, the competition between food and fuel crops may become the overriding issue in the fuels *vs*.

food debate and the issue could be addressed by investing in soil management and water saving technologies, some of which may become economical under present circumstances with escalating commodity prices. Improvement in crop productivity, as well as shifting from high water-use biofuel crops (such as sugarcane) to drought-tolerant crops (such as sweet sorghum) are also future options to address the issue of water scarcity.

The processing of energy crops into biofuels also requires water and, though modern conversion plants offer options for controlling water pollution, existing processing facilities can discharge organically contaminated effluent. All agrochemical runoff and sediments are problematic, but these problems apply as much to food crops as they do to biofuel crops.

Impact on soil is another environmental concern that, again, is not unique to biofuels. For rural areas that fertilize with crop wastes and manure rather than external inputs, biomass production could lead to dramatic declines in soil fertility and structure. However, biofuel plants such as Jatropha and pongamia that grow on more degraded lands have potential to improve soil quality and coverage and reduce erosion while their oilcakes can provide organic nutrients for improving soil (Kartha, 2006). There are many different scenarios and rigorous lifecycle analysis of potential environmental impacts is needed of different biofuel production systems to ensure the development of environmentally friendly biofuel programs.

4.6.4 Carbon financing

The **Clean Development Mechanism** (**CDM)** allows net global greenhouse gas emissions to be reduced at a much lower global cost by financing emissions reduction projects in developing countries where costs are lower than in industrialized countries. Although there is a lot of interest in earning carbon credits from biofuel production through the CDM mechanism, the process is quite onerous and may not be immediately applicable for community-run projects. However, some project promoters are optimistic for the use of the CDM mechanism to enhance the economics of biofuel projects in developing countries, particularly for Jatropha biodiesel production. The first plantation scale project on restoration of deforested and degraded land in Mali is undergoing registration with the CDM Executive Board and plans have been announced by Eco-Carbone from France to develop Jatropha biodiesel production with local farmers and communities in Cambodia and Vietnam. It would be useful to monitor the progress of these initiatives for possible application to pro-poor biofuel production in the Greater Mekong Region.

- **Food vs. fuel?** In the studied area cropping of biofuel feedstocks does not appear to be a threat to food security because smallholders first act to protect household security nets. However this means that successful production of biofuel feedstocks, without negative social or environment impacts, is currently limited to small-scale community based projects. In general a bigger issue in the region is how to manage limited water and land resources to promote both food and fuel production.

- **Climate change and environment?** Further research is required however if biofuel feedstocks are farmed using the low input land-use practices currently found in the region (besides slash-and-burn) then GHG emissions could be negligible unless deforestation takes place. Nevertheless due to the shortage of arable land, land-clearing and encroachment into HCVs is a real threat. Significant improvements in the enforcement of government policies and creation of effective rural extension services are needed to ensure that biofuel projects follow the RSB guidelines and are produced using sustainable practices. In the future, there may be potential for the region to benefit from the CDM under the Kyoto Protocol, but this might be too onerous and complicated at this stage of development in the region.

- **Land use and tenure security?** There is a risk that under existing land tenure systems in the four countries, large scale plantations of biofuel feedstocks could affect land security among smallholders. This is an area where government policy must act and be enforced to make sure that smallholders can continue their activities and at the same time benefit from biofuel development.

- **Impact on poverty alleviation?** Biofuels in the region do appear to have a significant potential to contribute to poverty alleviation in the region by increasing incomes and providing energy security. This assumption is based on business models involving smallholder production and community usage of biofuels.

5. Potential intervention Strategy for WWF and SNV

5.1 Business models

Based on the finding within the four targeted countries, there are five basic business models described in the case studies. These include:

1. **Casual producer/collector of feedstock** (Jatropha) for sale to collectors/traders and processing enterprises. The net value added for this business model averages, USD0.06/kg after subtraction of the household labor opportunity cost. For commercial rice, the net margin for the casual producer is USD0.08/kg after subtracting the household labor opportunity cost. The main disadvantage to the casual collector/producer of feedstock is that smallholders receive very little of the value addition from the enterprise.

2. **Casual producer/extruder of CJO, Option 1**. A second and far more profitable business model for the smallholder producer of biofuels is the production and processing of CJO at the household/community level. With this model, farmers capture a much larger percentage of the value addition of biofuel production. The net margin (after discounting household labor opportunity costs) from producing feedstock and CJO for on farm and community use is USD0.188/kg (Lao PDR and Cambodia case studies). This model does not compete with rice and generates a net margin of more than 2 times the margin from commercial rice.
3. **Casual producer/extruder of CJO, Option 2.** This model is a form of cooperative contract farming and production of CJO whereby the company provides the extruder and filter and extracts CJO for farmers and the company. Farmers are permitted to keep as much CJO as they wish and sell the surplus to the company at a price which is pro-rated to the price of fossil fuel diesel in the domestic market. Since the company provides the technology for extracting oil from Jatropha, they subtract a premium for the oil price paid to farmers to cover technology transfer costs and a premium for higher quality CJO. In this model the farmer received a net margin of USD0.134/kg (after deducting the opportunity cost of household labor) for CJO produced on non-agricultural land, which is 1.67 times higher than the net margin from commercial rice.
4. **Contract farming.** With this model of contract farming of biofuel feedstocks, companies provide plant material and some technology, but fix prices at an arbitrary level which does not take into account seasonal price swings in domestic markets. In this study, this model appeared to be unsuccessful for smallholders because contractors squeeze farmer profit margins to protect their downside risks and to maximize their upside profitability. Farmers participating in this model received net margins ranging from USD272/ha/year or USD1.36/day (for sugarcane), compare with USD2.5/day for commercial rice. In the

case of Jatropha contract farming, the daily return to smallholder labor is USD1.5/day

5. **Smallholder daily hire of labor only.** This is a labor hire model through which farmers have no equity in the production process, but work as hired labor for a daily wage paid by the biofuel feedstock plantation company. In this model, the smallholder's return to labor for sugar is USD1.54 for sugarcane and USD2.12 for Jatropha. This return to hired labor is 95% of the labor return from rice.

A **sixth business model**, worthy of consideration in this discussion, is the nucleus estate business model[44] used by D-1 oils in Indonesia and Africa. The development of the nucleus estate model, although, not yet practiced in the CLV&N, appears to offer promises in terms of improving biofuel profitability for vertically integrated growers and processors as well as possibly mitigating some of the adverse socio-economic and environmental problems of models four (4) and five (5) described above. During meeting with D-1 Oils in Vientiane in August, 2008, the company explained its experience with contract farming and the extreme difficulties it encountered in organizing farmers for contract farming in India, Africa and Indonesia. The representative from D-1 explained that the company has abandoned contract farming for a nucleus estate business model wherein biofuel crops (Jatropha) are produced in clusters of 20,000ha with the company professionally managing 40% to 50% of the feedstock farming operations on the nuclear plantation and providing technologies (by example) and in kind credit to satellite smallholder out-growers who sell additional feedstock to the company. The overall objective of the nucleus estate approach is to guarantee adequate feedstock throughput for the core processing facility while encouraging satellite growers to increase productivity and product quality via technology pass through from the nucleus estate. This should increase the company's profits and guarantee markets for smallholder satellite growers. Nevertheless, a problem with applying this model in the four countries may be access to enough arable land.

These models could provide SNV and WWF with guidance while defining their roles and developing their intervention strategy in the sector.

5.2 Roles for SNV-WWF

In light of the current status of the biofuel sector in the region, SNV-WWF aims:

> "To develop sustainable strategies and options for the development of biofuels in Vietnam, Laos, Cambodia and Nepal for reducing poverty among rural households within an environmentally sustainable framework."

[44] This model has been developed by many oil palm plantations

In order to achieve this goal several areas of key initiatives are proposed:

Sustainable National Biofuel Policies

With the present low level of biofuel development along the broader life cycle/value chain, the initial intervention point for SNV-WWF is to develop an institutional framework for a biofuels sector, with the aim of strengthening policies, strategies and programs with government and partners. A solid policy and strategy foundation is required to establish a base for selective intervention.

Inclusive Business Models

Interventions could also focus on biofuel supply chain diagnostics and the development of measures to optimize market chains at the country and regional levels, as well as up-scaling. This could include management and verification of environmental efficiencies at the processing and distribution stage of full biofuel development and distribution. This would involve public/private sector partnerships and other cooperative measures with various stakeholders, including governments, NGOs and businesses to promote sustainable vertical value chains from the farmer/producer to the retail consumer. There should be comprehensive life cycle analyses of biofuel value chains to identify measures to improve GHG and energy balances and improve feedstock and processing productivity.

Production Support

SNV-WWF should focus on knowledge and capacity development to improve institutional frameworks, extension services and farmer practices as well as market access. The types of activities suggested could be training in agricultural best practices among government staff and smallholders, on farm-trials and demonstrations of feedstock cropping and biofuel extraction, assistance in setting up specific courses at universities or training colleges etc.

A Sustainable Biofuels Standard

All interventions in the four countries should be based on the multiple line approach to sustainable energy development, according to which biofuels should be environmentally sound, socially equitable, and economically viable. Table 7 gives an overview of 4 different international initiatives developed over the past 2 years as guidelines for sustainable biofuel sectors; the highlighted areas (in blue for SNV and red for WWF) show areas in which SNV and WWF interventions could be targeted.

At each stage of development, SNV-WWF can make important contributions to sustainable biofuel development through a process of certification, using a socio-economic, environmental checklist. The checklist and certification process should review and certify biofuels that comply fully with accepted economic, socio-economic and environmental standards provided in the check list as shown below. Certification will provide a valuable framework for biofuel development supported by two reputable brand name NGOs. This process would help establish credibility to sustainable biofuel initiatives in the four developing countries covered in the present study and could be replicated in other countries undergoing energy sector transformation.

The following table 7 summarized various criteria from:

The 'Cramer Criteria' were written in consultation with a consortium of Dutch organizations, including oil major Shell and multinational Unilever, who both oppose the introduction of biofuels, for obvious reasons. It was commissioned by the Environment Minister Jacqueline Cramer and the report was available on 14 July 2006, it is based on 8 criteria.

The UN Sustainable Bioenergy: A framework for decision maker encompasses all bioenergy systems but focuses in particular on modern bioenergy which includes liquid biofuels, biogas, and solid biomass for heat and power generation and it is based on 9 criteria.

The Sustainable Biofuels Consensus is a multi-stakeholder declaration following a workshop hosted by the Rockefeller Foundation Bellagio, Italy, 24-28 March 2008 and it is based on 8 criteria.

The Roundtable on Sustainable Biofuels (RSB) for sustainable biofuels production, Version Zero, August 13th, 2008, and it is based on 12 criteria

TABLE 7: OVERVIEW OF CRITERIA FOR SUSTAINABLE BIOFUEL DEVELOPMENT AND FOCUS AREAS FOR SNV/WWF

INITIATIVES	Cramer NL (July 2006)	UN Framework (April 2007)	Sustainable Biofuel Consensus (March 2008)	RSB (August 2008)
Legal Framwork & governance		Implication for Trade, Foreign exchange balances and Energy Security	Integrate and better coordinate policy frameworks	Legality: Follow laws of th country
			Make sure that trade policies and climate change policies work together	Land rights: biofuel should r violate land rights
Social responsability & Pro poor development	Welfare & Wellbeing	The ability of Bioernergy to provide energy services for the poor	Assess benefits and impacts of biofuels trade, use and production, and monitor them	Human and labour rights: En decent work and the well bei workers
	Labor condition conform to local law	Implications for Agro-Industrial development and job creation	Address negative indirect effects of biofuels trade, use and production	Rural and social developmen indigenous peoples and communities
		Health and Gender implication of Bioenergy		Biofuel should not impaire w food security
	Food security	Implication for food security		
Natural Ressource Managment	CO2 Balance	Impacts on Biodiversity and Natural Ressource Management	Reward positive impacts and investments, including through carbon management	Greenhouse Gas Emission reduction
	Nature and biodiversity, Soil, water	Implication for Climate Change		Conservation in Biodiversity, Air and Water
Partnership & Concertation		Implications for Government Budget	Use informed dialogues to build consensus for new projects	Consultation, planning, an monitoring
Capactiy strenghening and development			Increase investment in research, development and demonstration	Economic efficiency, technol and continuous improveme
			Build capacity to enable producers to manage carbon and water	

The intervention concept framework including a timeframe proposition could be followed as presented in table 8:

TABLE 8: INTERVENTION CONCEPT FRAMEWORK

Intervention/Country	**Nepal**	**Lao PDR**	**Cambodia**	**Vietnam**	**Key Players**	**Time Fram**
Biofuel Policy Strengthening and reinforcement. 1. Energy supply and demand projections; 2. Energy source identification 3. Program and project review using RSB	Refine and elaborate to include strategies, plans, programs, targets and time bound action plans				WWF in cooperation with consultants and key stakeholders	2-3 Years
Community Based Biofuel development for production and processing of fuel oils for low speed engines and marketing of feedstock for cross border processing. 1.Training farmers as extension workers for community based Jatropha production, oil extraction and filtering; cassava and sugarcane raw material feedstock production and marketing. 2.Collection and multiplication of Jatropha indigenous varieties 3.Genetic research, plant breeding and provenance trials for Jatropha and Cassava to improve productivity and agro-ecological adaptation 4.Research and trials on engine performance and/or modifications for higher speed engines 5.WWF/SNV Certification program for biofuels that meet economic, social and environmental standards	Trials and demo of Jatropha and Sugarcane production for smallholder	Support farmer operated Trials and demonstrations of Jatropha, cassava and sugarcane operated by contract buyers. Trial and demonstrations of community based CJO extraction, filtration and use in farm level diesel engines. Extension support to smallholders for production and marketing of cassava and sugarcane. Biofuel certification			SNV in cooperation with consultants, extension and farmer organizations and other stakeholders	5-6 years
Development of new feedstocks 1.Research and trials of other first generation biofuels such as sweet sorghum or tropical beet 2.Coconut oil production and processing and engine trials 3.Farmer extension development	Trials and demonstration for sweet sorghum or tropical beet production; coconut oil trials and testing.				SNV in collaboration with farmer groups, extension agents and other stakeholders	5-6 Years
Value Chain Development- supply chain development through vertical linking of growers and processors in contract farming arrangements where growers receive payment for biofuel feedstocks and hold equity in the processing and distribution enterprises- the model of new agriculture	Development of Jatropha, sugarcane, sweet sorghum, and cassava pyramid production systems that link smallholders and processors of biodiesel and gasohol processing and distributing networks within which all stakeholders share profits and receive margins at transaction points				SNV-WWF; Academia; Consultants; Business Enterprises, Government energy sector agencies; Producers, Processor	10-15 Years

The **expected results** of the SNV-WWF intervention are:

- Comprehensive energy policies, management and development plans for each of the four countries;
- Existing and future projects ranked in terms of their compliance with the global principles and criteria for sustainable biofuel production;
- Land-use zoning in the four countries to identify areas suitable for biofuels as well as environmentally sensitive areas which are off limits to biofuel and other agricultural production;
- Complete Environmental, Social and Economic impact assessments for all existing and future biofuel projects;
- Improved environmental governance at national, provincial and district levels.

And more specifically some indicators could be:

- 50% of smallholders in the targeted countries owning pedestrian tractors produce Jatropha in hedges and extract their own biofuel oil for tractors and pumps (210,000 smallholder households in 4 countries);
- Participating household incomes increase by USD250/ha through cost savings from diesel fuel substitution;
- Community based energy security models increase the incentives for farmers to form cooperatives for community purchase of processing equipment and local area marketing of CJO.
- Community-based feedstock production of Jatropha, cassava and, possibly sugarcane, organized around smallholder cooperatives produce feedstocks for regional biofuel enterprises.
- Biofuel feedstock costs decline dramatically as bioethanol is produced from wastes (bagasse, grasses, algae, etc.), replacing the use of primary products in biofuel production

To some extent:

- Identification of weak and strong nodes of biofuel value chains, including those related to smallholder livelihoods, economic sustainability and environmental impacts;
- Studying lessons from this activity to locate areas of possible biofuel value chain optimization
- Possible improvements in some biofuel value chain efficiencies and sustainability

In summary, three types of strategic interventions by SNV-WWF are recommended:

1. **Development of an institutional framework for the biofuels sector**
2. **Development of environmentally and sociably sustainable biofuel markets**
3. **Knowledge and capacity development**

5.3 Policy briefs

With regards specifically to policy development in the biofuels sector, SNV-WWF (2008) have stated that: ***"Biodiversity concerns should be incorporated in the broader energy policies."***

Policy reviews are required to help the targeted countries achieve further refinement and development of their energy and biofuel policies. Concrete measures are needed to ensure that policy directives and regulations are followed.

Activities to be undertaken, would include a thorough review and provision of technical assistance to governments in refining and strengthening their energy and biofuel sector policies, strategies, programs and projects. A national energy policy comprises a set of measures involving that country's laws, treaties and agency directives. The energy policy of a sovereign nation may include one or more of the following measures:

- Statement of national policy regarding energy planning, energy generation, transmission and usage;
- Legislation on commercial energy activities (trading, transport, storage, etc.);
- Legislation affecting energy use, such as efficiency standards, emission standards;
- Instructions for state owned energy sector assets and organizations;
- Active participation in, co-ordination of and incentives for mineral fuels exploration and other energy-related research and development;
- Fiscal policies related to energy products and services (taxes, exemptions, subsidies;
- Energy security and international policy measures such as:
    - International energy sector treaties and alliances,
    - General international trade agreements,
    - Special relations with energy-rich countries, including military presence and/or domination.

There are a number of **critical factors to consider in strengthening** national energy policies, regardless of which of the above measures are used to arrive at the resultant policies. The chief elements intrinsic to an energy policy are:

- The extent of energy self-sufficiency for the nation;
- The derivation of future energy sources;
- Future energy consumption (e.g. among sectors);
- Fraction of the population that will be acceptable to endure energy poverty (winners and losers);
- Future goals for future energy intensity, ratio of energy consumed to GDP;
- The standards for distribution reliability;

- Identifying and forecasting acceptable environmental externalities;
- Forecasts of "portable energy" forms (e.g. sources of fuel for motor vehicles);
- Measures to encourage energy efficient hardware (e.g. hybrid vehicles, household appliances, etc.);
- How national policies can drive province, state and municipal functions;
- Specific mechanisms (e.g. taxes, incentives, manufacturing standards, temporary subsidies, etc.) needed to implement the total policy framework.

Of particular urgency is the formulation of progressive energy sector policies. The needs are variable and extensive and include viable bioenergy targets, taxation and subsidy and support policies, fuel standards, land concessions for economic production, and land-use zoning to protect vulnerable eco-systems and biodiversity conservation areas. The present state of energy policy formulation is rudimentary and will likely require donor assistance for policy and regulatory formulation and the development of viable enforcement regimes.

And also that: ***"Governments should implement complementary measures: including land-use planning, food security measures, improvement of law enforcement and governance"*****.**

Agricultural policy encouraging growth of biomass in marginal rather than prime agricultural areas would serve the dual purpose of meeting national energy and food needs. It would also require: (a) improving both food and energy crops to ensure that the plants selected for production in remote areas have the productivity to be competitive: and (b) investing in soil and water conservation practices and infrastructure to ensure competitive development of biofuels. Such policies should also aim to develop an active rural energy policy as this would provide the basis for intensifying agriculture and with it, food security.

Finally: ***"Public subsidies and other financial instruments should be directed towards additional measures to help ensure sustainable and pro-poor biofuel production"*****.**

One challenge is to design and implement policy measures to ensure that the growing use of bioenergy is conducive to reducing poverty and hunger and, thus, that "bioenergy becomes pro-poor". This will be the case if the production is labor intensive, the processing technology for provision of local energy is simple and there is promotion of public-private sector partnerships when producing for national or international markets.

As an element of a risk mitigation strategy, governments should be encouraged to evaluate and score biofuel projects on the basis of both their positive and negative impacts. The scoring mechanism should be based on the international standards, as shown on table 7, as measures to contribute to adverse impact mitigation and to encourage pro-poor biofuel development where appropriate.

5.4 Summary of recommendations

Finally, in summary, the principal requirements for biofuel sector interventions in the CLV&N include:

- Mainstreaming environmental considerations into biofuel policy and regulation development processes, by including a strategic environmental assessment of the national biofuel policy in coordination with the ministries and provincial authorities concerned;
- Giving priority to smallholder cassava and sugarcane production in addition to Jatropha because the feedstocks, cassava, sugarcane and Jatropha, produce the highest on-farm benefits, produce the highest biofuel yields, employ simple technology, have low cost of production and easy to manage environmental impact mitigation measures;
- For Jatropha, biofuel development should proceed in two phases as specified in the government's biofuel strategy and policy on farm energy development with (1) hedge rows and household processing of cold pressed oil for tractors, water pumps and rice mills; (2) assistance in evaluating the feasibility of larger scale Jatropha plantations through public-private sector partnerships;
- Conducting environmental impact assessments of Jatropha, cassava and sugarcane biofuels in order to promote environmentally sustainable and integrated rural development as part of developing a national policy;
- Drafting a "master plan" for the utilization of land, encouraging farm level biofuel production to integrate crop rotation with other crops, and to incorporate natural resource-use considerations;
- Land-use ecological zoning with designation of specific areas for land-use practices; there is a major requirement to restrict agricultural and biofuel development to areas outside of ecological zones and high value conservation areas;
- Establish an apex centralized institution to address current gaps in knowledge, skills, equipment and capital to carry out integrated planning and management of a standard biodiesel program;
- Establishing a government-supported system to check the quality of biofuels produced and to ensure the equipment is operated efficiently during production and delivery;
- Encourage the private sector to adopt best practices, through strengthening the strategic environmental assessment process to ensure the private sector addresses environmental and social issues of their operations;

- Provide incentives to attract investment from both domestic and foreign sources to develop suitable biofuel crops in line with the findings of this report; give preferences to those investors with a proven environmental and social track record;

- Mobilize resource and stakeholders to participate in and finance adaptive research in other promising next generation biofuel feedstocks;

- Conduct further research and development of alternative renewable energy sources including (i) biodiesel produced from oil-bearing seeds and by-products of food processing; and (ii) bioethanol produced by fermentation of cereals, and by-products of agriculture processing.

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