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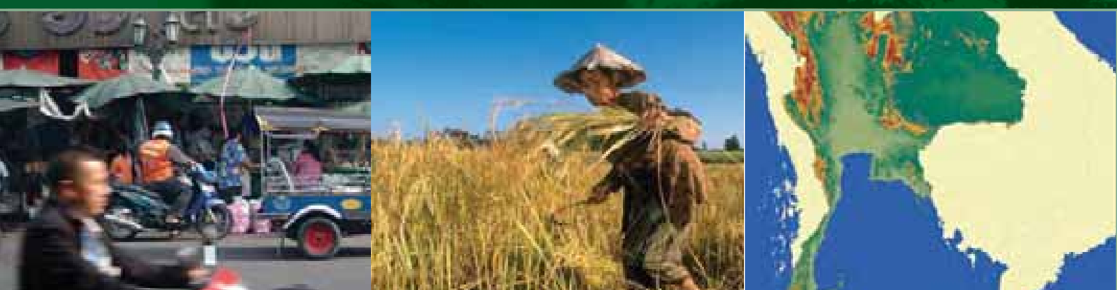
BEFS Thailand

Key results and policy recommendations for future bioenergy development



BEFS

ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT WORKING PAPER

ENVIRONMENT CLIMATE CHANGE [BIOENERGY] MONITORING AND ASSESSMENT

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ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT WORKING PAPER 43

ENVIRONMENT CLIMATE CHANGE [BIOENERGY] MONITORING AND ASSESSMENT

BEFS Thailand

Key results and policy recommendations for future bioenergy development

Beau Damen

BEFS
Bioenergy and Food Security Project

Food and Agriculture Organization of the United Nations, Rome 2010

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FOREWORD

In an effort to improve energy access, energy security and to lower global green house gas emissions, many countries have placed bioenergy developments high on their agenda. Over time, however, serious concerns about the effect of bioenergy on food security, its social feasibility and level of sustainability have arisen, especially with first generation biofuels. In this context FAO, with generous funding from the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), set up the Bioenergy and Food Security (BEFS) project to assess how bioenergy developments could be implemented without threatening food security.

During its term, the BEFS project has supported Peru, Tanzania and Thailand assess the feasibility of the bioenergy sector and its, potential impacts on food security, growth and poverty. In this effort, BEFS has constructed an analytical framework that aims to assist countries with the development of bioenergy policy and/or clarification of the potential impacts of bioenergy developments.

The analysis presented in this document includes the main findings and recommendations for policy-makers on how to achieve Thailand's envisaged biofuel targets in a sustainable way without impacting food security. A draft of this document was the centrepiece of policy discussions with the Thai Government conducted during the *BEFS Thailand Policy Consultation* in June 2010.

Full details of the methodologies and data employed to produce the material in this document are being published in a separate volume entitled "*Bioenergy and Food Security – The BEFS analysis for Thailand*".

As part of its activities, BEFS has also run training programmes in the participating countries to ensure full ownership, replicability and potential extensions to the analysis presented.

Heiner Thofern
Senior Natural Resources Management Officer
BEFS Project Coordinator

ABSTRACT

The Government of Thailand, through its Alternative Energy Development Plan, has set a target to increase biofuel production to five billion litres by 2022. The Thai Government sees this expansion as a way to strengthen the country's energy security, foster rural development and reduce greenhouse gas emissions.

The FAO Bioenergy and Food Security (BEFS) project aims to strengthen the capacity of developing countries to balance the trade-offs associated with bioenergy development and mitigate the impact of bioenergy on food security. The analysis presented in this document includes the main findings and recommendations for policy-makers on how to achieve Thailand's envisaged biofuel targets in a sustainable way without threatening food security.

The targets are found to impact on Thailand's future agricultural outlook and lead to additional utilization of Thailand's natural resources. Growth of the sector in line with the targets has the potential to affect the national economy and households through various channels such as the price of food made from biofuel feedstock crops. How the Thai Government manages the potential pressures that the bioenergy sector will exert on its natural resources and agricultural markets and the general populace will determine the future sustainability of biofuels and bioenergy as alternative energy sources in Thailand.

Full details of the methodologies and data employed to produce the material in this document are being published in a separate volume entitled "*Bioenergy and Food Security – The BEFS analysis for Thailand*".

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by Beau Damen

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CONTENTS

LIST OF FIGURES AND TABLES

ACRONYMS

AEDP	Alternative Energy Development Plan
AF	Analytical Framework
B2	Biodiesel blending target at 2 percent
B5	Biodiesel blending target at 5 percent
BEFS	Bioenergy and Food Security
CGE	Computable general equilibrium
COSIMO	Commodity Simulation Model
DEDE	Department of Alternative Energy Development and Efficiency
EU	European Union
FAO	Food and Agriculture Organization
GDP	Gross domestic product
GHG	Greenhouse gas
IRR	Internal rate of return
JGSEE	Joint Graduate School of Energy and Environment
LCA	Life cycle analysis
LDD	Land Development Department
LEF	Low efficiency fossil
LSA	Land Suitability Assessment
LUC	Land use change
MDG	Millennium Development Goal
MEF	Medium efficiency fossil
MOAC	Ministry of Agriculture and Cooperatives
MoE	Ministry of Energy
MoU	Memorandum of Understanding
NESDB	National Economic and Social Development Board
NSO	National Statistical Office
OAE	Office of Agricultural Economics
RASMI	Rural and Social Management Institute
RE	Renewable energy
R&D	Research and Development
TDRI	Thailand Development Research Institute
TRWR	Total renewable water resource
UN	United Nations
UNDP	United Nation Development Programme
WF	Water footprint

UNIT OF MEASURES

$	United States dollar
g	Gram
ha	Hectare
kg	Kilogram
L	Litre
m^3	Meter cubic
MJ	megajoule
MLPD	Million litre per day
MLPY	Million litre per year
MW	Megawatt
THB	Thailand bath (local currency unit)
ton	Tonne

CHAPTER 1

INTRODUCTION

As concerns about global greenhouse gas emissions and a desire for clean energy sources mount, many countries are exploring bioenergy developments as a possible solution. The Food and Agriculture Organization (FAO) of the United Nations has set up the Bioenergy and Food Security (BEFS) project to assess how bioenergy developments can be implemented without threatening food security. Essentially, BEFS aims to strengthen the capacity of countries to balance the trade-offs associated with bioenergy development.

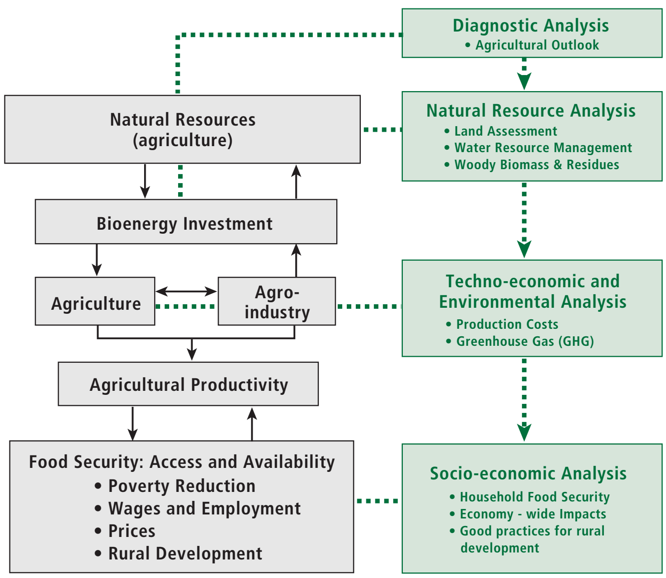
BEFS examines how bioenergy development may affect food security through two key instruments:

1. The BEFS Analytical Framework (AF) which examines the relationship between food security and bioenergy;
2. The BEFS tool box which helps to improve understanding of the dynamics of the bioenergy and food security interface through quantitative analysis.

These two instruments provide the means for examining the many varied consequences of bioenergy developments on food security, poverty reduction and rural development in specific country contexts. The information generated by these instruments helps support evidence-based bioenergy policy development. While there are currently three BEFS partner countries, namely Peru, Tanzania and Thailand, the BEFS tool box is available for use by other countries in considering food security within the context of bioenergy.

FIGURE 1.1

The BEFS analytical framework and BEFS tool box



1.1 BEFS ANALYTICAL FRAMEWORK

The AF presented in Figure 1.1 describes the complex relationship between bioenergy development and food security. The relationship is complex in part because food security is determined by many factors and bioenergy encompasses many forms of energy.

The starting point of the BEFS AF considers the balance between the natural resource base and food security. Rural and poor communities are heavily dependent on the natural resources used to support the agricultural sector. High levels of poverty and food insecurity can result in natural resources being used in an unsustainable manner. Over time, this leads to a vicious circle of poverty and degradation of the natural resource base. As a result, agricultural development is critical to achieve long-term sustainable food security. The core objective of the BEFS project is to identify to what extent bioenergy interventions can play an instrumental role in improving agricultural performance for food security.

1.2 THE BEFS TOOL BOX

Whether bioenergy has a positive or a negative impact on food security is a complex issue and needs to be considered within a specific country context. Figure 1.1 shows that bioenergy interventions affect food security through two principal channels. First, they compete for many of the same natural resources used to support food production. Second, the structure of bioenergy interventions can have an impact on agricultural productivity and affect food security outcomes.

The BEFS tool box analyzes these relationships in more detail. It assesses a number of critical interactions and trade-offs between food security, natural resource use for bioenergy, and the structure of the bioenergy industry in the following areas:

1. Agricultural outlook (diagnostic analysis);
2. Land assessment, water availability and biomass residues (natural resources);
3. Production costs profiles under different industrial set-ups and greenhouse gas emissions (techno-economic and environmental); and
4. Household vulnerability, economy-wide impacts, and good practices in bioenergy for rural development (socio-economic).

Each of these instruments was deployed to analyze the specific bioenergy situation of Thailand.

1.3 BEFS IN THAILAND

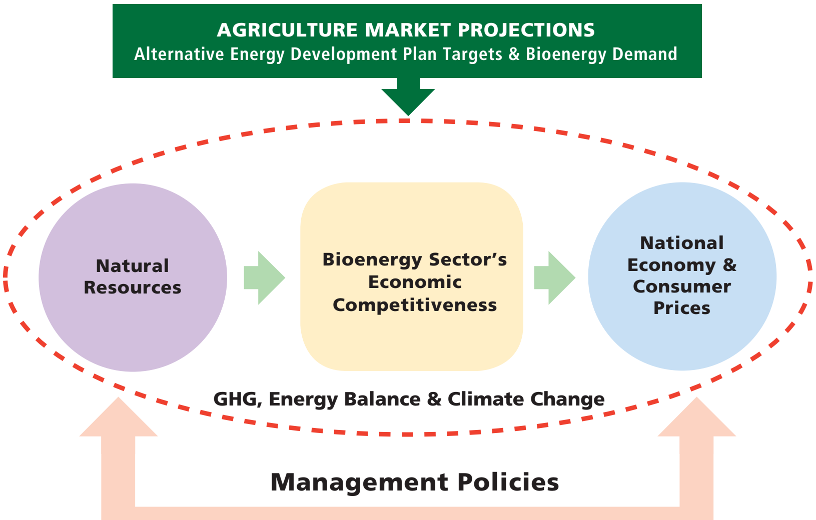
The BEFS project in Thailand is strongly focused on issues associated with development of the biofuels sector. While other forms of bioenergy were also considered by the BEFS Thailand research team, the findings presented in this report pertain largely to biofuels produced from key feedstocks (sugar cane [molasses], cassava and palm oil) and their potential effects on Thailand's agricultural markets and broader stock of natural resources.

The BEFS analysis in Thailand is underpinned by the Thai Government's Alternative Energy Development Plan, which outlines targets for biofuels development out to 2022 and a number of supporting initiatives. These targets will have an impact on Thailand's future agricultural outlook and imply additional utilization of Thailand's natural resources. The efficiency of the Thai bioenergy sector in managing these resources determines the economic competitiveness of the sector and also its impact on the environment and climate.

Ultimately the sector will have some effect on the national economy and households through various channels such as the price of food made from biofuel feedstock crops and the price of biofuels. Biofuels could also generate higher returns for farmers growing biofuel crops, opening up opportunities for deeper, more equitable rural development in Thailand. How the Thai Government manages the pressures that the bioenergy sector will exert on its natural resources, agricultural markets and the general populace will determine the future sustainability of biofuels and bioenergy as alternative energy sources.

FIGURE 1.2

BEFS Analytical Framework in Thailand



CHAPTER 2

THAILAND'S POLICY CONTEXT

Key Findings

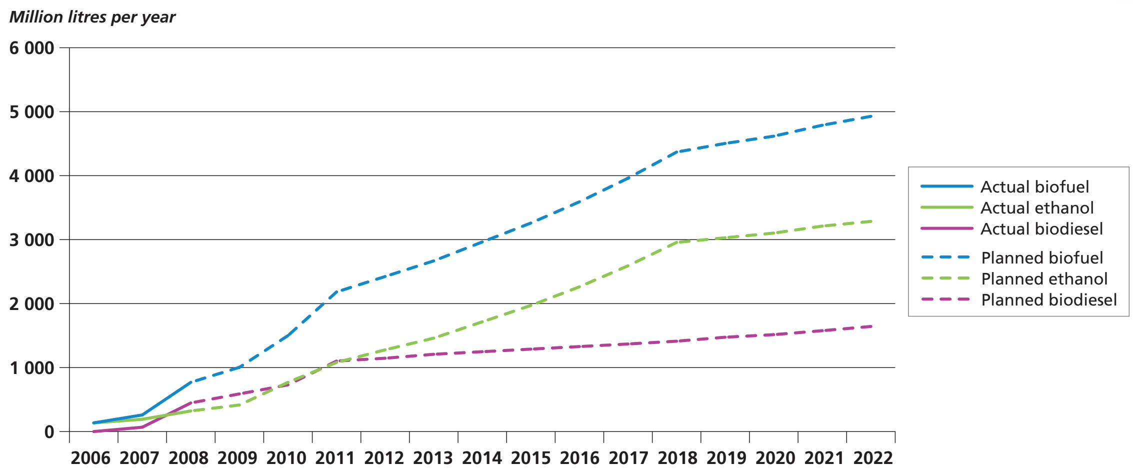
- Thailand already has a developing biofuels sector.
- Thailand has established an ambitious plan for the further development of the biofuel sector.
- The Thai Government wants to encourage the use of biofuels and other alternative energy sources to strengthen energy security, foster rural development and reduce greenhouse gas emissions from the energy sector.

2.1 THAILAND'S BIOENERGY POLICY FRAMEWORK

Thailand's policy framework for bioenergy is underpinned by the Alternative Energy Development Plan (AEDP), which covers the 15 year period from 2008 until 2022. The plan is broken into three phases (short-term 2008-2011, medium-term 2012-2016 and long-term 2017-2022) and aims to increase the share of Thailand's energy supply delivered from alternative energy sources to 20.4 percent by the final year of implementation. The plan includes targets for a wide range of alternative energy sources including electricity and thermal energy from renewable resources and alternative transport fuels including biofuels and natural gas. While small-scale electric and thermal power generation are considered briefly in Chapter 8, as noted in Chapter 1, the BEFS analysis in Thailand focuses strongly on biofuels.

FIGURE 2.1

Actual and planned biofuel production under AEDP



Source: MoE.

The Thai Government's rationale for the implementation of the AEDP is multifaceted. The objectives of the AEDP include:

- *Energy security and economic benefit*. By developing alternative, domestic energy sources Thailand wants to reduce energy imports and, in the long-term, become a regional export hub for biofuels and alternative energy technologies.
- *Rural development*. It is expected that development of the bioenergy sector will lead to better income for farmers and encourage rural development.
- *Low carbon fuels*. With wider use of alternative energy Thailand aims to reduce its GHG footprint and foster a low carbon society.

The Thai Ministry of Energy (MoE)'s Department of Alternative Energy Development and Energy Efficiency (DEDE) is responsible for implementation of the AEDP.

2.1.1 Thailand biofuel sector

While the biofuel sector's share of Thailand's alternative energy mix is still relatively small, it has considerable potential to expand in response to the AEDP. As noted in Chapter 1, the key feedstocks for biofuel production are sugar cane (molasses) and cassava for ethanol and palm oil for biodiesel. However, other feedstocks are used to produce biodiesel such as waste cooking oil and stearine – a by-product of palm oil refining.

The production of ethanol for transport purposes in existing alcohol refineries and sugar milling operations began in 2004. Since this time the number of ethanol refineries has expanded with total production capacity now at 2.575 million litres per day (MLPD) or 940 million litres per year (MLPY). Actual ethanol demand is around one MLPD meaning that there is currently excess production capacity. The Thai Government's plan to expand the market for ethanol has encouraged new entrants into the ethanol sector with a number of refineries planned or under construction. However, unlike existing facilities most new production facilities are expected to use cassava as their key feedstock. Once these facilities are complete, production capacity will increase to 3.24 MLPD or 1180 MLPY.

Large-scale biodiesel production for blending into fossil diesel began in 2007. In 2008 biodiesel consumption increased to 1.2 MLPD (438 MLPY) and around two MLPD (730 MLPY) in 2009. Refineries planned or under construction will bring total production capacity to 4.5 MLPD or 1 640 MLPY. Large-scale biodiesel refineries are concentrated in the south of Thailand near oil palm plantations and around Bangkok near fossil fuel refineries and fuel distributors. Biodiesel production at small-scale facilities is currently not included in national statistics, but is thought to be minimal.

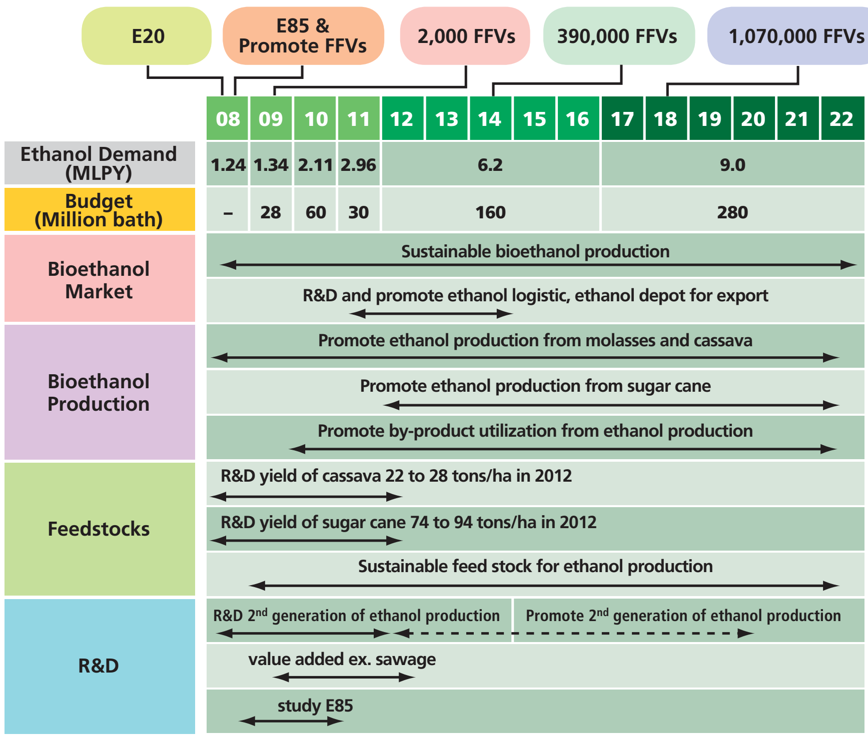
2.1.2 AEDP measures for biofuels

The AEDP anticipates that the biofuel output of Thailand will grow five-fold by 2022 to almost 5 000 ML. To meet the ambitious targets outlined in the AEDP a series of policies are being implemented.

Figure 2.2 provides an overview of the AEDP roadmap for ethanol. Under the road map the increased demand for feedstock will be met mainly through increases in yields for both sugar cane (i.e. molasses) and cassava. The roadmap also includes provisions for the use of sugar juice harvested from contaminated lands as ethanol feedstock.

FIGURE 2.2

AEDP roadmap for ethanol



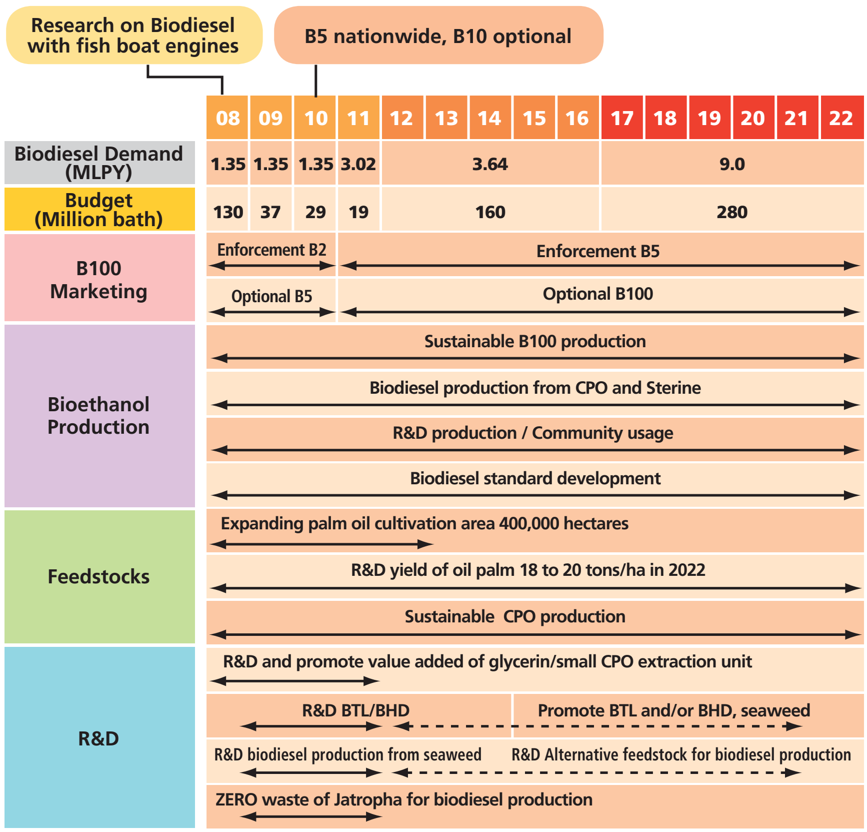
Source: MoE.

To facilitate the long-term development of the sector the Government has also provided an eight year tax holiday for new ethanol plants and plans to undertake a number of research activities including investigation of ligno-cellulosic ethanol and opportunities to promote flexible-fuel vehicles. As the gasoline market is relatively small in Thailand compared to diesel, promoting flexible fuel vehicles will be an important way to expand the domestic market for gasohol in the later years of the AEDP.

A similar policy roadmap has been developed for biodiesel (Figure 2.3). A prominent feature of the biodiesel roadmap is the phased introduction of mandatory blending targets – two percent biodiesel blending (B2) in 2008 and five percent (B5) in 2011. To meet future anticipated demand for biodiesel the roadmap envisages an increase in yield as well as an increase in plantation area for oil palm. The additional land required to meet the target is expected to be as much as 400 000 hectares by 2022, which will effectively double the present plantation area. Research will also be undertaken to identify opportunities for algae-based biodiesel, the use of jatropha plants as feedstock and biomass-to-liquid operations.

FIGURE 2.3

AEDP roadmap for biodiesel



Source: MoE.

2.1.3 Biofuel pricing policies

In addition to the measures outlined in the AEDP the government uses different fiscal mechanisms to support biofuel production and consumption. At the consumer level, the price of biofuel blends is maintained below the price of their fossil equivalents by using different tax and levy exemptions/reductions. The price difference is regularly adjusted to reflect fluctuations in fossil fuel prices. At the producer level, the wholesale price of biofuels is also managed by the government.

The producer price of ethanol is based on the (hypothetical) landed price of Brazilian ethanol. This price typically fluctuates around 20 THB/L ($0.62/L) per litre and is less than the fossil gasoline price, which includes all tax and levy components. The producer price of pure biodiesel is based on the price of Malaysian crude palm oil and additional components for methanol and processing. This producer price is generally between 27 and 28 THB/L ($0.76 and $0.79/L) and therefore generally higher than retail prices for fossil diesel. As a result, additional assistance for blenders and/or retailers is needed to bring biodiesel into the market. However, detail of this additional assistance is not readily available.

2.2 THAILAND'S AGRICULTURAL POLICY FRAMEWORK

Despite a recent decline as a proportion of final GDP, the agriculture sector is a crucial source of export revenue and employment in rural areas. The agricultural sector currently accounts for approximately 39 percent of Thailand's labor force.

The Thai Government assumes a large role in the development and direction of the Thai agriculture sector through its national planning process, which began in 1959. Recent national plans for the agriculture sector have focused on improving agricultural productivity in a sustainable manner. While the agriculture sector is an incredibly important element of the Thai economy average yields per hectare for many key crops languish at low to medium levels when compared to international standards. Policy intervention is still required to assist improve agricultural practices, develop necessary infrastructure, reverse land degradation and strengthen land tenure and credit facilities.

2.2.1 Biofuel feedstock policies

Through the Ministry of Agriculture and Cooperatives (MOAC) the Thai Government implements additional policies designed to improve the productive capacity of biofuel feedstock producers. Under the 2008 – 2010 action plan for cassava development, MOAC adopted a number of measures to improve cassava yields. Also, under the 2008 – 2012 Oil Palm Industrial Development Plan, MOAC is implementing initiatives to encourage expansion of oil palm plantings including low interest loans from the Bank for Agriculture and Agricultural Cooperatives.

Given the importance of agriculture to bioenergy production and biofuels production in particular, a new Memorandum of Understanding (MoU) was executed between the MoE and MOAC in March 2010. This is an important measure to ensure that the AEDP is implemented uniformly across all relevant branches of government.

CHAPTER 3

AGRICULTURE MARKET PROJECTIONS

Key Findings

- Meeting the AEDP biofuel targets will require sizable increases in the production of key biofuel crops: sugar cane, cassava and oil palm.
- To fulfil the targets a reduction in Thailand's exports of rice and cassava are expected.
- Reduction of cassava exports implies that the returns from domestic production of biofuels are assumed to be greater than from exporting the raw commodity.
- In the absence of strong growth in agricultural productivity an expansion of area under biofuel crop production will be required.

3.1 OVERVIEW OF ANALYSIS

The purpose of this element of the analysis was to assess how Thailand's agricultural market could be affected by implementation of the AEDP targets for biofuels. Detailed agricultural projections were developed for each key biofuel feedstock crop as well as other key agricultural crops over a ten year time period. The projections were derived using the FAO Commodities Simulation Model (COSIMO). The value of the analysis presented is not in the precision of projections for any one year, but rather in being able to display how markets could evolve over the time period assessed.

3.2 ASSUMPTIONS FOR DEVELOPMENT OF BIOFUEL

The key assumption underlying the analysis presented in this chapter is that the AEDP targets, until 2018, will be achieved. Table 3.1 reports the detailed ethanol targets.

TABLE 3.1

Ethanol targets

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gasoline total consumption	7 811	7 928	8 034	8 154	8 271	8 388	8 503	8 620	8 736	8 853
Anticipated ethanol demand	415	770	1 080	1 278	1 460	1 716	1 971	2 263	2 592	2 957
Potential ethanol mandate (%)	5	10	13	16	18	20	23	26	30	33

Note: the consumption and demand are expressed in million litres per year.
Source: OAE and MoE.

As part of the AEDP, the Thai Government has specified the proportion of the ethanol target that will be met from both sugar and cassava feedstock in each year. These proportions are presented in Table 3.2. Whether these proportions can be met depends on the existing capacity and configuration of available ethanol production plants and feedstock output.

In 2009, there were 17 ethanol plants with total capacity of 2.57 MLPD. Over half of these facilities are equipped to use only molasses as a feedstock. However, a number of new cassava ethanol facilities are expected to come online in the near future. In terms of production, cassava output has grown recently in line with higher prices arising from increased international demand for food and fodder. While the harvested area of cassava has grown by around one million hectares over the last few years, it is anticipated that the majority of growth in cassava output will come from improved yields. At present, cassava yields in Thailand are low when compared to their potential levels. This is because cassava in Thailand is generally planted in less productive soils with little irrigation and few inputs. These issues will be discussed in more detail in Chapter 4.

TABLE 3.2

Share of ethanol targets by feedstock

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Molasses	70%	50%	35%	35%	30%	30%	30%	25%	25%	20%
Cassava	30%	50%	65%	65%	70%	70%	70%	75%	75%	80%

Source: OAE and MoE.

In Thailand sugar cane is one of the major cash and export crops and the industry is well established. Over the last ten years the average area of harvested sugar cane has remained stable at around one million hectares. The yield in Thailand is generally lower than other major sugar producing countries, mostly because only a small area of sugar cane is produced on irrigated lands.

Table 3.3 provides a detailed description of future biodiesel demand anticipated by the AEDP. Palm oil is clearly the biofuel crop with the most potential to meet future demand for biodiesel in Thailand, accounting for roughly 90 percent of Thailand's crude vegetable oil production. The planted area of oil palm has grown recently and yields have reached an average of 20 ton/ha. Palm oil is generally consumed on the local market. However, Thailand also currently has a small net trade surplus in crude palm oil.

TABLE 3.3

Biodiesel targets

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Diesel total consumption	15 968	16 284	16 538	16 785	17 028	17 267	17 505	17 745	17 985	18 225
Anticipated biodiesel demand	589	730	1 102	1 146	1 208	1 248	1 288	1 329	1 369	1 413
Potential biodiesel mandate (%)	4	4	7	7	7	7	7	7	8	8

Note: consumption and demand are expressed in million litres.
Source: OAE and MoE.

3.3 MARKET PROJECTIONS OF KEY AGRICULTURAL CROPS

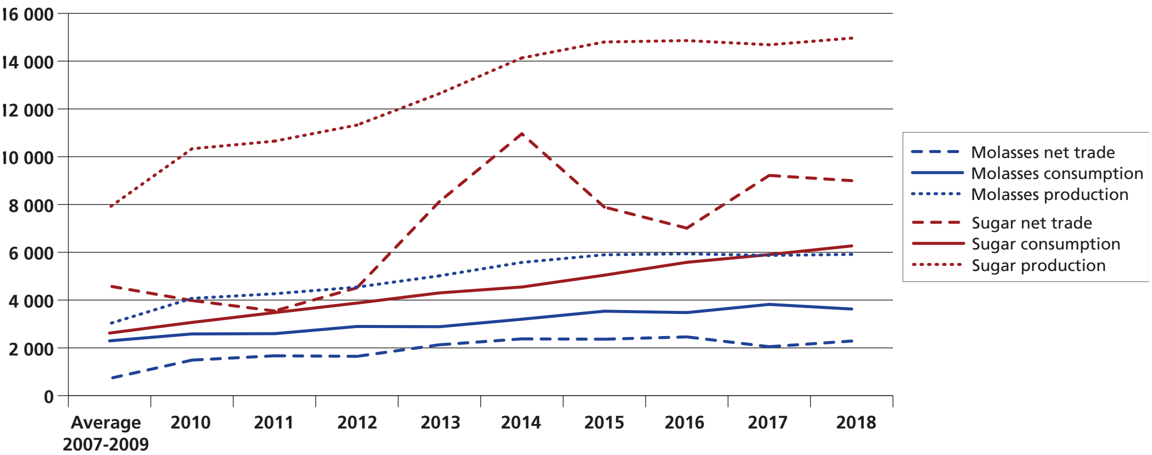
The key agricultural products that will be the focus of the analysis presented in this chapter are sugar, molasses, cassava, palm oil and rice.

3.3.1 Sugar and molasses

As can be seen in Figure 3.1, production of sugar is expected to double over the projection period. This growth is expected largely as the result of improved yields, which are projected to grow from 70 ton/ha in 2009 to almost 80 ton/ha in 2018. Most of the corresponding growth in molasses production will be consumed for ethanol production. While domestic consumption is also forecast to grow strongly, the net trade balance of both sugar and molasses is expected to improve over the projection period.

FIGURE 3.1

Projected production, consumption and net trade of sugar and molasses

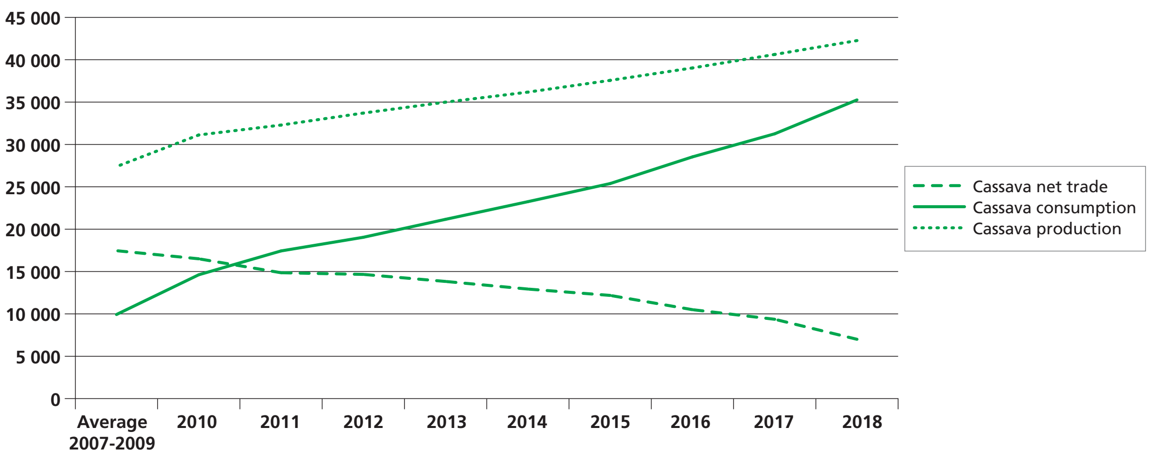


3.3.2 Cassava

Cassava production is forecast to grow by 15 million tons over the projection period (Figure 3.2). In response to increased demand, the total area under cassava cultivation is expected to grow by two percent annually. By the end of the projection period the area of land used for cassava production is expected to increase by 350 000 hectares. The growth in cassava area anticipated by the COSIMO model is almost 250 000 hectares more than that expected by the Thai Government under the AEDP. While the COSIMO model also projects that cassava yields will grow to reach almost 27 tons/ha by 2018, this improvement is somewhat less than what is currently factored into the AEDP.

FIGURE 3.2

Projected production, consumption and net trade of cassava



Cassava consumption is expected to increase more than three-fold over the projection period to meet the requirements of the AEDP ethanol targets. While Thailand is expected to remain a net exporter of cassava (i.e. chips, pellets and starch), by the close of the projection period, net trade in cassava products will decline considerably in response to the increase in domestic demand. As a result, exports are expected to decline by more than half over the period. However, the COSIMO analysis anticipates a smaller decline in cassava exports than what has been factored into the AEDP.

The reduction of cassava exports implies that the returns from domestic production of ethanol are assumed to be greater than from exporting the feedstock commodities. There is a risk that in times of weaker domestic demand and high world prices for biofuel crops, producers may be tempted to look for opportunities in export markets. The Thai Government will need to ensure that the policy environment for biofuels creates a satisfactory domestic or international market for ethanol so that feedstock producers will have incentive to supply the biofuel industry.

In this regard it is important to note that from a demand perspective, ethanol's proportion of the gasoline market is expected to grow substantially in the next five years under the AEDP to around 20 percent. As the gasoline market in Thailand is relatively small, the use of ethanol in such large amounts will necessitate an accompanying shift in Thailand's automobile market towards flexible-fuel vehicles. This will present a significant policy challenge in terms of providing the right incentives to consumers to shift to this new vehicle type. In the event that the domestic market for ethanol does not expand at the required rate there may be opportunities for excess ethanol production to be exported. But this will require that the ethanol produced meet any prevailing product and sustainability standards in target export markets. The GHG requirements of the EU sustainability standard for biofuels will be discussed in the context of the GHG analysis of Thai biofuels in Chapter 7.

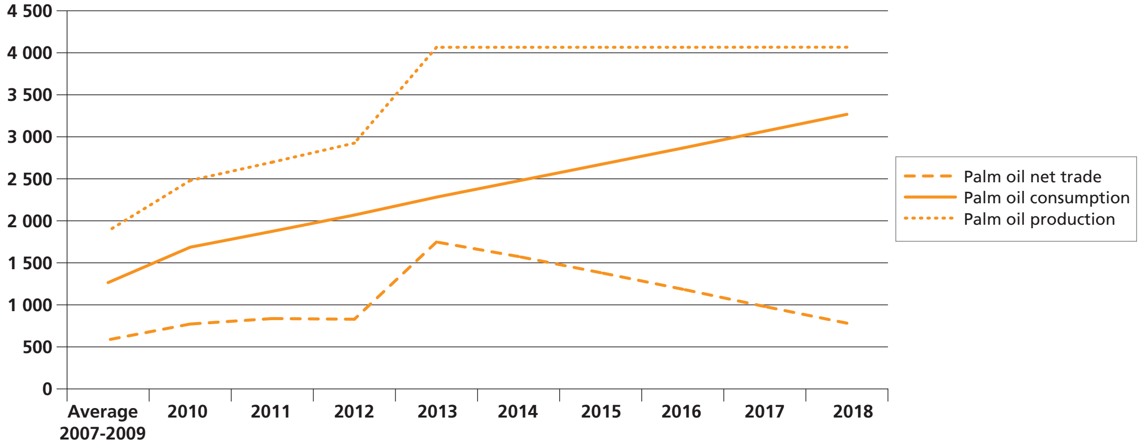
3.3.3 Palm Oil

As can be seen in Figure 3.3, production of palm oil is expected to double over the projection period with an average annual growth rate of 8.5 percent. This growth is expected as the result of a doubling of planted oil palm area from an average of 506 hectares in 2007-09 to 1 027 hectares by 2018.

Palm oil consumption will also increase as a result of new demand for biodiesel. However, consumption as food will also increase up to 1.5 million tons by the end of the period largely due to strong expected growth in GDP over the projection period. Thailand is expected to remain a small net exporter of palm oil over the projection period.

FIGURE 3.3

Projected production, consumption and net trade of palm oil

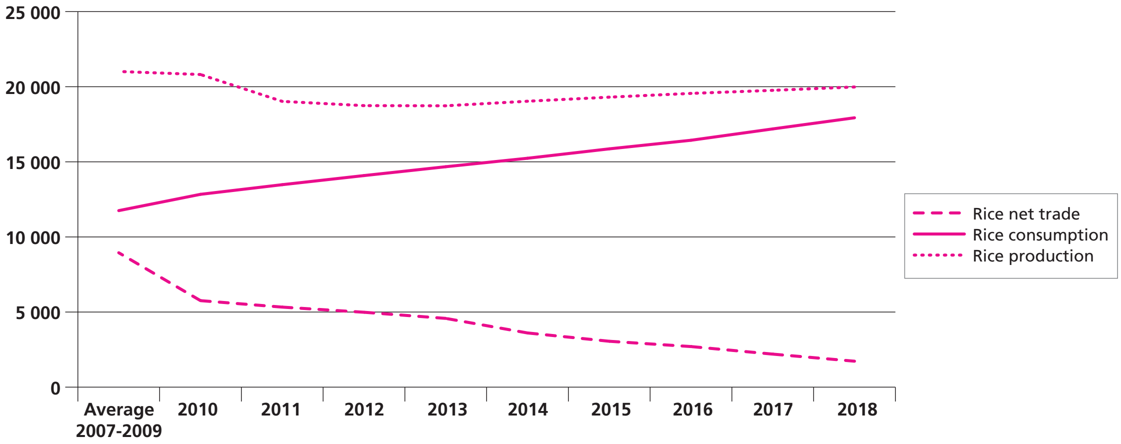


3.3.4 Rice

Rice is Thailand's most important agricultural crop and a large source of export revenue for smaller farmers. It is also the key staple food crop in Thailand. To understand how biofuel development may impact on food security in Thailand it is important to give special attention to potential changes in the rice sector.

FIGURE 3.4

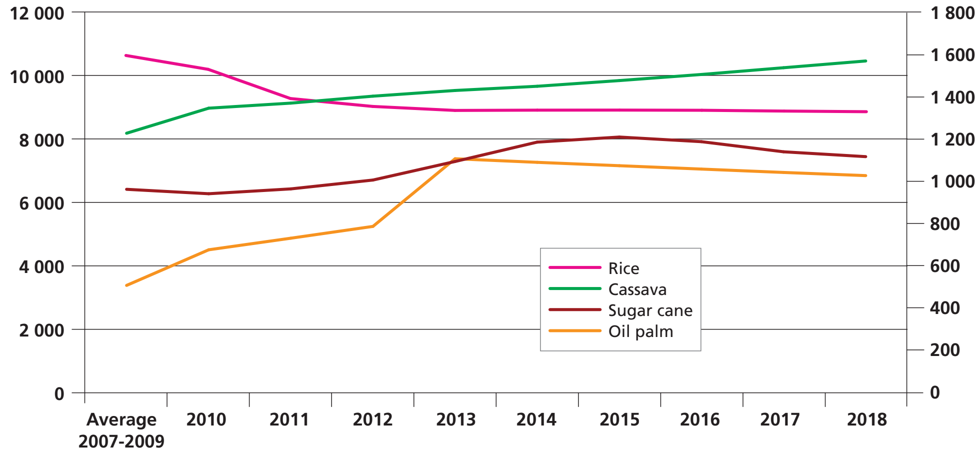
Projected production, consumption and net trade of rice



The total rice production is expected to decline slightly at an average annual rate of 0.3 percent over the projection period. Meanwhile consumption is expected to increase at an average annual rate of 4.5 percent. The decline in rice production is expected due to a progressive decline in the planted area of rice over the projection period and static growth in yields. Although Thailand remains a net exporter of rice over the projection period, exports are expected to decline considerably at an average annual rate of 15 percent.

FIGURE 3.5

Projected changes in area for key agricultural crops



Note: refer to the left axis for the rice values and to the right axis for the other crops

As can be seen in Figure 3.5, of the crops analysed here, rice is the only one that is projected to decline in terms of cultivated area over the outlook period. As a result, it can be inferred that the decline in the planted area of rice is due to the anticipated expansion of planted area for some biofuel crops. The feasibility of these expansions in terms of the suitability and availability of land are considered in the next chapter. Such expansions could also have a number of implications in terms of GHG emissions from crop change as well as rural livelihoods and food security. These issues will be considered in Chapters 7 and 8 respectively.

CHAPTER 4 NATURAL RESOURCE ANALYSIS: LAND

Key Findings

- Potential yield improvements of the key biofuel crops are feasible through more efficient and sustainable agriculture management.
- Technical support and extension services for farmers will be crucial to increase biofuel crop production and fulfil the short-term targets of the AEDP.
- The required expansion of biofuel crop production is feasible but should be carefully planned to avoid deforestation, biodiversity loss, expansion into areas affected by natural disasters and excessive harmful crop changes.
- Monitoring of the AEDP targets over the long-term is required to prevent the risk of any harmful land use and/or crop changes.

4.1 OVERVIEW OF ANALYSIS

The purpose of this element of the analysis was to assess the potential land resources available for the production of biofuel crops. This was done by conducting a land suitability assessment and, based on the findings, assessing the availability of suitable land. The land suitability assessment (LSA) is centred on a zoning approach developed and used by FAO since 1978. The LSA considers a range of climatic (i.e. temperature and rainfall) and soil related geo-referenced (i.e. pH, nutrients, slope) elements to identify the most suitable areas for growing the key biofuel crops and to understand how much of each crop can be produced given specific agricultural practices and levels of inputs. The yield information for each crop was verified with field visits and farmer interviews.

The suitability of a given portion of land is expressed as a percentage of the maximum attainable yield for each crop. In this chapter the results are presented in terms of a suitability index which consists of four classes. These classes are defined in Table 4.1.

TABLE 4.1

Attainable yield by suitability class for the key biofuel crops

Suitability Class	Achievable yield* (%)	Sugar cane (ton/ha)	Cassava (ton/ha)	Oil palm (ton/ha)
Very suitable	95 – 100	69.6 – 73.3	27.6 – 29.0	26.6 – 28.0
Suitable	60 – 95	44.0 – 69.6	17.4 – 27.6	16.8 – 26.6
Moderately suitable	40 – 60	29.3 – 44.0	11.6 – 17.4	11.2 – 16.8
Marginally suitable	0 – 40	< 29.3	< 11.6	< 11.2

* Of the maximum attainable yield.
Source: LDD.

The availability of suitable land was determined taking into account that areas designated for other use, such as urban areas, areas assigned by law to commercial activities, such as forestry concessions and areas with environmental concerns cannot be considered even if they are highly suitable. Further areas already under agricultural food production should be analysed carefully.

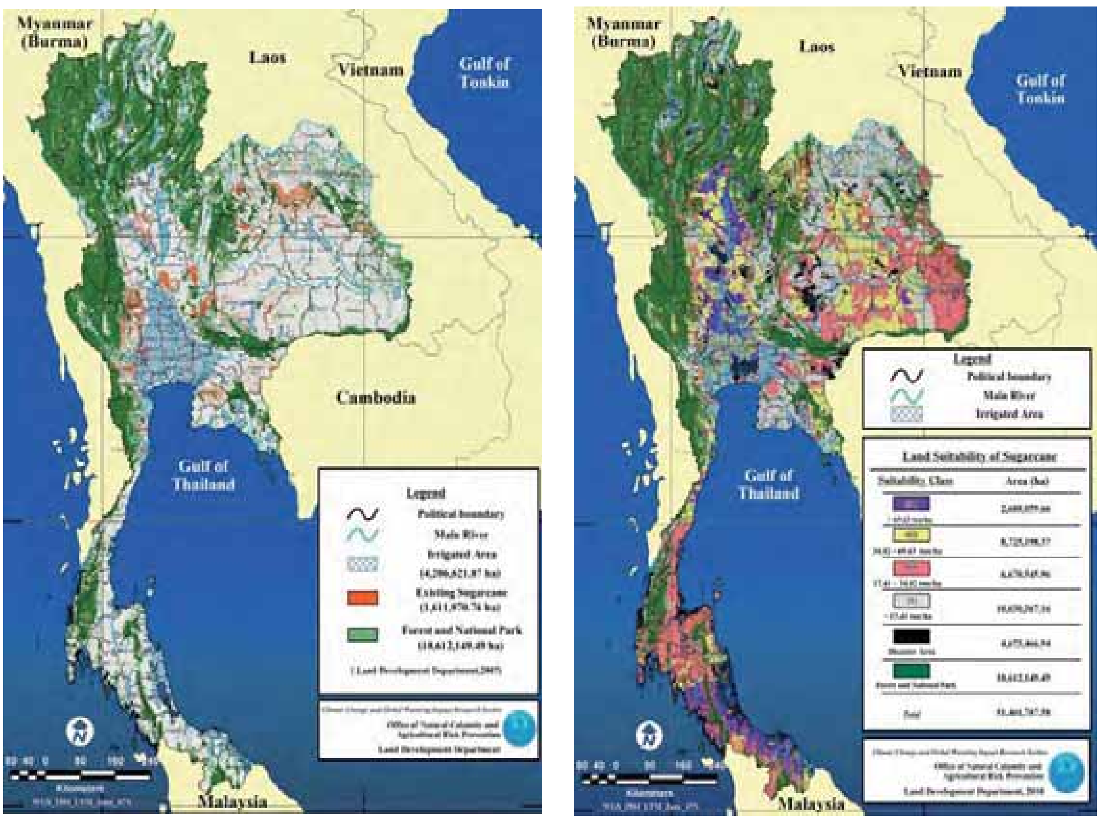
4.2 SUGAR CANE

Figure 4.1 displays the location of actual and potential areas for sugar cane production by suitability class. The planted area of sugar cane in Thailand is around 1.6 million hectares. Currently, of this area, 45 percent is classified as marginally suitable land with yields of less than 29 tons/ha. An additional 35 percent is being grown on suitable lands where higher yields between 44 and 69 tons/ha are achievable.

Based on the land suitability assessment there are almost 2.7 million hectares of very suitable land and 8.7 million hectares of suitable land for sugar cane cultivation in Thailand (excluding forests, protected areas and areas prone to natural disasters). The very suitable areas are concentrated mainly in the central provinces and also in Phatthalung and Songkhlain in the south. Suitable areas are located around the central provinces and in the north-eastern region.

FIGURE 4.1

Actual versus potential area for sugar cane by suitability class



Source: LDD.

The reason that more land classified as highly suitable and suitable is not being used for sugar cane cultivation is that these areas are already dedicated to other crops including rice, rubber and maize. In fact, 80 percent of the very suitable land and 55 percent of the suitable land for sugar cane cultivation is either used for rice, rubber or maize production or cannot be used due to the presence urban areas or water bodies. Whether farmers change their crop configurations will depend on the prices of each crop and whether the return from such a change outweighs the cost.

Alternatively, there is potential to improve the yields of existing land used for sugar cane production based on agro-ecological factors. Better agricultural management such as the use of optimum combinations of chemical and organic fertilizers and efficient irrigation techniques could improve the suitability of such land. Improving the suitability of the marginally suitable lands currently under sugar cultivation to moderately suitable could increase potential yield to as much as 44 ton/ha, which would generate better returns for farmers and lead to growth in sugar output.

4.3 CASSAVA

Figure 4.2 displays the location of actual and potential areas for cassava production by suitability class. The planted area of cassava in Thailand is around 1.6 million hectares. Of this area, 55 percent is classified as marginally suitable with potential yields below 12 ton/ha. The next largest area of land used for cassava production is classified as moderately suitable with potential yields ranging between 12 and 17 ton/ha. Existing cultivation of cassava is largely located in Nakhon Ratchasima in the north-east, Kampaeng Phet in the centre and Chachoengsao in the east.

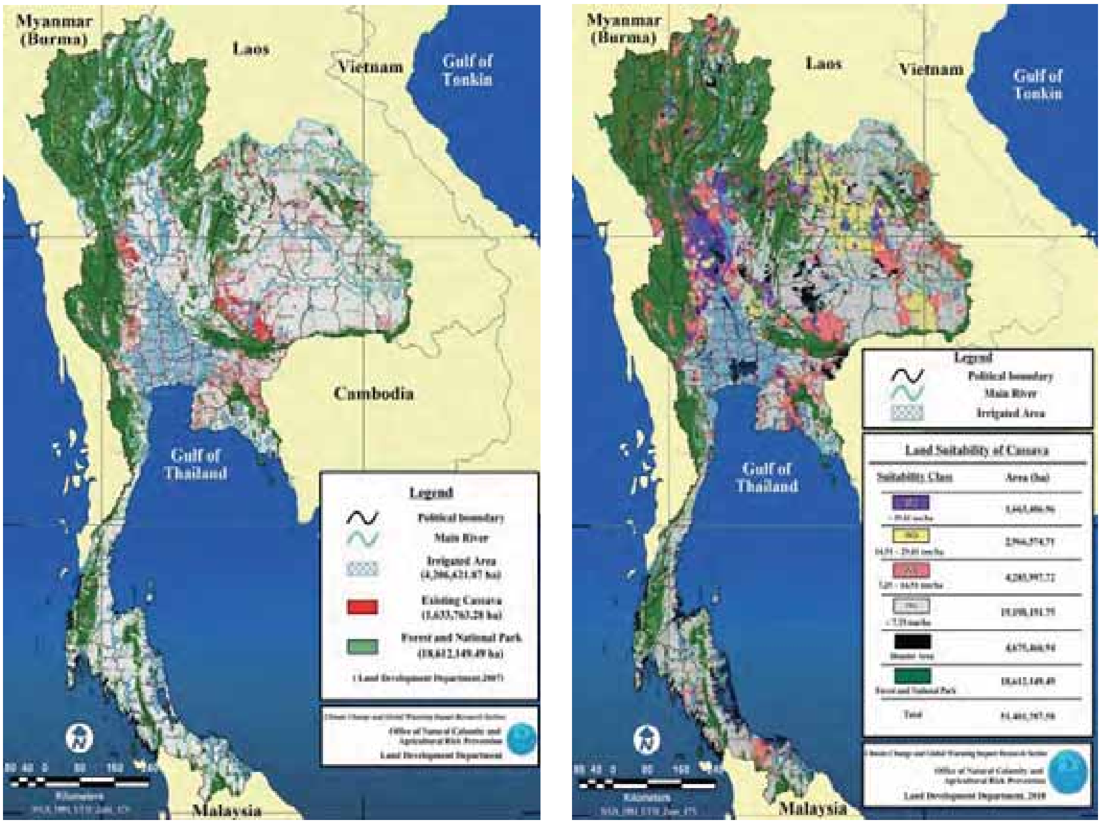
As noted in Chapter 3, the Thai Government anticipates a large increase in the production of cassava to meet the AEDP ethanol targets. At present it is expected that the growth in output will be met by increasing the average yield of cassava from 23 to 28 tons/ha. No significant expansion of cassava is currently anticipated under the AEDP.

This will require that the suitability and productivity of existing cassava crop be improved to achieve the feedstock targets implied by the ADEP. While this is possible, it will require substantial effort. Traditionally cassava is considered to be a low-value crop offering minimal returns to farmers, which is generally why cassava is currently grown under deficient management practices on less suitable lands.

Based on the agro-ecological conditions observed most of the land currently under cassava cultivation could feasibly advance by at least one suitability class. The provision of improved varieties, pest disease control and better management practises such as the appropriate use of nutrients to restore soil fertility are some of the options for improving yields and productivity on the vast majority of land under cassava cultivation. However, undertaking these activities will require investment, appropriate policies and technical support. Higher demand and prices for cassava output could provide the necessary incentives to encourage this investment.

FIGURE 4.2

Actual versus potential area for cassava by suitability class



Source: LDD.

An alternative course could be to expand the land area under cassava cultivation. This course of action would be particularly relevant in the short-term if cassava production was failing to match ethanol demand. The magnitude of the expansion depends upon whether the land under cassava cultivation could be improved or more suitable lands can be identified for cassava production. According to the land assessment there are almost 1.6 million hectares of very suitable land and 2.9 million hectares of suitable land available for cassava cultivation in Thailand. The most suitable areas are mostly located in the central and north-eastern regions as shown in Figure 4.2. Ten percent of this land is already used for cassava production with the remaining 65 percent under rice and sugar cane cultivation. As a result, approximately 400 000 hectares could be available for expanding cassava cultivation with minimal impact on other crops. Similarly, there is potential to expand cassava cultivation on around 900 000 hectares of land classified as suitable. However, whether farmers are willing to expand cassava plantings will depend on prevailing crop prices and the cost and return involved.

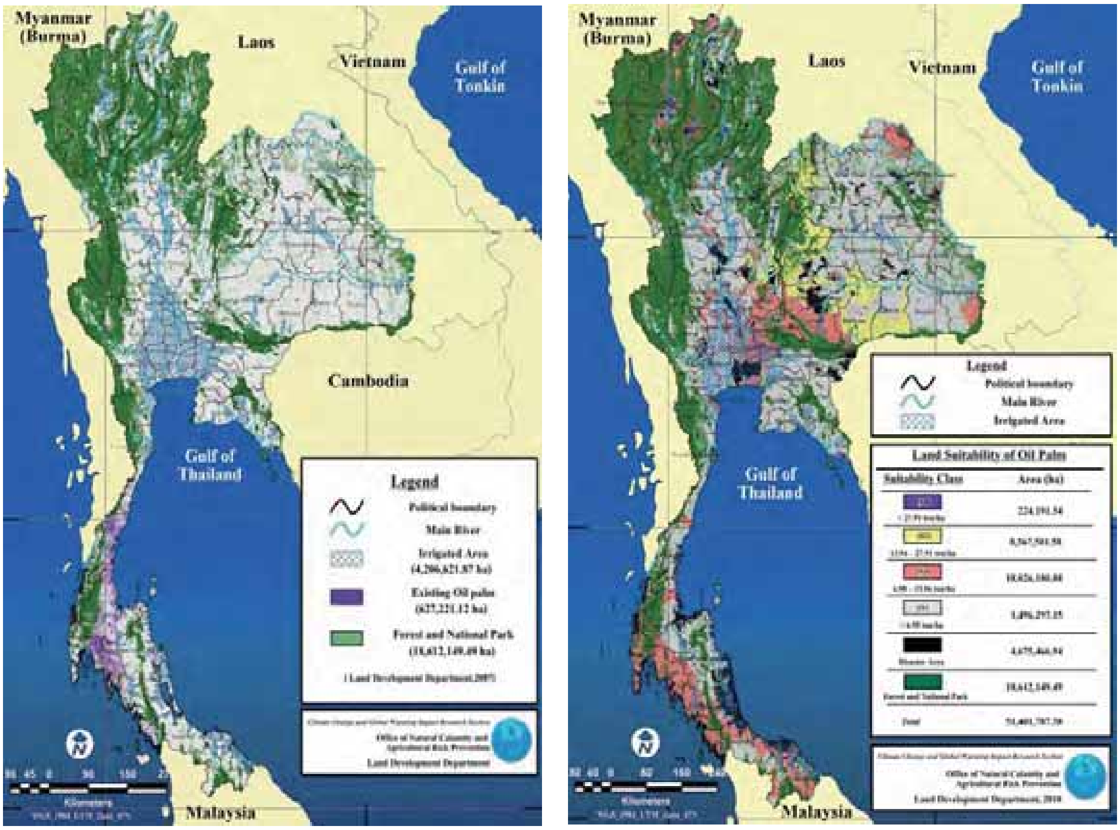
4.4 OIL PALM

Figure 4.3 displays the location of actual and potential areas for oil palm production by suitability class. The planted area of cassava in Thailand is around 630 000 hectares. All of Thailand's oil palm production is situated on either land classified as suitable or moderately suitable in nearly equal proportions offering potential yields of between 11 and 27 ton/ha. Generally, all existing plantations are currently located in the southern provinces.

Better management practices and limited use of chemical fertilizers in favour of organic products has been proven to have positive impacts on oil palm yields and reduce production costs. Wide dissemination of these practices will potentially raise the suitability classification of land already under oil palm cultivation.

FIGURE 4.3

Actual versus potential area for oil palm by suitability class



Source: LDD.

Under the AEDP the Thai Government anticipates that oil palm plantations could increase by as much as 400 000 hectares to meet the new demand created by Thailand's biodiesel targets. In Chapter 3 it was projected that the increase in planted area for oil palm could be as high as 500 000 hectares. Based on the land suitability assessment, there are an additional 200 000 hectares of very suitable land for oil palm production located in the south. This land is largely already under rice and rubber cultivation. Rubber is a high value cash crop, with margins reportedly greater than oil palm.

The area of land considered suitable for oil palm production is much greater at around 8 million hectares. Geographically this land is generally located in the North-East region. Financial analysis conducted by LDD suggests that oil palm may produce better returns for farmers in these areas than some of the key crops currently under cultivation such as rice and maize. As a result, policies to promote an expansion of oil palm plantings in the north-east may also result in improved returns for farmers in the region and positive implications for rural development. In order to be effective these policies will need to be accompanied by agriculture extension services to assist in development of appropriate varieties and build the capacity of farmers who will have limited knowledge of the crop.

CHAPTER 5

NATURAL RESOURCE ANALYSIS: WATER

Key Findings

- The ethanol industry in Thailand uses a relatively small amount of the country's total water resources.
- Thailand should have sufficient water resources to meet the anticipated expansion of ethanol under the AEDP targets.
- However, to achieve the improvements in the yield of sugar cane and cassava required by the AEDP, irrigation of both crops may need to expand rapidly, which could present challenges in the short-term.
- While the expansion of ethanol production is not expected to strain water resources in terms of volume, it may have serious impacts on water quality near processing facilities.

5.1 OVERVIEW OF ANALYSIS

The purpose of this element of the analysis was to assess how an expansion of ethanol production could impact on water resources and water systems in Thailand. This assessment was undertaken by constructing a water footprint for molasses and cassava ethanol produced in Thailand. The water footprint for biodiesel was not assessed for the BEFS project.

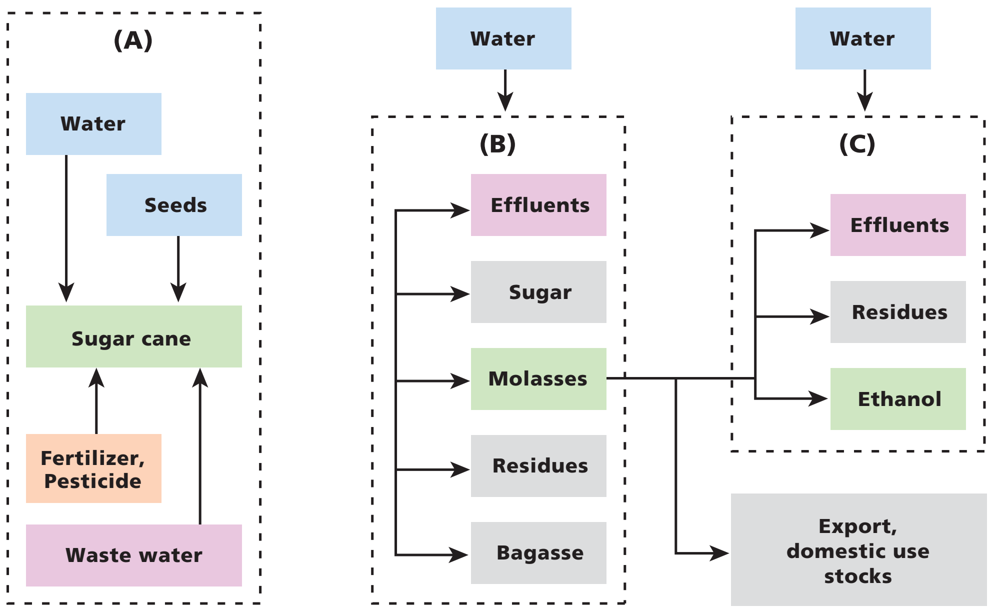
The water footprint is a geographically explicit indicator that is constructed using a location-specific set of factors such as hydrology, climate, geology, topography, agriculture management and yields. The WF has three components: green, blue and grey. The green component is the volume of rainwater that evaporates during the production process. The blue component refers to the volume of surface and groundwater that evaporates during crop growth and the amount of surface and groundwater that does not return to the system from which it came after the industrial production process. The grey component is the volume of water that becomes polluted during production.

5.2 WATER FOOTPRINT OF SUGAR-BASED ETHANOL

Water depletion in sugar-based ethanol production occurs at three stages (Figure 5.1). The first stage of water use is a result of sugar cane production (A). The second stage of water use is related to the industrial production of sugar and molasses from sugar cane (B). The final stage accounts for water used in the ethanol production process (C).

FIGURE 5.1

Process of sugar-based ethanol production



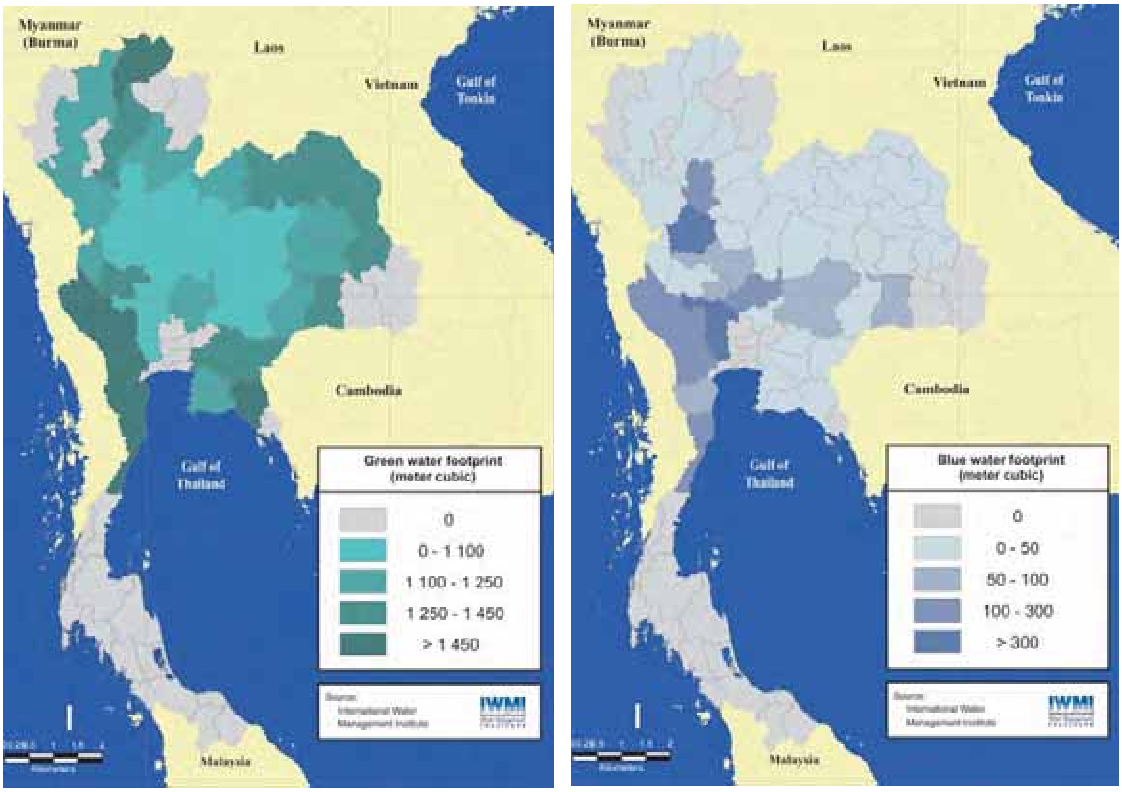
Notes: A – Sugar cane production; B – Sugar/molasses production; C – Ethanol production.

The total WF of sugar-based ethanol production is 1 646 m³/ton. Alternatively, 1 299 litres of water is consumed during the complete production cycle of one litre of ethanol from molasses. Effective rainfall is found to contribute 90 percent of the total WF of sugar cane production and 89 percent of the total WF of molasses ethanol production. The slight difference is due to water withdrawn during industrial production processes. Water consumed as part of industrial production processes is only 12.7 litres per litre of ethanol. This accounts for just nine percent of the total blue WF of sugar-based ethanol.

Interestingly, effective rainfall can generally meet only 57 percent of sugar cane's total water requirements, yet just 14 percent of the sugar cane plantations are irrigated. The presence or absence of irrigation can be used to explain the discrepancies in total WF across regions observed in Figure 5.2. The Central provinces account for 70 percent of irrigated sugar cane production. Some irrigation of sugar cane also occurs in the Northern provinces.

FIGURE 5.2

Sugar-based ethanol WF by districts



Source: IWMI.

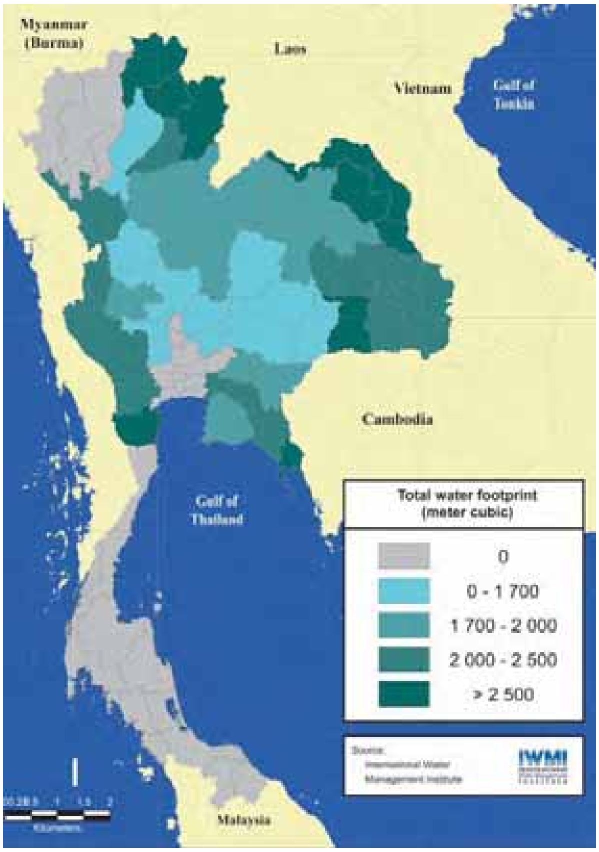
5.3 WATER FOOTPRINT OF CASSAVA-BASED ETHANOL

The process of water depletion resulting from cassava ethanol production is similar to that of sugar-based ethanol except that there is no water used to pre-process the raw cassava product as there is when sugar cane is first processed into sugar and molasses.

The total WF of cassava-based ethanol production is 2 304 m^3/ton. Alternatively, 1 817 litres of water is consumed during the complete production cycle of one litre of ethanol from cassava. Effective rainfall is found to contribute 81 percent of the total WF of cassava ethanol production. At present, cassava crops are not irrigated in Thailand. As a result, the blue WF of cassava ethanol is comprised only of the industrial production process and represents just 12.3 litres per litre of ethanol output.

FIGURE 5.3

Cassava-based ethanol WF by districts



Source: IWMI.

Like sugar-based ethanol, the WF of cassava ethanol varies across districts (Figure 5.3). However, in the case of cassava, these discrepancies are the result of different rainfall patterns, The variations in rainfall also result in large variations in cassava yields across districts ranging from 14.0 to 31.5 tons/ha.

5.4 OUTLOOK FOR BIOFUEL WATER FOOTPRINT

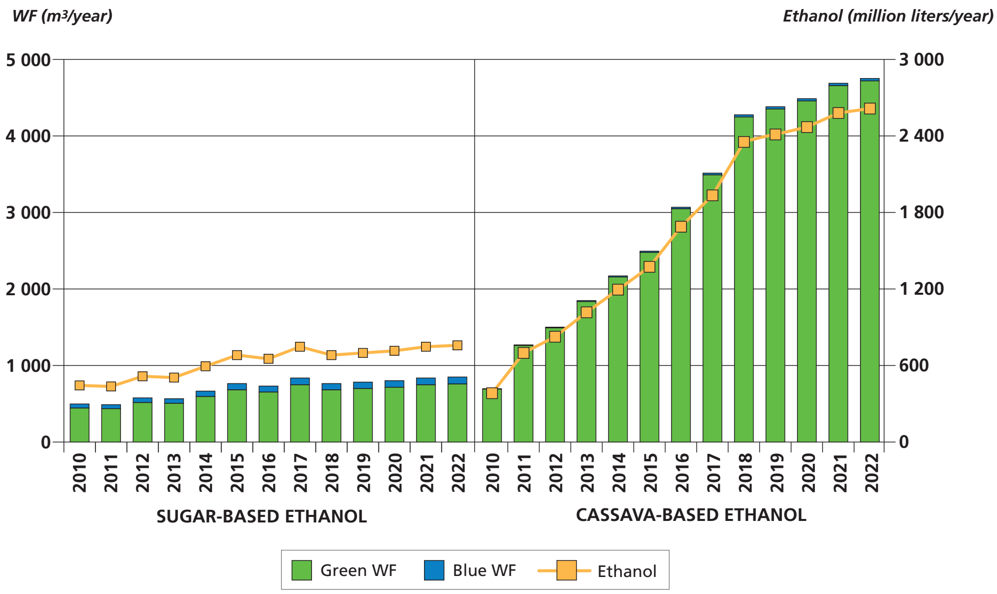
Thailand is estimated to have around 444 billion m^3 of total renewable water resources (TRWR). Increases in biofuel production in line with the AEDP targets will have some impact on these resources. As discussed in Chapter 2 and Chapter 3, cassava is expected to become the main biofuel crop for Thailand's future ethanol production as canvassed in the AEDP.

Based on the AEDP ethanol targets, ethanol production from molasses and cassava feedstock is expected to consume 500 million m^3 and 710 million m^3 of water respectively in 2010. Therefore ethanol production will account for 0.3 percent of Thailand's TRWR. At the rate of current water consumption and taking into account the anticipated increase in cassava's share of Thailand's ethanol production, ethanol production from molasses and cassava feedstock is expected to consume 853 million m^3 and 4 846 million m^3 of water respectively in 2022. As a result, in the final year of implementation of the AEDP ethanol production could account for almost 1.3 percent of TRWR.

Based on this analysis it is anticipated that the impact of the AEDP ethanol expansion on Thailand's water resources will be relatively small with the vast majority of growth in water consumption to come from effective rainfall. However, the total water consumption associated with cassava-based ethanol production is expected to grow dramatically; particularly consumption of water from effective rainfall. As can be seen in Figure 5.4, unless there is a substantial increase in crop yield or reduction in exports over this period, rain-fed crop lands under cassava will need to increase significantly to meet future ethanol demand.

FIGURE 5.4

Total WF of sugar and cassava-based ethanol



Source: IWMI.

A possible way to improve yields is to expand the area of irrigated land. However, while this will result in greater agricultural output, it will also require the use of more water resources. Assuming little change to prevailing land management practices, significant increases in irrigation would be required to meet the future feedstock requirements of the AEDP. To achieve a 10-30 percent increase in yield will require increased irrigation withdrawals of between 76-222 percent. Realizing this type of growth in the short-term will present a significant challenge.

An alternative to new irrigation is reallocation of irrigation from other crops. For example, rice is a key irrigated crop in Thailand. Forgoing the production of one ton of rice could provide irrigation to produce at least ten tons of sugar cane. However, such action will have additional external impacts in terms of food security as rice is the staple food crop in Thailand.

5.5 WATER QUALITY IMPACTS

In addition to withdrawing water from water systems, ethanol production can also affect the water quality of these systems. Wastewater generated by processing mills and ethanol plants is the largest potential threat to the water quality of local water systems resulting from the ethanol production process. By way of example, sugar mills in Ratchaburi and Lop Buri provinces were found to generate about 1 500 - 2 000 m^3 of wastewater and 400 - 650 tons of molasses per day.

As Thailand's wastewater regulations enforce a zero discharge policy it is assumed that no direct discharge of wastewaters occurs from factories into water systems. Typically, an anaerobic treatment method and infiltration are used to treat wastewater. Some wastewater, also known as spent wash, is also reapplied as a crop fertilizer. However, while treatment avoids the negative effect of direct discharge, there is a risk that leaching will result in soil and water pollution in neighbouring areas. High organic loads in these effluents can easily permeate through the soil, particularly in areas with high distribution of sandy soil.

Although the quantity of wastewater generated at present is small, it could increase substantially in the future with an expansion of biofuel production. By 2022, the total wastewater generated from sugar-based ethanol alone would be at least 7.89 million m^3. While some of this wastewater could be recycled as spent wash fertilizer, given the relatively small area of land currently under sugar-cane cultivation, it would be difficult to use such a large quantity of wastewater for this purpose.

Storing the remaining wastewater/spent wash in ponds would be an enormous task, and, if stored, the effect of leaching on groundwater and surface water systems in and around mills and production facilities could result in long-lasting damage. While these effects need to be investigated in more detail, it is clear that strategies are required to ensure that wastewater from the biofuel production process is managed sustainably.

CHAPTER 6

ECONOMIC COMPETITIVENESS

Key Findings

- Biofuels produced in Thailand are generally competitive with fossil fuels.
- Feedstock costs are the deciding factor of the economic competitiveness of biofuel production in Thailand.
- Improving the yields of key biofuel feedstock crops will provide an avenue to reduce feedstock costs and boost economic competitiveness.

6.1 OVERVIEW OF ANALYSIS

The purpose of this element of the analysis was to examine the economic competitiveness of biofuels produced in Thailand from each of the key biofuel feedstock crops. The economic competitiveness of each fuel type is assessed using two main criteria namely, the final production cost per unit of biofuel and the internal rate of return.

6.2 COMPETITIVENESS OF SUGAR-BASED ETHANOL

The sugar-based ethanol production configurations assessed in this chapter are presented in Table 6.1.

TABLE 6.1

Characteristics of sugar-based ethanol configurations

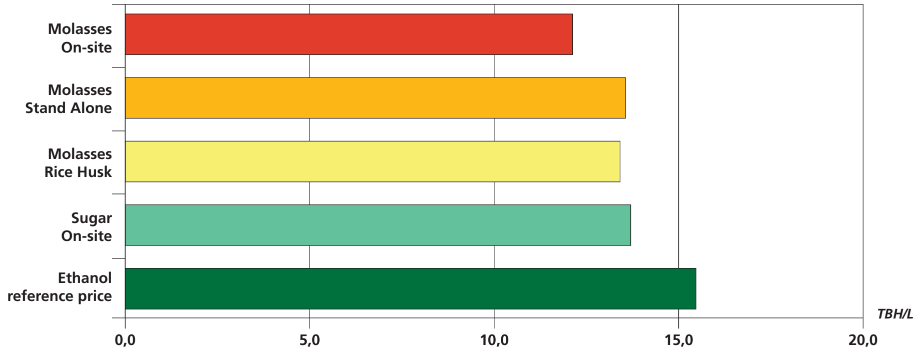
Production scenario	Description
Sugar – On-site	■ 182.5 million litre capacity powered by renewable energy (bagasse) plant attached to sugar mill ■ Ethanol produced from sugar juice ■ Theoretical scenario – no actual example in Thailand
Molasses – Rice Husk	■ 73 million litre capacity powered by renewable energy (rice husk cogeneration plant) ■ Molasses transported to off-site refinery for processing
Molasses – Stand Alone	■ 73 million litre capacity powered by renewable energy (bagasse) plant attached to sugar mill ■ Additional feedstock is sourced from surrounding suppliers
Molasses – On-site	■ 73 million litre capacity powered by renewable energy (bagasse) plant attached to sugar mill ■ Energy and feedstock are made available at internal prices

Source: JGSEE.

From Figure 6.1 it can be observed that production costs for sugar ethanol are found to be competitive under each feedstock scenario. Production costs are below the ethanol reference price of 19.3 THB/L (0.60 $/L) for each configuration and well below the fossil gasoline 91 reference price of 35 THB/L (1.10 $/L). The internal rate of return for each configuration is high ranging between 28 percent for the molasses stand alone configuration and 42 percent for the molasses on-site configuration before accounting for tax. The lowest production costs are recorded for molasses-based ethanol using an on-site refinery, which allows for substantially reduced transport costs and the ability to source energy supplies from a co-located sugar mill. This configuration describes most existing ethanol production operations in Thailand indicating that the industry is already highly competitive.

FIGURE 6.1

Comparison of sugar-based ethanol production costs



Source: JGSEE.

6.3 COMPETITIVENESS OF CASSAVA-BASED ETHANOL

In the BEFS Thailand analysis particular focus is directed towards cassava ethanol. This focus is warranted because, as noted previously, cassava ethanol is anticipated to constitute an increasing proportion of Thailand's ethanol targets. Unless cassava ethanol production generates sufficient returns for producers it cannot be assumed that there will be enough cassava ethanol supplied to meet the long-term demand anticipated by the AEDP targets.

TABLE 6.2

Characteristics of cassava-based ethanol configurations

Production scenario	Description
Low efficiency fossil (LEF)	■ 36.5 million litre capacity powered by coal and electricity grid ■ Ethanol produced from fresh cassava root
Medium efficiency fossil with waste water management (MEF)	■ 73 million litre capacity powered by coal and electricity grid ■ Biogas plant established to generate additional energy from waste water flows ■ Ethanol produced from cassava chips
Renewable energy (RE)	■ 73 million litre capacity powered by renewable feed electricity plant attached to co-located sugar mill ■ Biogas plant established to generate additional energy from waste water flows ■ Ethanol produced from cassava chips with capacity to switch to molasses

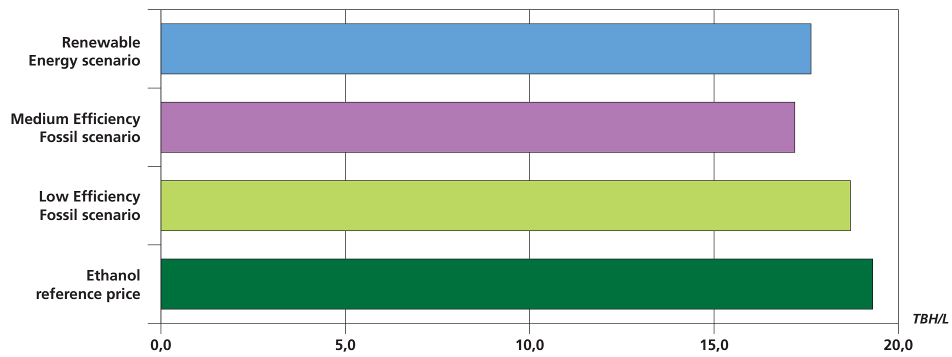
Source: JGSEE.

The cassava-based ethanol production configurations assessed in this chapter are presented in Table 6.2. Each of the configurations described have been implemented in the Thai context, although the RE configuration is a relatively new addition to the industry.

Figure 6.2 shows that production costs for cassava ethanol are found to be competitive under each scenario. Production costs are below the ethanol reference price of 19.3 THB/L (0.60 $/L) for each configuration with a cassava root price of 1.8 THB/kg (0.06 $/kg), which is higher than the OAE reference price of one THB/kg (0.03 $/kg). Cassava ethanol production under existing practices is found to create enough of a margin to generate a profit for farmers. The internal rate of return (IRR) of the configurations assessed ranges between 18.8 percent for the MEF configuration and 23.3 percent for the RE configuration before accounting for tax. However, small changes in product sales or the price of raw materials exert large influence on the economic competitiveness of cassava ethanol (Figure 6.3).

FIGURE 6.2

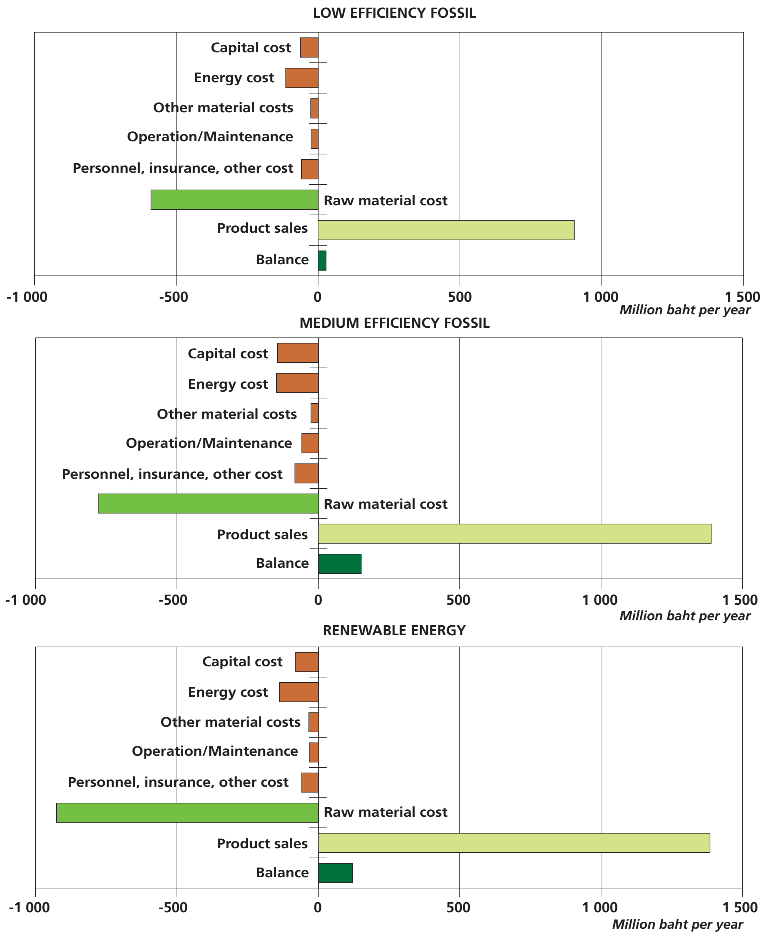
Comparison of cassava-based ethanol production costs



Source: JGSEE.

FIGURE 6.3

Cost and benefit summary for cassava-based ethanol scenarios



Source: JGSEE.

A 20 percent increase in feedstock cost for each scenario results in a final product cost above the ethanol reference price and a significant decline in IRR. A reduction of the ethanol sale price by one Thai baht per litre reduces the potential range of IRR to between 2.8 percent for the LEF configuration and 14 percent for the RE configuration.

Looking at the feedstock component in more detail it is found that costs associated with fertilizers are the largest contributor to final feedstock cost followed by land preparation and then labour costs. However, it was observed that slightly higher inputs lead to better yields and larger net profits. There may also be opportunities to reduce fertilizer costs through increased use of organic products. Field testing by LDD has indicated that use of cheaper organic fertilizers in place of chemical varieties can also improve yields in some instances.

Generally it was found that prices received for cassava root are above the OAE national reference price. This results in revenues per farmer higher than those estimated by OAE. It was also found that the average yield in surveyed areas was higher than the OAE national average of 21 tonnes per hectare. In most cases cassava farmers are small-holders with equally small operations. Improved returns from cassava crops via improved yields and stable prices could deliver considerable benefits to these farmers.

6.4 COMPETITIVENESS OF BIODIESEL

The biodiesel production configurations assessed in this chapter are presented in Table 6.3.

TABLE 6.3

Characteristics of biodiesel configurations

Production scenario	Description
CPO – Large Scale	■ 146 million litre capacity powered by grid electricity and/or coal ■ CPO is produced in location proximate to oil palm plantation ■ CPO transported to off-site biodiesel refinery
Multi-Feed – Large Scale	■ Feedstock includes CPO, refined palm oil, stearine and waste cooking oil
CPO – Small Scale	■ 365 thousand litre capacity powered by grid electricity and/or coal ■ Batch operation
Waste Cooking Oil – Small Scale	■ 365 thousand litre capacity powered by grid electricity and/or coal

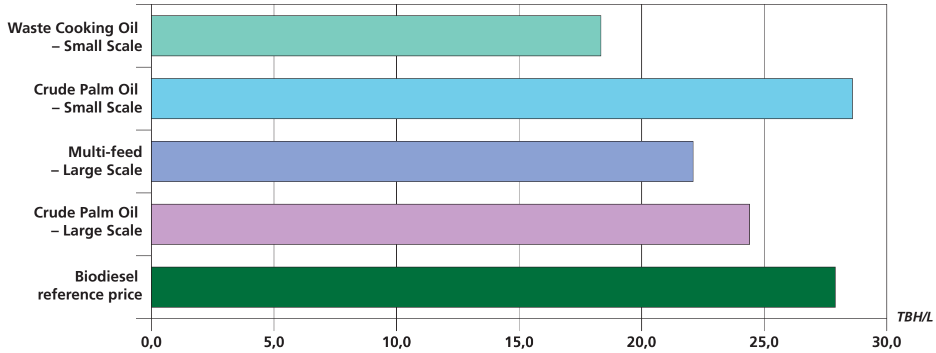
Source: JGSEE.

From Figure 6.4 it can be observed that production costs for palm oil biodiesel are found to be competitive under most feedstock scenarios. Generally, production costs are below the biodiesel reference price of 27.9 THB/L (0.87 $/L) for each configuration and below the fossil diesel reference price of 27 THB/L (0.84 $/L) per litre. The IRR before tax is above 50 percent for each configuration except the small-scale, crude palm oil configuration. Generally the findings indicate that strong returns are possible for biodiesel producers in Thailand. This should provide the necessary incentives to attract additional investment and new entrants to expand production capacity in line with the AEDP biodiesel target.

Interestingly, the small-scale configuration using crude palm oil as feedstock is found to be economically unviable. This is because the conversion process is less efficient – requiring more inputs per unit of output. At present, the Thai biodiesel industry employs a large-scale, crude palm oil configuration.

FIGURE 6.4

Comparison of biodiesel production costs

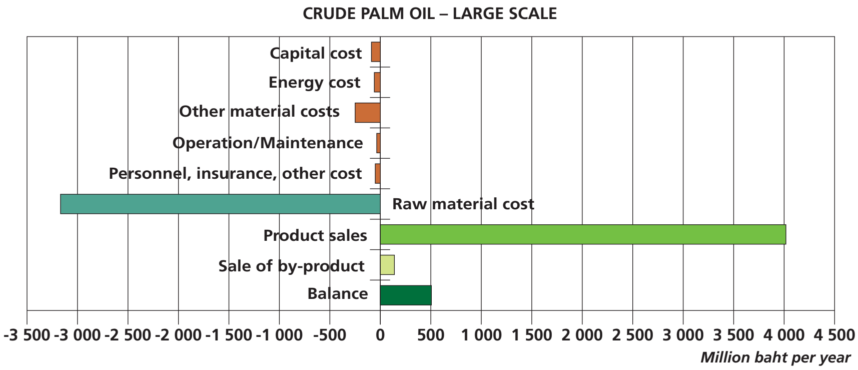


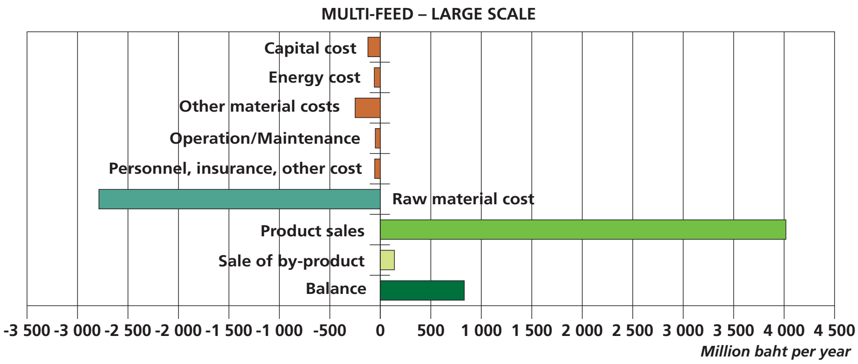
Source: JGSEE.

As already seen in the case of cassava, feedstock costs are also a key determinant of the economic competitiveness of biodiesel production in Thailand (Figure 6.5). Strategies to reduce the cost of this component for biodiesel producers will dramatically improve the economic competitiveness of Thai biofuel producers.

FIGURE 6.5

Cost and benefit summary for large scale biodiesel scenarios





Source: JGSEE.

CHAPTER 7

CLIMATE CHANGE MITIGATION

Key Findings

- Biofuels produced in Thailand display measurable GHG benefits when compared to fossil fuels.
- The refining process is the most critical determinant of the overall GHG balance of biofuels.
- Agriculture is also a key contributor to the GHG profile particularly when land use and crop changes are involved.
- The Thai biofuel sector could reduce emissions through better agricultural practices and by using wastes and by-products for energy.

7.1 OVERVIEW OF ANALYSIS

The purpose of this element of the analysis was to assess the impact of biofuels produced in Thailand in terms of greenhouse gas emissions and energy balance. To complement and build on the analysis presented in the previous chapter, a full life cycle analysis (LCA) was developed for each of the biofuel production configurations examined in the economic analysis. An LCA is a tool for the systematic evaluation of potential environmental impacts associated with a product, process or activity, from the production of raw materials through to its final disposal. In this case, the LCA focused on the emission of greenhouse gases and energy required at every stage of the biofuel production chain from the farm to the refinery gate. The calculated GHG emissions for the fuels produced from each production configuration assessed in this chapter are expressed as grams of carbon dioxide equivalent per megajoule (gCO_{2eq}/MJ).

7.2 GHG EMISSIONS OF SUGAR-BASED ETHANOL

For the purpose of comparison hypothetical scenarios were developed that use fossil energy as the main source of power for the refining step. These scenarios are presented in Table 7.1.

TABLE 7.1

Additional sugar-based ethanol processing scenarios

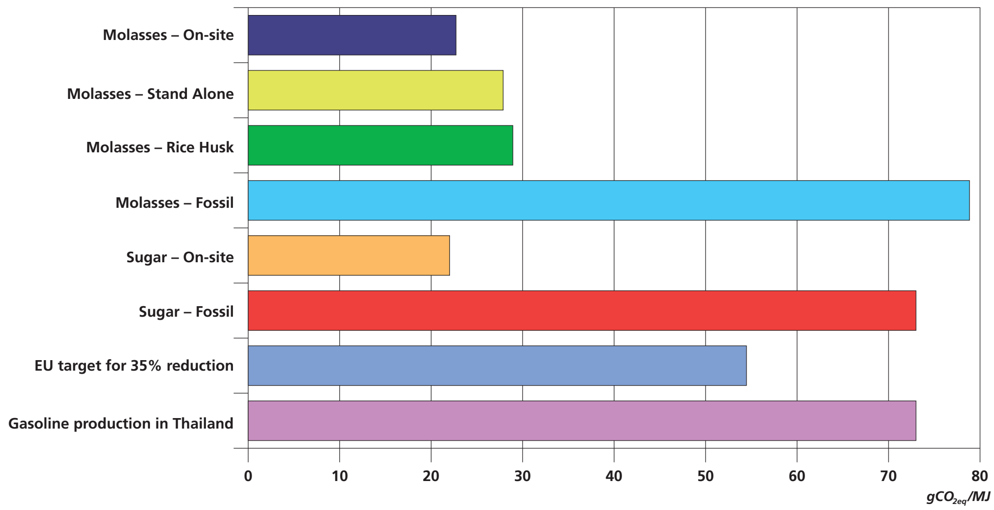
Production Scenario	Description
Sugar – Fossil	■ 182.5 million litre capacity powered by grid, electricity and/or coal ■ Ethanol produced from sugar juice in off-site facility ■ Theoretical scenario – no actual example in Thailand
Molasses – Fossil	■ 73 million litre capacity powered by grid, electricity and/or coal ■ Theoretical scenario – no actual example in Thailand

Source: JGSEE.

Figure 7.1 presents the life cycle GHG balances of different sugar ethanol production configurations in Thailand. It can be observed that in most cases ethanol production in Thailand either from molasses or from sugar juice offers considerable GHG reductions when compared to threshold values for fossil gasoline and the EU sustainability directive. The research also suggests that ethanol production in Thailand offers net fossil energy savings when compared to fossil gasoline.

FIGURE 7.1

GHG emissions of different sugar-based ethanol configurations

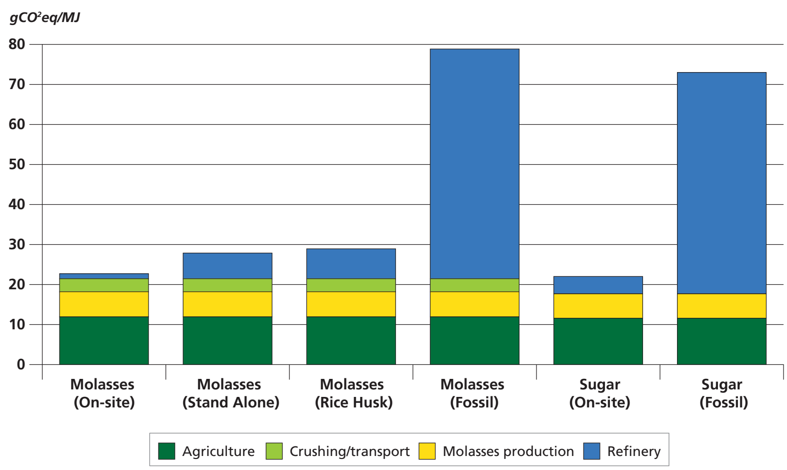


Source: JGSEE.

The use of fossil energy in the refining process is a key variable determining the sustainability of each ethanol scenario in terms of climate and energy balance. In scenarios where fossil energy is used, the refining process is the main contributor of GHG emissions. But in the case where only renewable energy is utilized in this step, the largest GHG contributor is agriculture (Figure 7.2). This suggests that policies to improve the GHG balance of sugar ethanol could be targeted toward both better utilization of renewable biomass for power generation and encouraging more efficient agriculture.

FIGURE 7.2

Breakdown of GHG emissions by step for sugar-based ethanol scenarios



Source: JGSEE.

7.3 GHG EMISSIONS OF CASSAVA-BASED ETHANOL

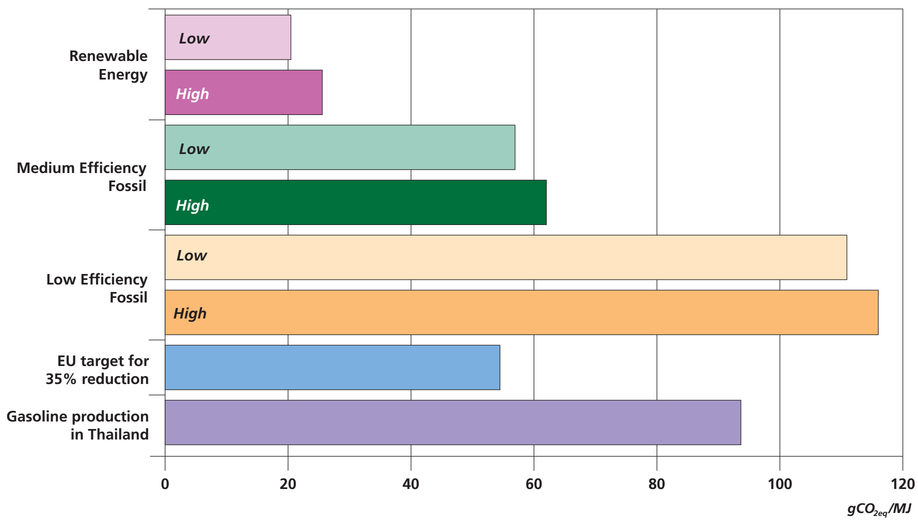
As with the economic analysis, the potential climate impacts of cassava ethanol were given special attention in the BEFS Thailand analysis. In terms of life cycle analysis, Thai cassava ethanol has previously been less scrutinized than sugar-based ethanol and palm oil biodiesel.

Figure 7.3 presents the life cycle GHG balances of the different cassava ethanol production configurations. It indicates that the GHG emissions profile of cassava ethanol varies dramatically. Cassava ethanol produced using inefficient fossil fuel configurations is found to result in greater GHG emissions than fossil gasoline. More efficient fossil fuel configurations, i.e. MEF, display reduced emissions but fail to meet the EU emissions reduction target. This could have implications if Thai cassava ethanol producers were to look for future export markets in Europe. The most efficient configuration in terms of GHG is the renewable energy configuration, co-located with an existing sugar mill. From Figure 7.3 it can be observed that this configuration also meets the EU emissions threshold.

Cassava ethanol's demand for energy during the production process is greater than fossil gasoline if the inefficient fossil fuel configurations are employed. Otherwise the energy balance of cassava ethanol is superior to fossil gasoline.

FIGURE 7.3

GHG emissions of different cassava-based ethanol configurations



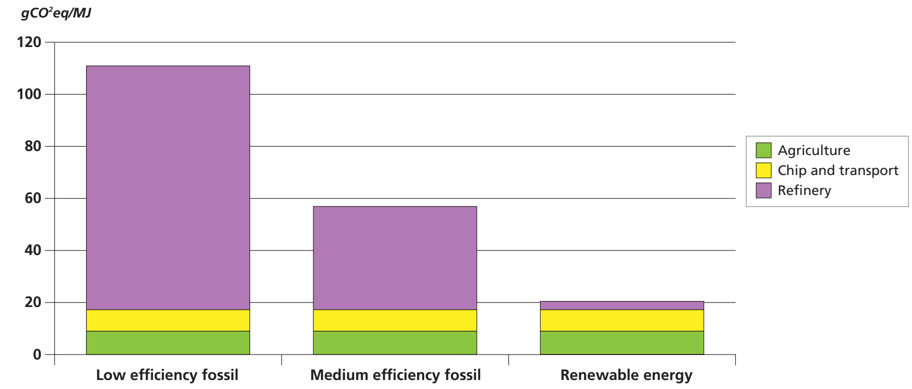
Source: JGSEE.

The location of the ethanol refinery and energy configuration employed is the most important determinant of the final GHG balance of cassava ethanol. Figure 7.4 clearly displays the importance of refinery configuration to final GHG emissions from cassava ethanol.

Generally, the contribution of agriculture to the GHG profile of cassava ethanol is low (Figure 7.4). It can be observed in Figure 7.3 that the difference in emissions between low and high input farming in the cassava sector is minimal. Further it was found that increases in yields generally offset the subsequent increase in emissions from adding further inputs. However, in the event that significant land use or crop changes are involved in cassava feedstock production, the contribution of agriculture to the GHG emissions profile increases – in some cases dramatically.

FIGURE 7.4

Breakdown of GHG emissions by step for cassava-based ethanol scenarios

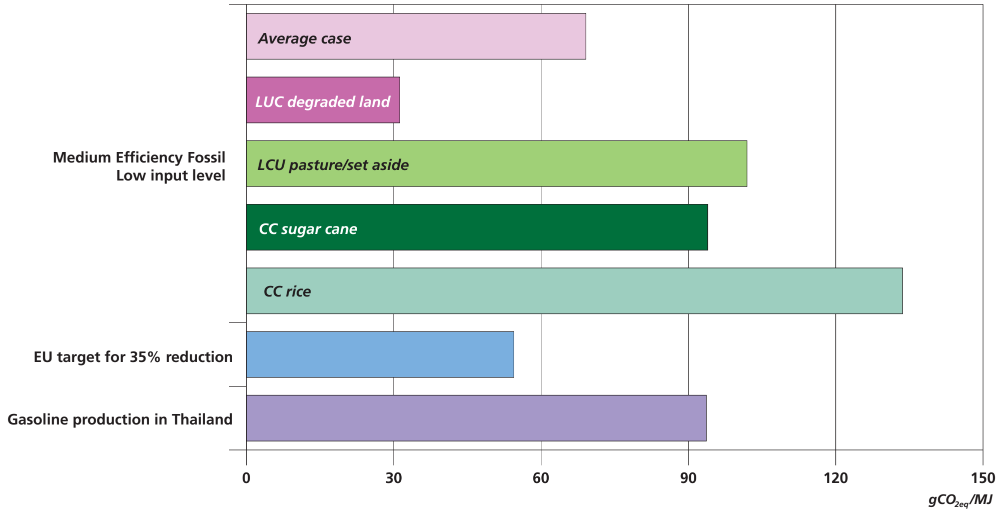


Source: JGSEE.

In Chapter 3 it was indicated that a sizable increase in cassava plantings, particularly on land currently allocated to rice, may be necessary to meet the anticipated feedstock demand for cassava ethanol if yields were unable to grow at rates required by the AEDP. Figure 7.5 presents a comparison of GHG emissions from cassava ethanol when land use or crop changes are involved in the agricultural process under the MEF configuration. The change in GHG emissions is dramatic – particularly for crop changes from rice to cassava. Based on the findings presented here and in Chapter 3, it is clear that caution will be required to ensure that this type of activity is minimized if cassava ethanol produced in Thailand is to retain its GHG mitigation potential and benefit the climate.

FIGURE 7.5

Influence of LUC and CC on the medium efficiency fossil scenario



Source: JGSEE.

7.4 GHG EMISSIONS OF BIODIESEL

Two additional biodiesel scenarios were developed for the purpose of the LCA analysis. Further details of these scenarios are available in Table 7.2.

TABLE 7.2

Additional biodiesel processing scenarios

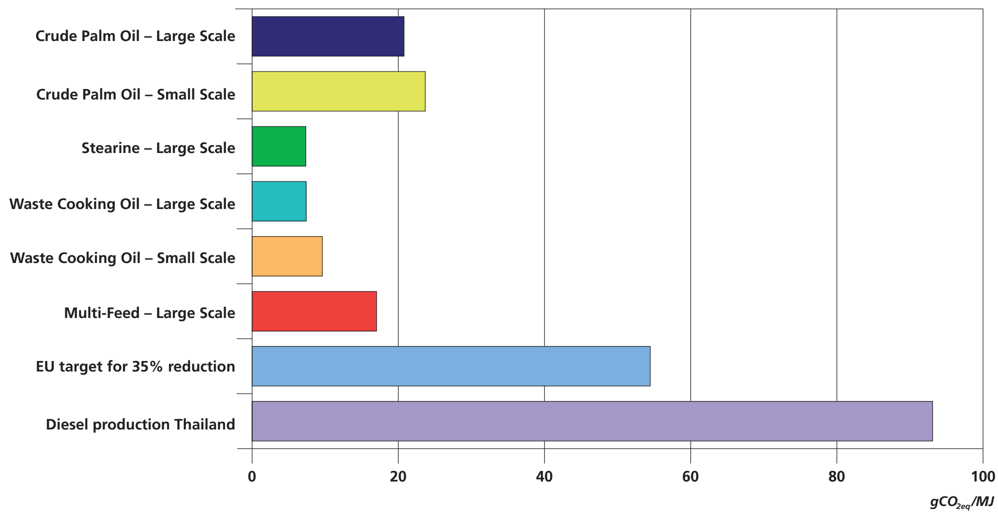
Production scenario	Description
Stearine – Large Scale	■ 146 million litre capacity powered by grid, electricity and/or coal
Waste Cooking Oil – Large Scale	■ 146 million litre capacity powered by grid, electricity and/or coal

Source: JGSEE.

From Figure 7.6 it can be seen that the production of biodiesel from palm oil in all cases generates less GHG emissions when compared to fossil diesel over the life cycle. Interestingly the small-scale biodiesel production scenarios are less efficient in terms of GHG emissions and energy balance when compared to industrial scale operations. This is largely due to the fact that small-scale production has higher energy requirements per unit of energy produced. Small-scale production also entails higher demand for methanol inputs per unit of energy produced.

FIGURE 7.6

GHG emissions of different biodiesel configurations

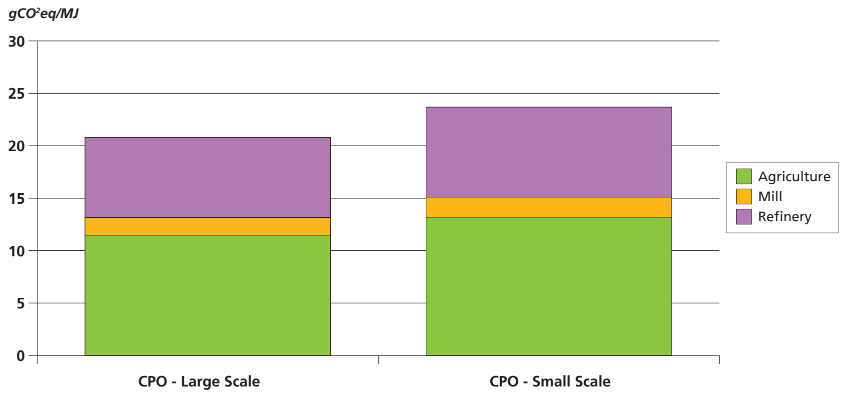


Source: JGSEE.

The research also indicates that biodiesel production is generally more energy efficient than ethanol production. This is because the energy demand for ethanol refining is high; particularly when fossil energy refineries are employed. For biodiesel the largest contributor to GHG emissions is agriculture – except in the scenarios where waste cooking oil and stearine are used as feedstock. The significant contribution of agriculture to overall GHG emissions results from the application of fertilizers, use of fossil fuels on farm and product transport (Figure 7.7). If the effects of land use change are incorporated, GHG emissions increase dramatically when forested land is converted to oil palm plantations. However, converting degraded land to oil palm plantations would increase carbon stocks and may produce an overall benefit in the form of reduced emissions.

FIGURE 7.7

Breakdown of GHG emissions by step for crude palm oil biodiesel scenarios

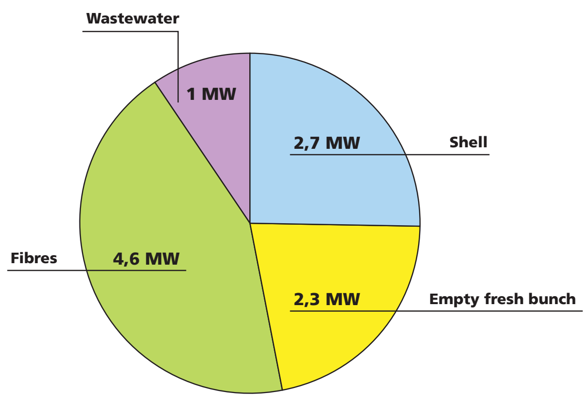


Source: JGSEE.

Generally there is considerable scope to improve the efficiency of existing systems by utilizing biomass wastes from the feedstock production process to generate energy that can fuel the biodiesel production process. Figure 7.8 provides an overview of the estimated additional energy in megawatts (MW) that could be sourced from by-products in the production of CPO at a medium sized processing mill that processes 45 tons of fresh fruit bunch per hour. The integration of processes and systems to manage wastes and other flows to produce energy could result in significant additional gains for overall efficiency and, ultimately, sustainability.

FIGURE 7.8

Renewable energy potential of medium sized CPO mill



Source: JGSEE.

CHAPTER 8

SOCIO-ECONOMIC ASPECTS

Key Findings

- Any increase in agricultural prices that arise from development of the biofuel industry could lead to increased incidence of poverty in Thailand.
- Strategies that aim to locate biofuel feedstock producing opportunities in poorer communities could have a positive effect and reduce the incidence of poverty.
- Higher agricultural prices will lead to growth in the agriculture sector.
- Further investigation and monitoring is required to understand the true impact of the biofuel sector on households and the Thai economy.
- Small-scale bioenergy systems may offer benefits for rural development, but require assistance to establish and operate.

8.1 OVERVIEW OF ANALYSIS

The purpose of this element of the analysis was to consider how the Thai Government's plans for the biofuel and bioenergy sectors could affect Thai households and the broader economy. This analysis was conducted in two parts. The first element of the analysis attempts to investigate the potential socio-economic effects of biofuel development by estimating how changes in the price of agricultural crops, and biofuel crops in particular, could impact on both households and the economy more broadly. This implies that the analysis is conducted at both the microeconomic and macroeconomic level. A key assumption underlying this type of analysis is that biofuels will create a new source of demand for biofuel feedstock crops and that this demand will result in a rise in the price of these commodities and, possibly, other agricultural commodities.

For further details regarding the methodologies underpinning the analysis in this chapter and their limitations please refer to "*Bioenergy and Food Security – The BEFS analysis for Thailand*".

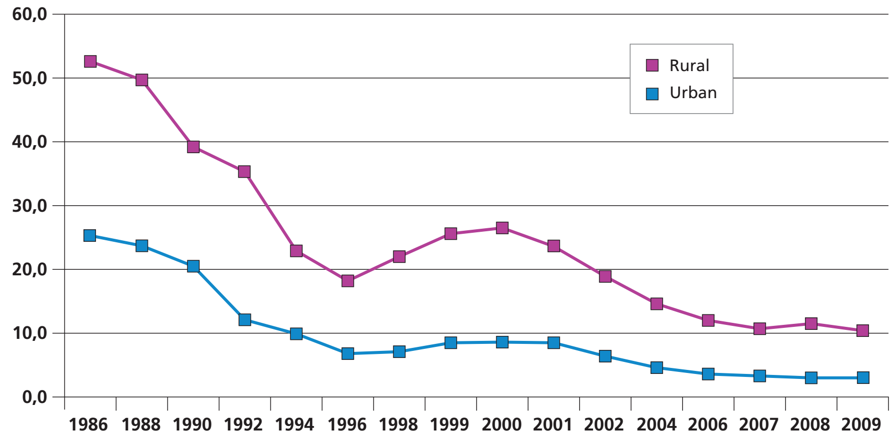
The second element of the analysis evaluates the potential benefits of small-scale bioenergy systems and barriers to their wider adoption in Thai rural communities. Unlike biofuels, which have been the focus of the BEFS analysis in Thailand and generally aim to provide an additional source of income for agriculture-based communities, small-scale bioenergy systems can benefit rural communities by reducing energy expenditures and increasing the value of otherwise discarded biomass wastes.

8.2 POVERTY SITUATION IN THAILAND

Before examining the potential impacts of biofuels and bioenergy on households in more detail it is useful to present some background information on poverty and household economic conditions in Thailand to contextualize the analysis. The poverty situation in Thailand has improved dramatically over the past two decades (Figure 8.1). However, pockets of poverty still exist throughout the country.

FIGURE 8.1

Poverty incidence by area, 1986-2009



Source: NSO - calculated from 2009 Socio-Economic Survey.

As can be seen in Table 8.1, the incidence of poverty in Thailand in 2009 was 8.12 percent with the vast majority of poor located in the North and Northeast regions of the country. The average food poverty line is generally higher than the non-food poverty line, except in Bangkok where there is a bias in consumption patterns toward more non-food items. A poverty line is the minimum amount of expenditure, expressed in baht per person per month (THB/person/month), on a category of goods required for a household to be considered out of poverty.

TABLE 8.1

Per capita income and expenditure, poverty line and incidence by region in 2009

Region	Income	Expenditure	Average poverty line Food	Non-food	Total	Poverty incidence Income	Consumption
	THB/person	THB /person	THB/person/ month	THB/person/ month	THB/person/ month	%	%
Bangkok	13 446	8 463	917	1 218	2 135	1.84	0.86
Central	7 080	5 094	893	760	1 652	3.06	2.54
North	4 965	3 420	929	556	1 485	9.49	11.08
Northeast	4 339	3 127	957	517	1 473	13.89	13.67
South	6 707	4 464	970	577	1 547	5.22	4.72
Total	6 239	4 308	934	652	1 586	8.18	8.12

Source: NSO – calculated from 2009 Socio-Economic Survey.

In Thailand, the incidence of poverty is also greatest amongst agricultural households. Over 75 percent of Thailand's poor are engaged in agricultural production. While this could imply that biofuel production may provide an opportunity to lift some of Thailand's agricultural producers out of poverty, the largest segment of Thailand's agricultural poor produce rice as their only crop. If these farmers are unable to diversify their source of farm income then the poverty reduction potential of the biofuel sector is severely reduced. The incidence of poverty could even worsen if development of the sector were to lead to a broad increase in food prices for poor rice farmers.

Generally, for households with no farm income, growth in the food poverty line might cause them to fall into poverty if their total income is only marginally above the poverty line to begin with. However, the extent to which food price changes affect the poverty situation of households with farm income depends on whether the increase in farm income compensates for the increase in the poverty line.

As noted above, both a microeconomic and macroeconomic analysis were undertaken to assess these potential issues in more detail.

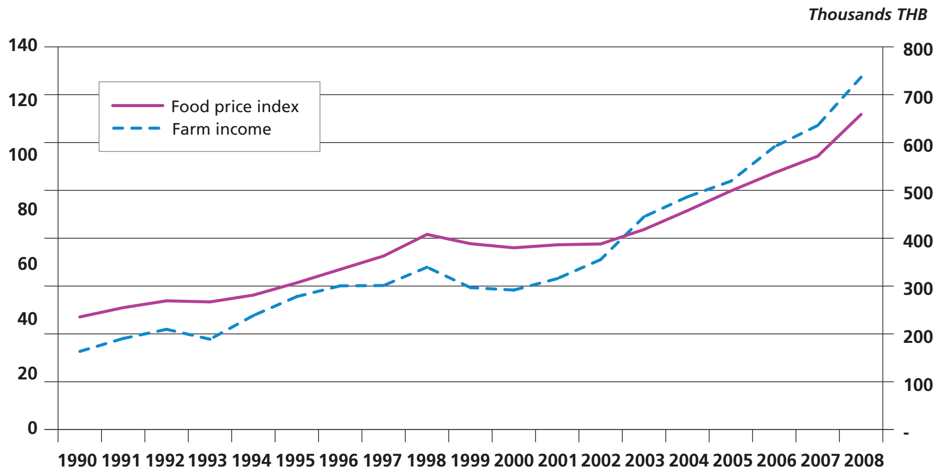
8.3 IMPACT OF BIOFUELS ON HOUSEHOLDS

The microeconomic analysis focuses on how movements in the price of agricultural commodities and biofuel crops could impact on Thai household income, consumption and poverty. At the household level it is assumed that these impacts will exert themselves through two channels, namely the cost of living and income from agriculture.

To simulate an increase in the cost of living, three scenarios of possible food price increases were tested ranging from three to ten percent. To estimate the potential impact of a price increase on farm income it is first required establishing a link between food prices and farm income. As can be seen in Figure 8.2 the two variables are correlated.

FIGURE 8.2

Food price and farm income 1990-2008



Source: TDRI.

As a result, a simple equation was developed to describe farm income as a function of food prices and agricultural production and a number of scenarios were tested. The assumptions of all six scenarios tested are shown in Table 8.2. These scenarios were then applied to household data from the 2009 Socio-Economic Survey and the results broken down by region and by household type.

TABLE 8.2

Scenario assumptions

Scenarios	Food price increase	Farm income increase Elasticity = 1.10	Farm income increase Elasticity = 1.25
	%	%	%
S1	3.00	3.30	3.75
S2	5.00	5.50	6.25
S3	10.00	11.00	12.50

Source: TDRI.

Following a rise in food prices the incidence of poverty was found to increase in all regions under the vast majority of scenarios tested. When looking at the impact by type of household, rice only farmers are hit hardest by rising food prices under each scenario (Table 8.3). This could be because rice only households are generally closer to the food poverty line than the other household types considered. Interestingly, the incidence of poverty among non-agriculture households generally increases at a rate greater than the agricultural households not producing rice and the ones producing rice and other crops. In fact, under the second elasticity case, the incidence of poverty in latter household types grows at a rate less than the other two household types and even declines for the household producing rice and other crops.

TABLE 8.3

Changes in poverty incidence by household type

Household Type	Elasticity = 1.00 S1	Elasticity = 1.00 S2	Elasticity = 1.00 S3	Elasticity = 1.25 S1	Elasticity = 1.25 S2	Elasticity = 1.25 S3
Non-agriculture	0.11	0.19	0.54	0.08	0.17	0.53
Agriculture – No rice	0.11	0.18	0.36	0.01	0.09	0.05
Agriculture – Rice only	0.31	0.58	1.14	0.23	0.43	0.66
Agriculture – Rice and other crop	0.17	0.16	0.46	0.04	-0.09	-0.31
Total	0.16	0.28	0.65	0.10	0.19	0.40

Source: TDRI.

This finding would seem to indicate that growth in farm income resulting from higher food prices may, under certain scenarios, offset the change in the food poverty line and lead to benefits for some households. In Chapter 4, the land suitability analysis indicated that rice, while very important for food security and Thai agricultural exports, is a relatively low value crop. Taking into account the findings above, assistance provided to poorer farmers to expand their plantings of biofuel feedstock crops could feasibly provide a valuable opportunity to improve earnings and even reduce the incidence of poverty.

However, in the absence of interventions that aim to provide poor farmers better access to opportunities in biofuel feedstock markets, this analysis indicates that a general increase in food prices leads to greater incidence of poverty. This is because poorer households will still tend to spend a large proportion of their slightly greater income on now more expensive food products.

8.4 IMPACT OF BIOFUELS ON THAI ECONOMY

The macroeconomic analysis focuses on how movements in the price of agricultural commodities and biofuel crops can impact directly and indirectly on the Thai economy as indicated by measures such as economic growth, average price levels, household consumption and income and aggregate trade and investment levels. To conduct this assessment a computable general equilibrium (CGE) model was employed. CGE models are simulation-based economic models where economic agents optimize their consumer preferences and interact with other agents in a market-clearing equilibrium manner.

As the CGE model employed for this analysis was not built specifically to study biofuels, the sectors involved in biofuel production are not separated out from those involved in food crop production. Fortunately, the production techniques of agricultural crops and biofuel crops generally differ only concerning the end use. Since the supply of agricultural produce for food and for energy is almost perfectly substitutable, it is assumed that biofuel crop prices will move also almost in unison with food crop prices.

As noted previously, it is assumed that as biofuels produced in Thailand will create an additional source of demand for biofuel crops, the effect of implementing the AEDP biofuel targets will be an increase in the price of these crops and food crops in general. In the absence of a separate biofuel sector, the CGE simulates this price increase via the world price of biofuel and food crops. Table 8.4 presents the outputs of the CGE model following a simulated increase of the price of food imports by one percent.

TABLE 8.4

Impact of one percent increase in import food price on economic growth and price levels

	Percent change from the base year
Overall GDP growth	-0.07
Agriculture sector	1.32
Industrial sector	-0.30
Service sector	-0.16
Price level	
Consumer index	0.47
GDP deflator	0.04

Source: TDRI.

Table 8.4 displays the impact in terms of economic growth and price levels. The agricultural sector clearly benefits from higher prices of imported food increasing production by 1.32 percent. However, industrial and service sectors suffer as they use agricultural products as inputs and increased prices for these products translate into increased production costs. General prices rise along with import prices. Consumer prices are more greatly affected than the GDP deflator because the consumer price index includes a higher proportion of food items than the GDP deflator.

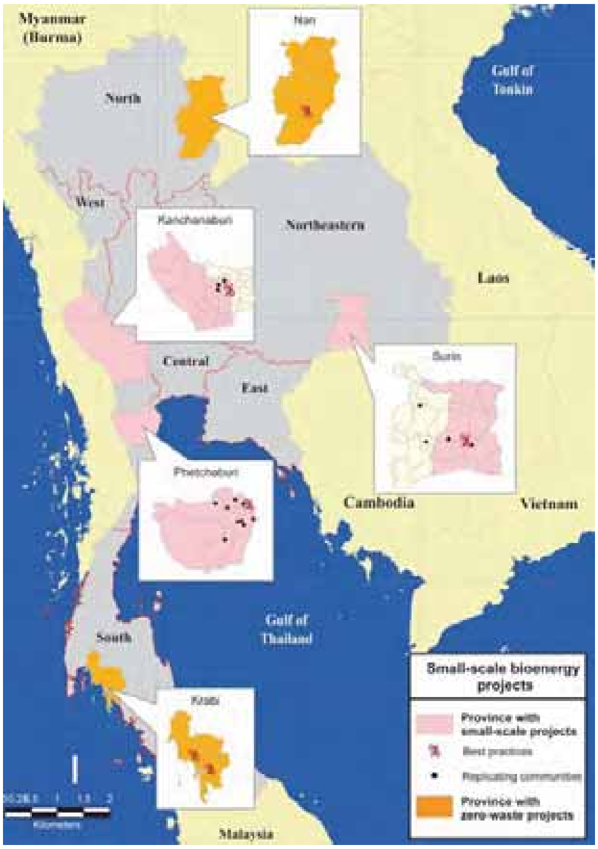
To assess the specific impacts of the rise in consumer prices on household incomes, households were disaggregated into 20 groups by income class and by farm versus non-farm households. Most farm households, with the exception of the poorest were found to gain in terms of real income while all non-farm households experienced reduced real income. The likely reason that the poorest farm households show no gains in terms of real income is because the share of food consumption among these households is higher compared to other groups. These results are generally consistent with those of the microeconomic analysis presented in Section 8.3.

8.5 SMALL-SCALE BIOENERGY AND RURAL DEVELOPMENT

For the purpose of the small-scale bioenergy assessment 20 communities were surveyed including three 'best practice' bioenergy communities, which served as example cases. The communities surveyed were located in five provinces encompassing a range of different technologies including biogas, biodiesel, high-efficiency charcoal kilns, thermal power generation and advanced wood stoves. Figure 8.5 shows the locations of each project surveyed.

FIGURE 8.3

Location of small-scale bioenergy projects



In general, the successful communities surveyed were satisfied with their bioenergy initiatives. These respondents indicated that as a result of their bioenergy initiative expenditures on external energy sources had been reduced and that, in some instances, the availability of bioenergy was believed to lead to improved health and local environmental outcomes. Some of the communities surveyed also reported success in selling energy and other outputs to neighbouring communities and provinces.

Generally, most of the projects surveyed required some form of external assistance to establish the operation and also maintain the bioenergy system. While this is a serious shortcoming, there was evidence that over time some communities would be able to support their bioenergy operations from revenues generated. Key elements of success common to effective projects were the availability of strong community leadership and access to technical knowledge and community finance. The key barriers identified by survey respondents were lack of access to government funding and lack of access to resources and knowledge.

To complement the survey of 'best practice' bioenergy communities, a financial analysis was conducted on three zero-waste bioenergy systems. Zero-waste bioenergy systems use a particular bioenergy feedstock to produce a range of outputs including energy, fertilizers and consumer goods. The financial analysis found that all assessed zero-waste projects were financially unviable at this stage unless they will get some kind of external support. The jatropha-based zero-waste system in Nan province was found to have the least potential in terms of viability because labour costs were particularly high when compared with the revenue that could be generated from the sale of jatropha seed or biodiesel produced from crude jatropha oil.

One limitation of the financial analysis was that revenues from the sale of other by-products such as fertilizers could not be assessed due to a lack of data regarding market prices for these outputs. In the future, if a market for these by-products develops and communities are able to sell them at a reasonable price, then the financial viability of these systems would improve. This is consistent with the findings of the survey analysis which found that the most successful rural bioenergy projects produce a range of outputs. These outputs can be substituted for other commodities that the communities would otherwise have to purchase such as liquefied petroleum gas, pesticides and fertilizers. The sale of by-products could be a valuable alternative source of revenue for rural communities and will be a key determinant of the success and viability of small and community scale bioenergy projects.

Interestingly, each community assessed for the financial analysis reported other benefits to the community associated with small-scale bioenergy operations such as self-sufficiency and improved cohesiveness within the community. This suggests that there may be other benefits derived from the implementation of small-scale systems that do not lend themselves to traditional financial analysis. It was determined that future assessments of these projects should attempt to monetize the external impacts of these operations to assess their true cost and/or benefit to rural communities.

The AEDP makes provision to support the development of small-scale bioenergy through investment grants for biogas and soft loans for small-scale bioenergy demonstration facilities. This support will provide interested communities with essential means to establish small-scale bioenergy systems. However, based on the survey and financial analysis conducted for BEFS, this assistance may not address challenges associated with long-term operation and system maintenance. Overcoming these challenges will require education and regular access to technical assistance.

CHAPTER 9

RECOMMENDATIONS

As noted in Chapter 1, BEFS aims to strengthen the capacity of target countries to balance the trade-offs associated with bioenergy development. This chapter considers how the BEFS analysis can inform Thailand's existing policy framework for bioenergy and biofuels in particular, so that benefits flowing from the implementation of future policies will be sustainably procured and managed equitably.

The principle underlying the BEFS approach is that policy enacted to influence one element of the bioenergy sector can have impacts – both positive and negative – on other elements of the sector, the broader economy and the environment. In contrast to the other BEFS countries, Thailand has a rapidly growing biofuel sector and a comprehensive policy framework for its further expansion. As a result, the BEFS analysis aims to provide an external assessment of the trade-offs involved with Thailand's current array of policy choices and provide information regarding key issues and recommendations for further policy action.

Revisiting the framework of the BEFS analysis in Thailand as presented in Chapter 1, the BEFS analysis in Thailand is underpinned by the Thai Government's AEDP bioenergy targets. These targets will have an impact on Thailand's future agricultural outlook and implications for Thailand's natural resources base, the competitiveness of the bioenergy sector, Thai households, the broader Thai economy and the climate. How the Thai Government manages the pressures that the bioenergy sector will exert on its natural resources, agricultural markets and the general populace will determine the future sustainability of biofuels and bioenergy as alternative energy sources.

9.1 NATURAL RESOURCES

Recommendation 1: *Initiatives to sustainably improve the productivity of Thai farmers should be prioritized through R&D, extension services and incentives.*

Improvements in agricultural yields are an important feature of the AEDP roadmap for biofuels. For each key biofuel crop increase in agricultural productivity is envisaged to meet the AEDP biofuel targets. The analysis in Chapter 4 indicates that there is potential to improve the output of Thailand's farmers; in some cases substantially. At present, agricultural productivity is below world standards for a wide range of crops.

As most Thai farmers are smallholders with poor access to information and modern sustainable farming practices, these findings imply a large role for government in expanding assistance to farmers, strengthening agricultural extension services and improving agricultural practices. Success in this regard will require significant public investment and better links between organizations involved in the dissemination of information, finance and support services to farming communities. Such organizations include local and provincial governments, agricultural research institutions, universities and national technical bodies such as OAE and LDD.

From a policy perspective, the provisions in the AEDP for R&D activities and the recent MoU between MoE and MOAC indicate that the Thai Government is already working in this direction. Implementing these measures that will encourage a sustainable improve in agricultural productivity in Thailand is an important strategy because it will unlock multiple dividends.

The BEFS analysis finds that improved yields could lead to better returns for smallholder farmers by increasing potential revenues. This will have positive implications for rural incomes, rural development and the potential of poorer farmers to regularly access more nutritious foods. It will guarantee more stable and efficient agricultural output over the longer term that it will also enhance the economic competitiveness of the biofuel sector, as described in Chapter 6. Given the relatively high contribution of agriculture to biofuels GHG profile, lifting agricultural productivity is also an important way to reduce emissions per unit of production and strengthen the sustainability of these fuels, as confirmed in Chapter 7. More sustainable agricultural practices could also help to restore the productivity and limit an irreversible degradation of Thailand's soil.

Recommendation 2: *Clear guidance should be developed and provided to Thai farmers regarding land use and crop changes to ensure that threats to food security are avoided and excessive harmful greenhouse gas emissions and biodiversity loss are mitigated.*

Chapters 4 and 5 confirmed that in the short term the AEDP biofuel targets could result in additional utilization of Thailand's land and water resources. While the magnitude of the additional strain on Thailand's natural resource base is projected to be modest in the case of land and minimal in the case of water there are potential issues that require specific attention to ensure that biofuels do not threaten food security and the environment.

Expansion of agricultural land to facilitate biofuel production could result in reductions of land area dedicated to other crops; particularly rice. As rice is Thailand's staple food crop and the main source of income for poor farmers, care needs to be taken to ensure that any expansion of biofuel crops does not threaten or worsen the food security situation of Thai people; particularly the poor and vulnerable. Expansion of the land area for biofuel crop production also implies land use and/or crop change. In Chapter 7 it was demonstrated that some land use and crop changes are more damaging in terms of the environment and GHG emissions; particularly in the case of rice. Guidance is needed for farmers in conjunction with the provision of technical assistance to minimize emissions from land use and/crop changes.

Recommendation 3: *Initiatives to improve agricultural productivity in Thailand should include an assessment of the potential benefits, costs and barriers to the expanding sustainable irrigation practices.*

As discussed in Chapter 5 an alternative method to improve the agricultural productivity of biofuel feedstock producers in Thailand is to expand or re-allocate irrigation networks. While expansion of irrigated land in Thailand is not anticipated to have a large impact on the country's TRWR, it is a process that takes time and careful planning. However, as the vast majority of Thailand's biofuel feedstock production areas are not currently under irrigation and in light of its potential to improve productivity, the possible costs and benefits of expanding irrigation for biofuel feedstock crops in a sustainable manner should be investigated further.

Recommendation 4: *Research should be commissioned into the potential impact of ineffective wastewater treatment on water systems proximate to biofuel production facilities for the purpose of developing a sector-wide wastewater management strategy.*

While the expansion of biofuels production is not expected to strain water resources in terms of volume, it may have serious impacts on water quality near processing facilities as described in Chapter 5. Biofuel production processes generate a large quantity of wastewater. As biofuel production grows in line with the AEDP targets the amount of wastewater requiring treatment will grow dramatically. Although the Thai Government has a zero discharge wastewater policy, local water systems could still be affected due to leaching from treatment ponds. This could have a significant negative effect on local groundwater systems and subsequently on neighbouring streams.

9.2 BIOENERGY SECTOR'S ECONOMIC COMPETITIVENESS

Recommendation 5: *Measures to improve the public perception of biofuels and develop the flexible-fuel ethanol vehicle market should be prioritized to ensure that domestic market demand for biofuels grows to meet the anticipated production.*

In Chapter 6 it was found that the biofuel sector in Thailand is highly competitive particularly when measured against the prevailing cost of fossil fuel prices and in terms of return on investment. Continuing high prices in energy markets will help maintain the competitiveness of the sector over the life of the AEDP. As noted above, improving agricultural productivity is an important way to reduce feedstock costs and a key challenge for the industry. However, a possibly even greater challenge to the long-term competitiveness of the biofuel sector will be ensuring that market demand for these fuels grows to meet the production targets; particularly in the case of ethanol.

In Chapter 3 it was noted that without significant changes to the gasoline automobile market, the Thai ethanol market will be constrained to a level below the anticipated growth in production. If the ethanol market fails to meet the growth in output then investments in agricultural productivity and production capacity could drive down prices with potentially negative implications for farmers and the future of the domestic ethanol industry. The AEDP aims to tackle this problem by investigating opportunities to increase the market for flexible fuel vehicles. Making the transition toward flexible-fuel vehicles is a huge endeavour that will require appropriate incentives for consumers, which in-turn needs effective coordination among the Ministries of Energy, Industry and Finance.

If policy support is maintained for ethanol supply in the absence of growth in the domestic ethanol market, export opportunities for Thailand's ethanol producers may be available as long as biofuel production satisfies any required product and sustainability standards. While the analysis in Chapter 7 indicates that ethanol produced in Thailand generally meets the EU sustainability thresholds, ethanol produced from cassava that involves certain land use or crop changes and/or employs fossil fuels in the refinery process exceeds these values. One way to address this issue is through the greater use of renewable energy in the production process. The implications of this are considered further in the section below on GHG, energy balance and climate change.

9.3 NATIONAL ECONOMY AND CONSUMER PRICES

Recommendation 6: *Further investigation and monitoring should be commissioned to better understand the impact of the biofuel sector on households and the Thai economy and develop more appropriate strategies to ensure that biofuel developments benefit poorer communities and do not lead to further incidence of poverty and a worsening of food security.*

In Chapter 8 it was shown that biofuel developments that affect agricultural and consumer prices could have significant impact in terms of poor agricultural households and the national economy. Despite significant progress in reducing poverty in Thailand, pockets of poverty still exist in certain regions of the country. Any increase in agricultural prices that arise from development of the biofuel industry could lead to increased incidence of poverty in Thailand; particularly in households that are living just above the poverty line or rely solely on the sale of rice crops for income. Policy makers should ensure that strategies are in place to assist poorer households cope with potential growth in agricultural prices arising from development of the biofuels sector.

One strategy to assist poorer households cope with potential growth in agricultural prices could be to direct biofuel crops producing opportunities toward poorer communities. The analysis presented in Chapter 8 indicates that households which produce a wider range of agricultural products will benefit more from any increase in agricultural prices. Development of the biofuel sector may present opportunities to encourage more crop diversification amongst poorer households providing additional sources of income and potentially lifting some households out of poverty.

Some of the most suitable regions identified for an expansion of biofuel feedstock crops in Chapter 4 were located in the North and North-East of Thailand, which also corresponds with the country's remaining pockets of poverty. However, for such a strategy to be effective government would need to ensure that farmers were afforded appropriate support to manage the transition into new biofuel feedstock crops.

The findings presented in this report are only the result of a partial analysis of what could occur if development of the biofuel sector were to lead to general growth in agricultural prices. The availability of better datasets and more comprehensive models will provide a clearer picture of the true impact of the biofuel sector on households and the potential for poverty reduction.

9.4 GHG, ENERGY BALANCE AND CLIMATE CHANGE

Recommendation 7: *Support and incentives to encourage biofuel producers to adopt renewable energy technologies should be continued and strengthened as instruments to improve the environmental sustainability and competitiveness of biofuels produced in Thailand.*

As discussed in Chapter 7, biofuel refineries which employ fossil fuels as an energy source were found to have considerably larger GHG emissions per unit of biofuel produced than those using renewable energy sources or a combination. It was also found that refineries which make use of wastes and by-products for energy generation had significantly less impact in terms of GHG emissions and preserved local environmental conditions. Interestingly, production processes that are more sustainable in terms of GHG emissions were also generally found to be more economically competitive.

Developing policies and regulations to encourage better integration of renewable energy in the biofuel sector will be necessary to ensure its future sustainability. Promoting more efficient agriculture and refinery configurations that improve the overall sustainability of Thailand's biofuels in terms of economic competitiveness and GHG emissions will also open up opportunities should Thai biofuel producers look to capture new export markets in the future that will increasingly be subject to sustainability standards. The Thai Government already provides a number of incentives and support programs for industry to adopt renewable energy technologies and processes. Based on the findings presented in this report there is good evidence to suggest that these measures should be continued and strengthened.

9.5 MANAGEMENT POLICIES

Recommendation 8: *A regular, multi-stakeholder review of progress toward the AEDP targets should be established to ensure that the targets are being met sustainably and not at the expense of food security and the environment.*

The AEDP will employ a wide range of demand and supply levers to achieve its biofuel targets. Maintaining the AEDP and creating policy certainty will be an important element of its future success. Implementation of the AEDP will provide the government with a strong mandate to investigate and enact the types of agricultural development necessary to meet the various biofuel targets. It will also provide a clear signal to investors to continue to invest in and develop the sector. If the biofuel targets were removed or revised significantly downward it could lead to large oversupplies in the market driving prices down and prompting feedstock growers to abandon biofuel feedstock production for other more lucrative opportunities.

But while policy certainty will be crucial in overcoming a number of the challenges inherent in the AEDP, the Thai Government must retain the ability and capacity to regularly assess progress toward the targets and re-evaluate policy in the face of changing circumstances.

At present, the AEDP focuses strongly on utilizing domestic bioenergy crop production to grow the market for biofuels. Adherence to the plan over the long-term should provide the right signals to improve agricultural productivity and encourage farmers to direct bioenergy crop production toward domestic biofuel production as opposed to international commodity markets. But regular assessment is required to ensure that farmers will not be worse off due to potential missed opportunities. Alternatively, new opportunities may be created for neighbouring countries in the region to supplement supply of these commodities in Thailand.

It is certain that over the life of the AEDP, the circumstances under which it was developed will change. The Thai Government needs to monitor progress toward the AEDP targets and carefully assess if and how policy should change. The BEFS tool may be of particular use in this regard.

CHAPTER 10

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ENVIRONMENT – CLIMATE CHANGE – BIOENERGY – MONITORING AND ASSESSMENT

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The Government of Thailand, through its Alternative Energy Development Plan, has set a target to increase biofuel production to five billion litres by 2022. The Thai Government sees this expansion as a way to strengthen the country's energy security, foster rural development and reduce greenhouse gas emissions. The FAO Bioenergy and Food Security (BEFS) project aims to strengthen the capacity of developing countries to balance the trade-offs associated with bioenergy development and mitigate the impact of bioenergy on food security. The analysis presented in this document includes the main findings and recommendations for policy-makers on how to achieve Thailand's envisaged biofuel targets in a sustainable way without threatening food security. The targets are found to impact on Thailand's future agricultural outlook and lead to additional utilization of Thailand's natural resources. Growth of the sector in line with the targets has the potential to affect the national economy and households through various channels such as the price of food made from biofuel feedstock crops. How the Thai Government manages the potential pressures that the bioenergy sector will exert on its natural resources and agricultural markets and the general populace will determine the future sustainability of biofuels and bioenergy as alternative energy sources in Thailand. Full details of the methodologies and data employed to produce the material in this document are being published in a separate volume entitled "*Bioenergy and Food Security – The BEFS analysis for Thailand*".




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