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.

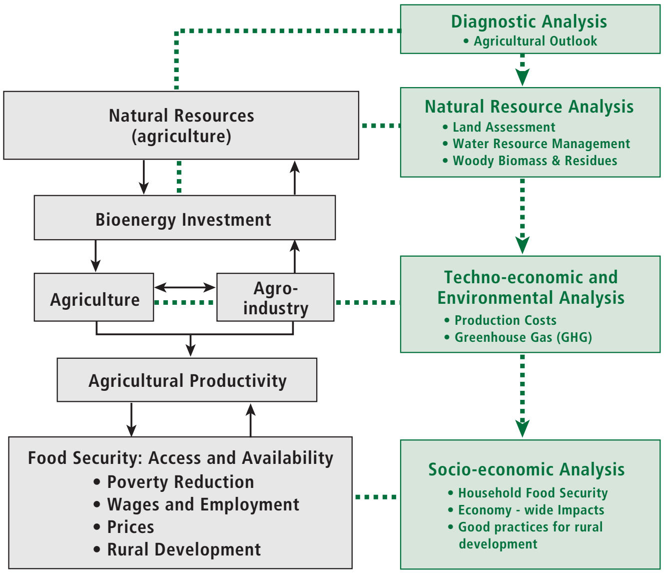
BEFS examines how bioenergy development may affect food security through two key instruments:

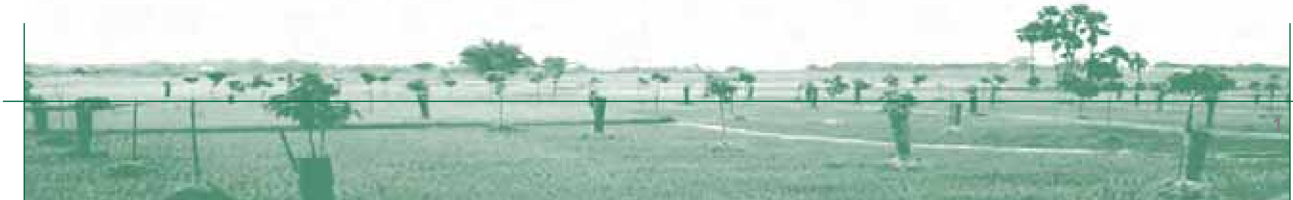
1. The BEFS Analytical Framework (AF) which examines the relationship between food security and bioenergy;
2. The BEFS tool box which helps to improve understanding of the dynamics of the bioenergy and food security interface through quantitative analysis.

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

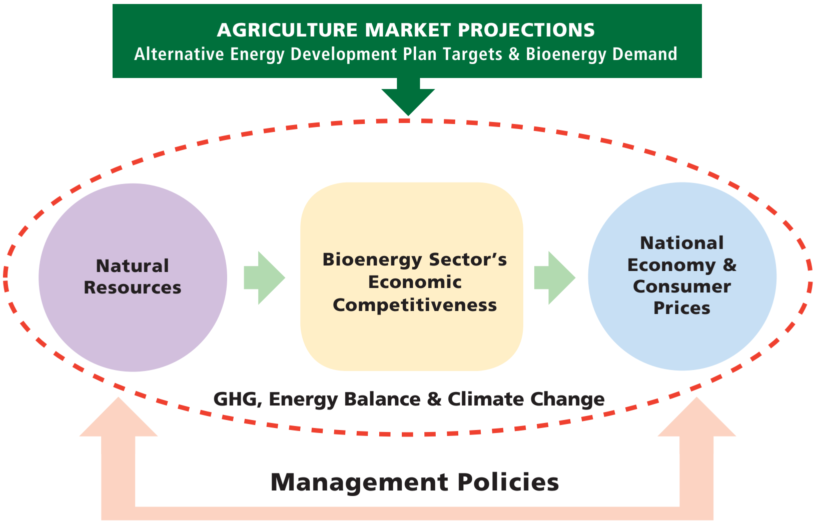
The BEFS project in Thailand is strongly focused on issues associated with development of the biofuels sector. While other forms of bioenergy were also considered by the BEFS Thailand research team, the findings presented in this report pertain largely to biofuels produced from key feedstocks (sugar 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

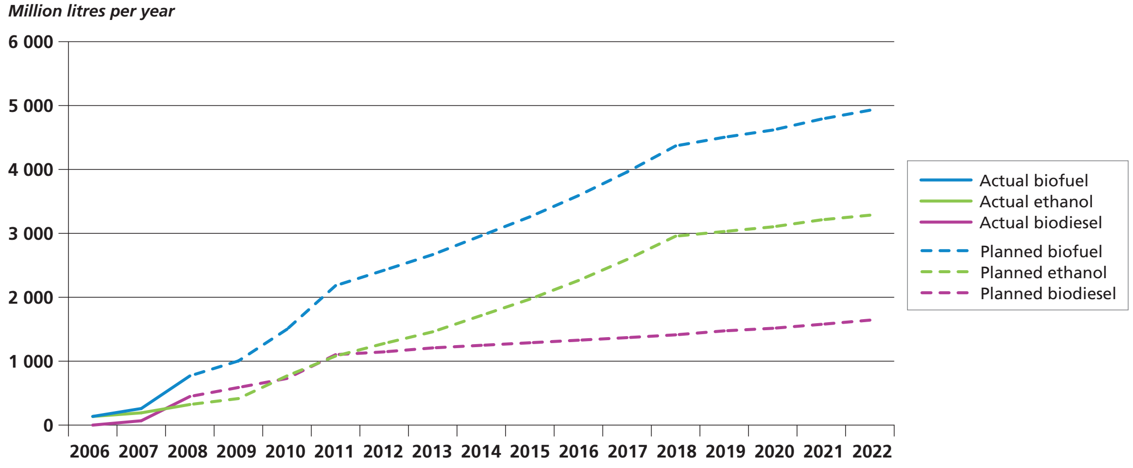
- Thailand already has a developing biofuels sector.
- Thailand has established an ambitious plan for the further development of the biofuel sector.
- The Thai Government wants to encourage the use of biofuels and other alternative energy sources to strengthen energy security, foster rural development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

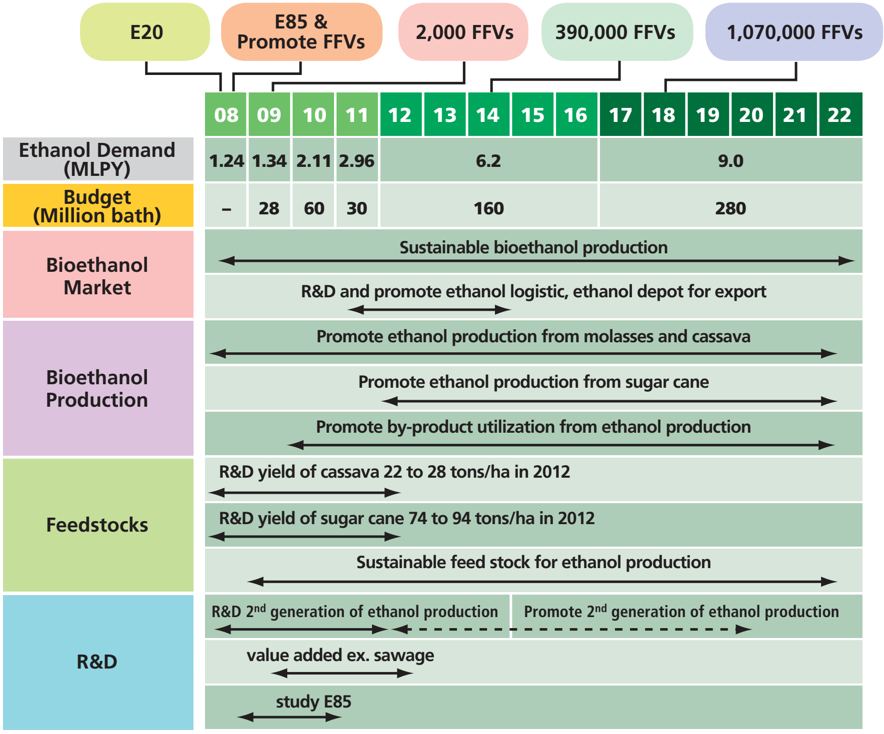
2.1.2 AEDP measures for biofuels

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



	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22
Ethanol Demand (MLPY)	1.24	1.34	2.11	2.96	6.2					9.0					
Budget (Million bath)	–	28	60	30	160					280					

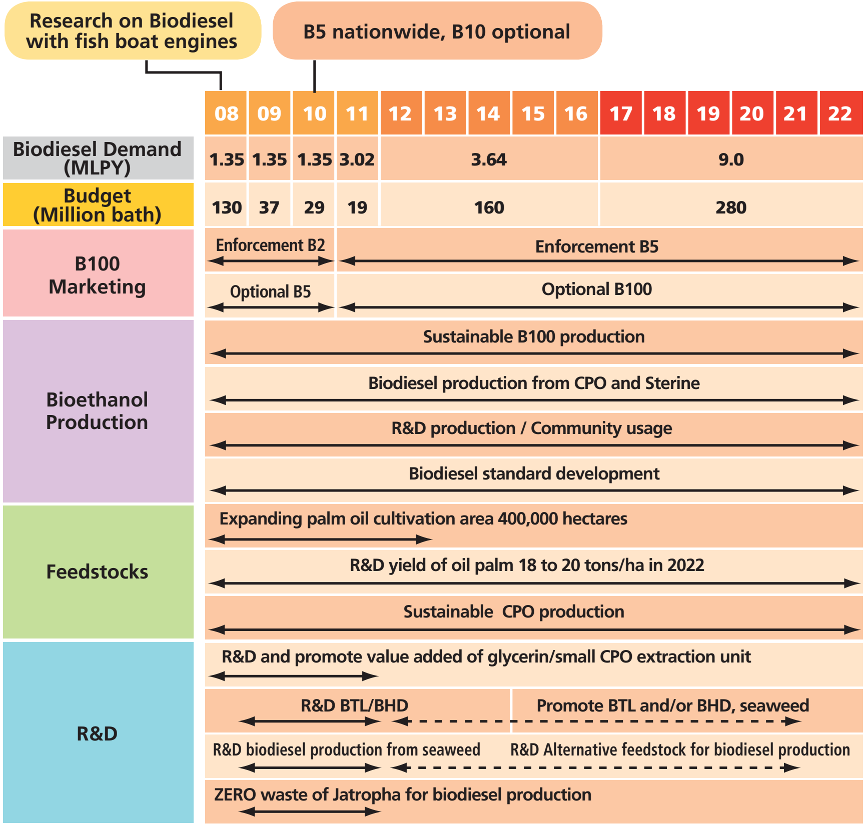
Source: MoE.

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.

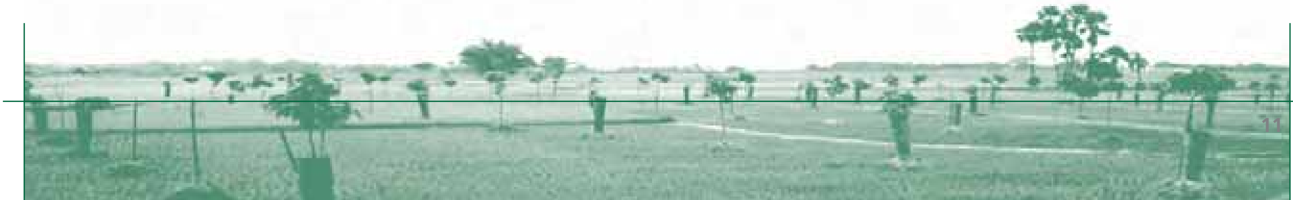
TABLE 3.1

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

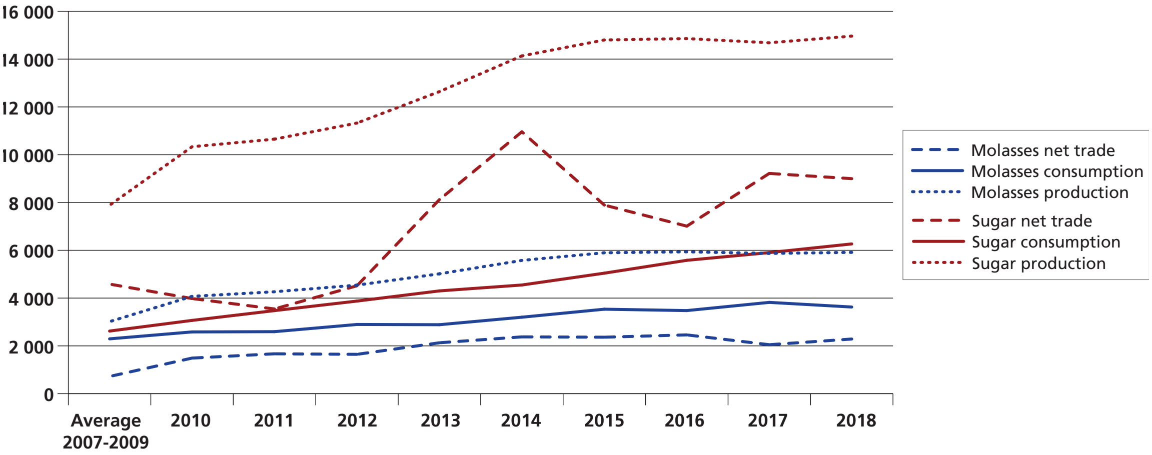
The key agricultural products that will be the focus of the analysis presented in this chapter are sugar, molasses, cassava, palm oil and rice.

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

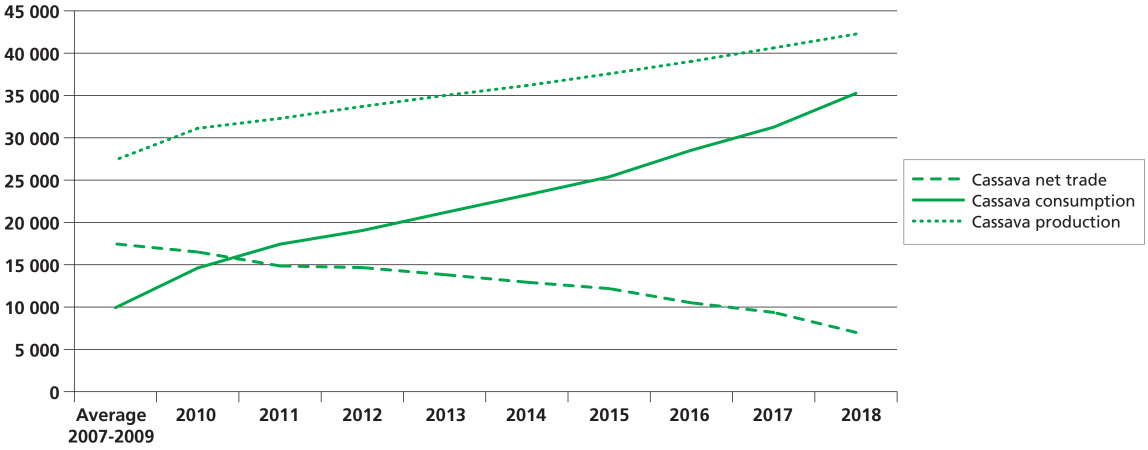


3.3.2 Cassava

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.

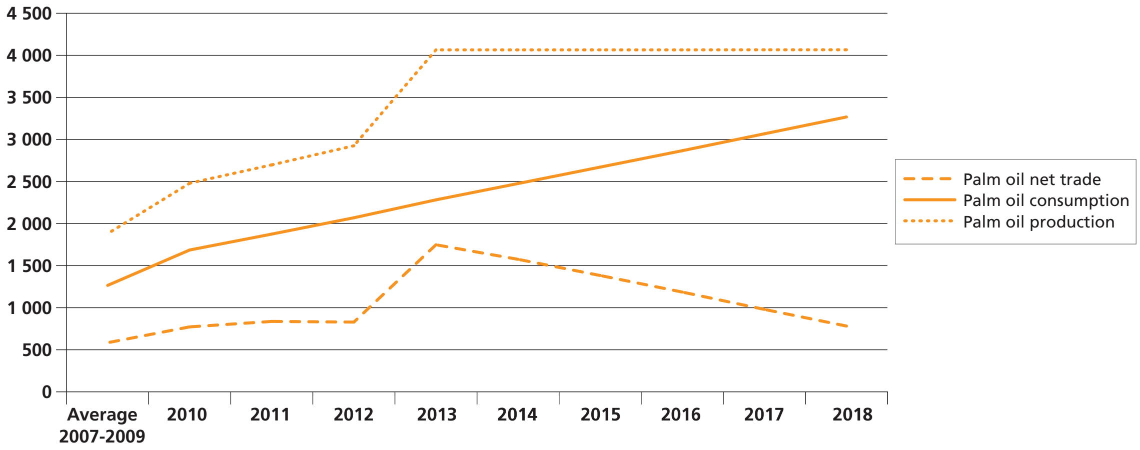
3.3.3 Palm Oil

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

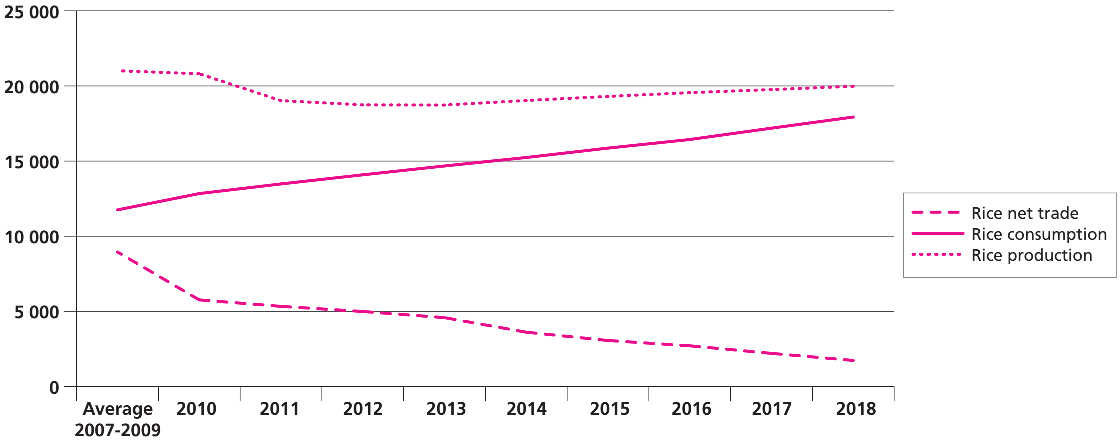


3.3.4 Rice

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

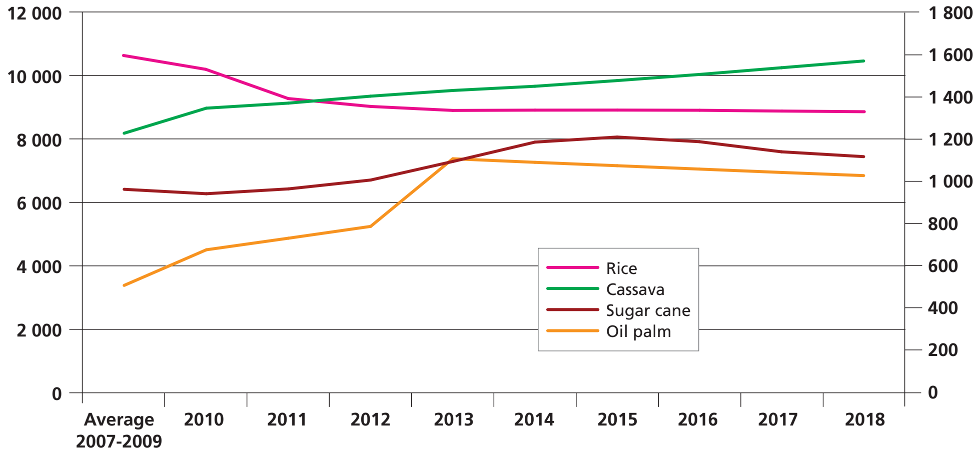
Projected production, consumption and net trade of rice



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.

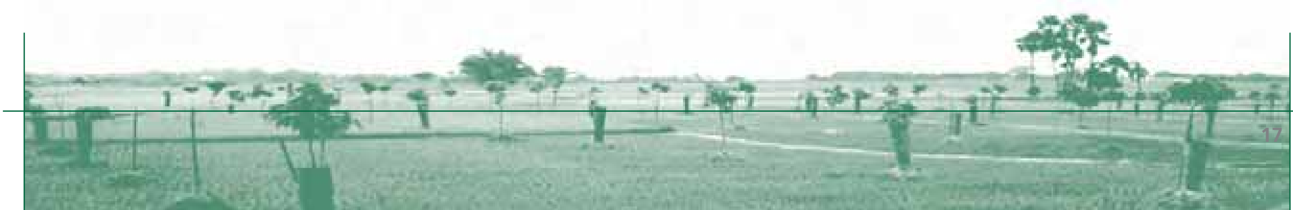
The suitability of a given portion of land is expressed as a percentage of the maximum attainable yield for each crop. In this chapter the results are presented in terms of a suitability index which consists of four classes. These classes are defined in Table 4.1.

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.

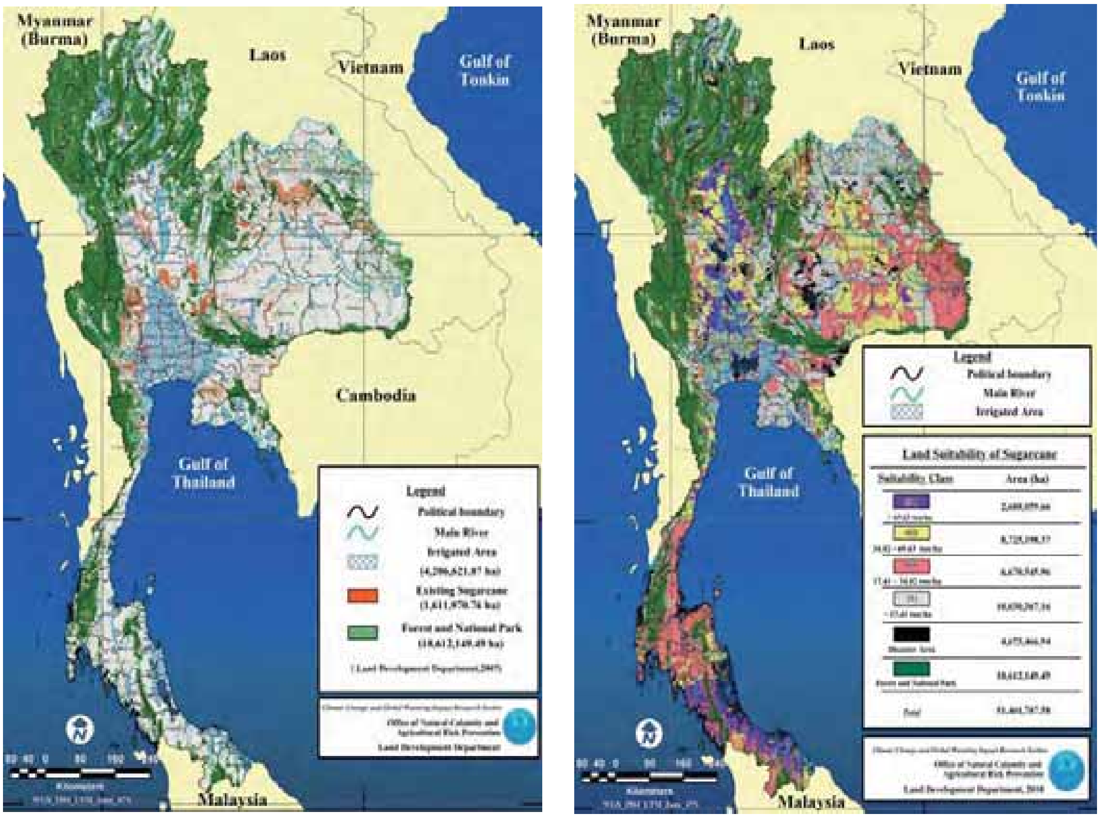
4.2 SUGAR CANE

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.

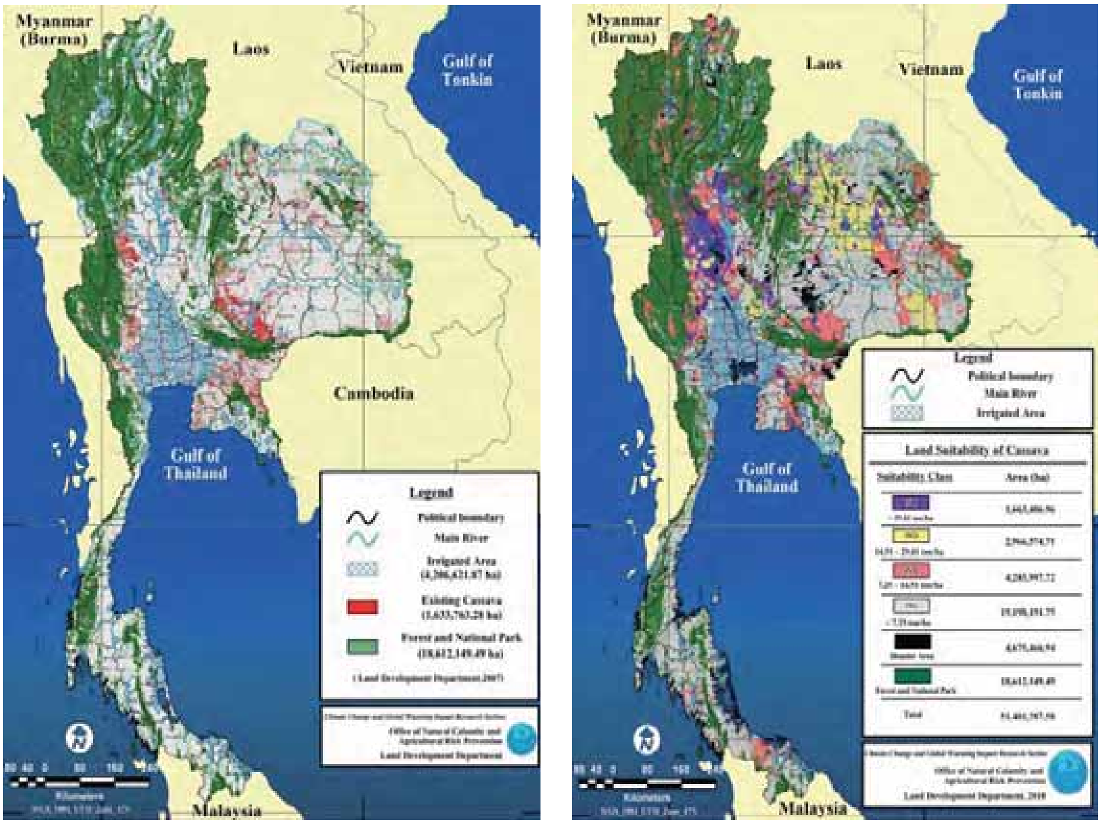
As noted in Chapter 3, the Thai Government anticipates a large increase in the production of cassava to meet the AEDP ethanol targets. At present it is expected that the growth in output will be met by increasing the average yield of cassava from 23 to 28 tons/ha. No significant expansion of cassava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

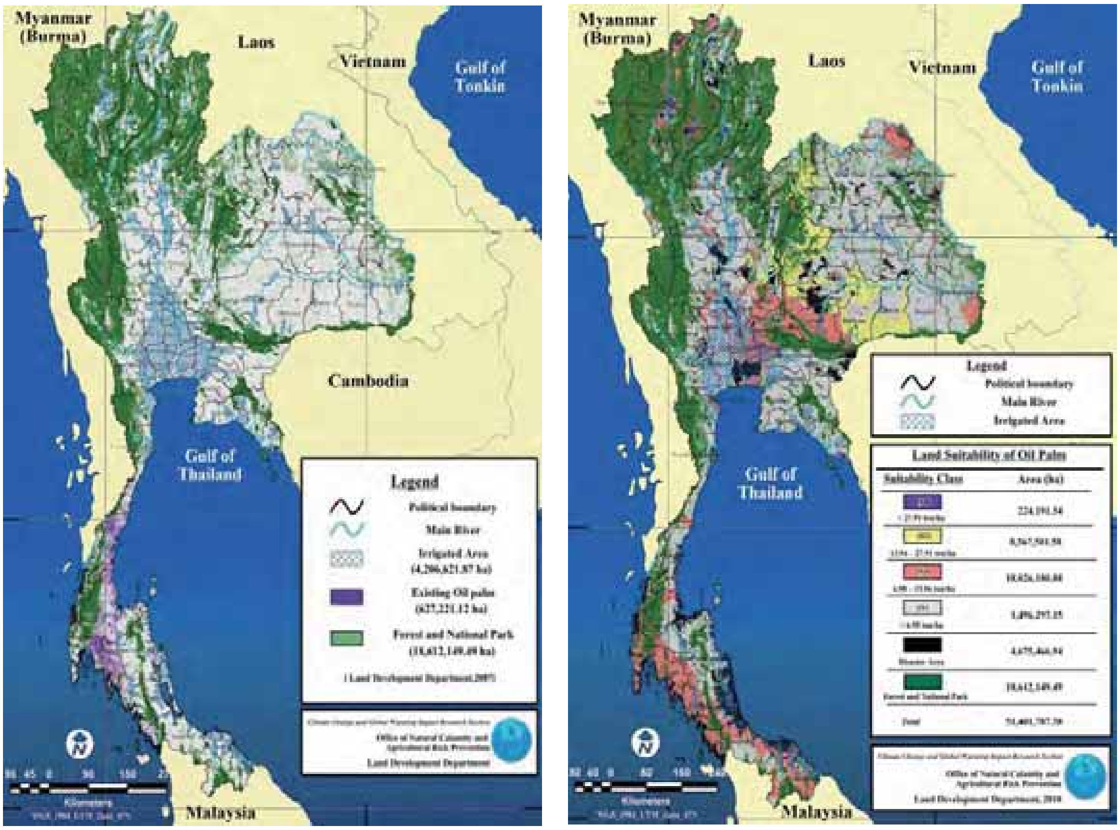
4.4 OIL PALM

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).

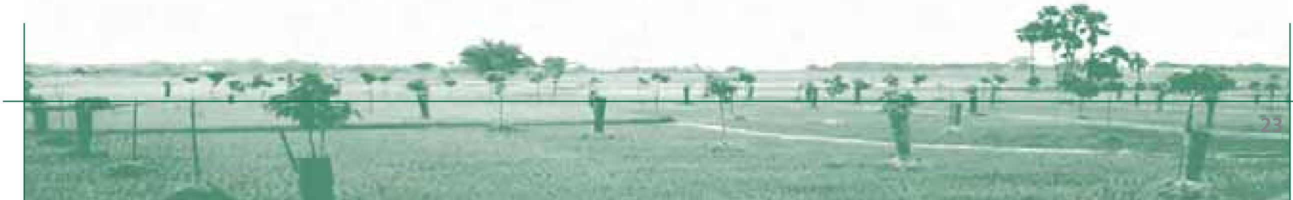
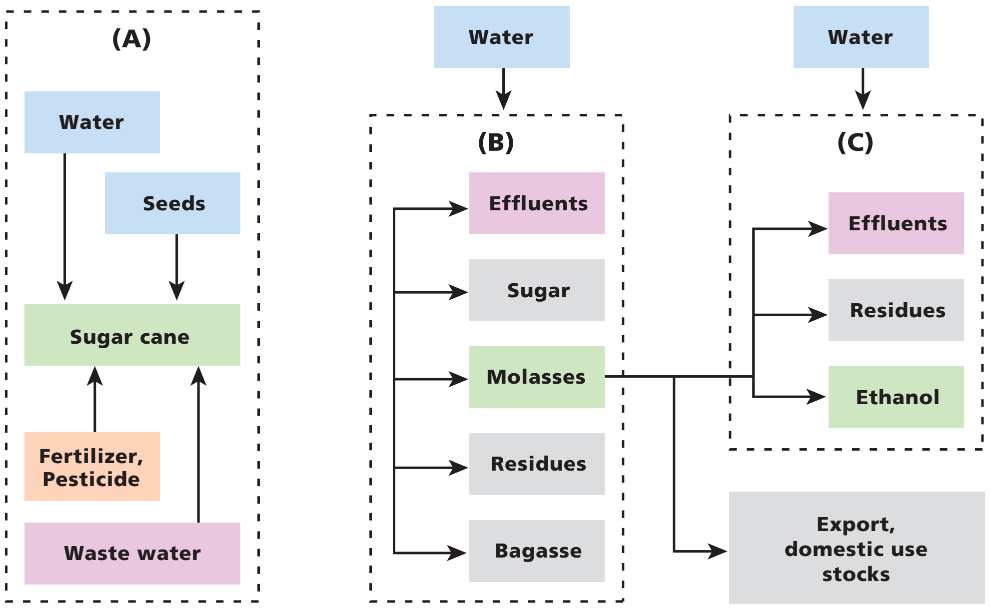


FIGURE 5.1

Process of sugar-based ethanol production



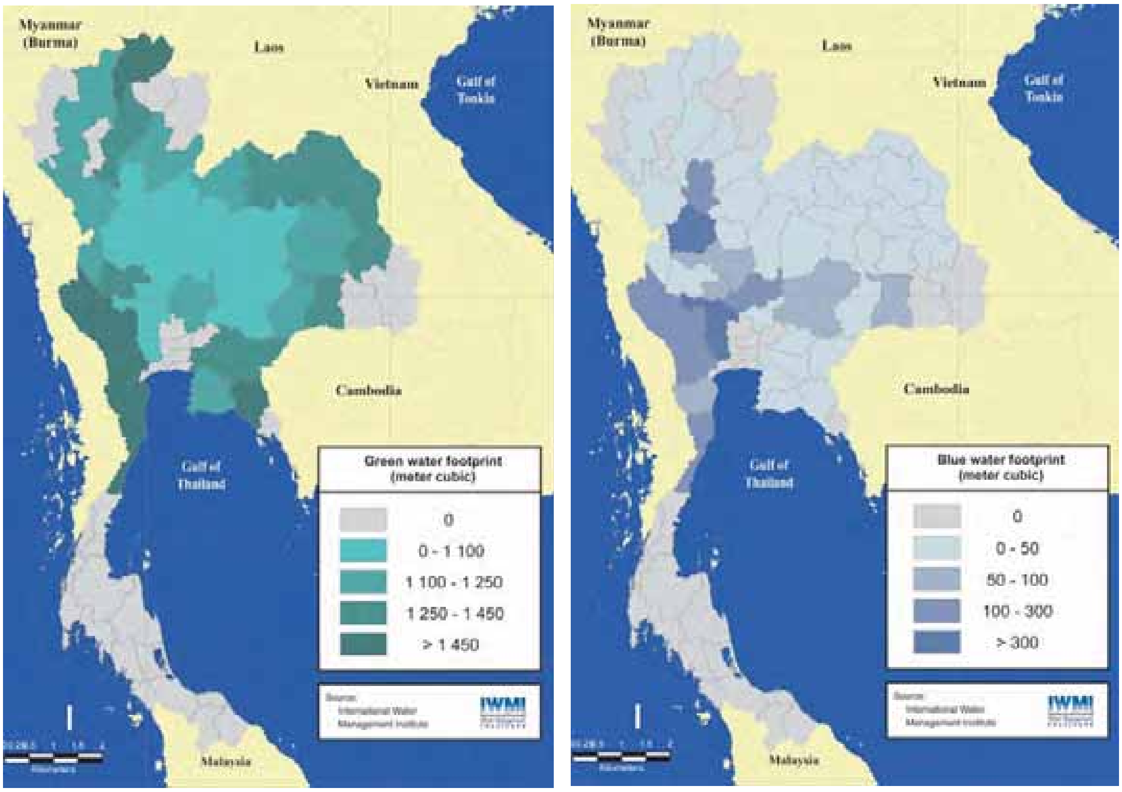
Notes: A – Sugar cane production; B – Sugar/molasses production; C – Ethanol production.

The total WF of sugar-based ethanol production is 1 646 m^3/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.

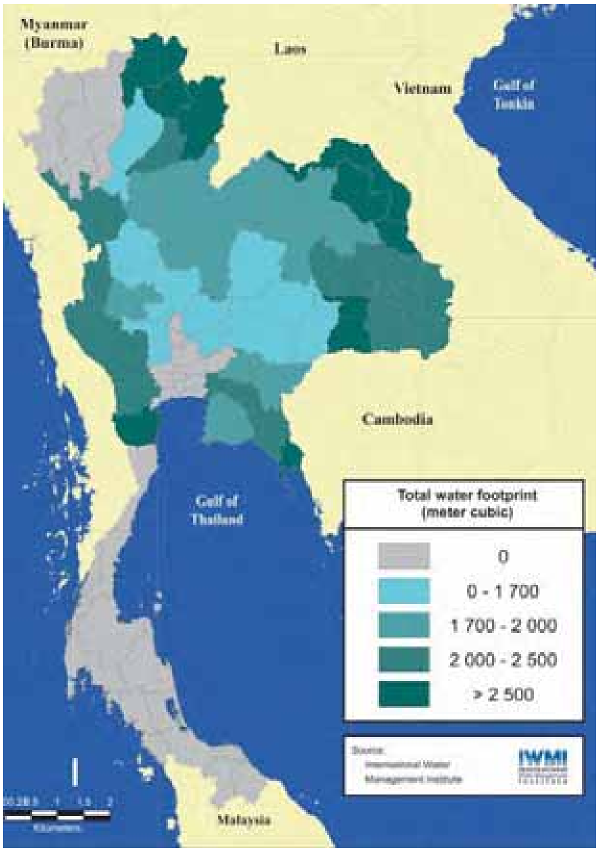
5.3 WATER FOOTPRINT OF CASSAVA-BASED ETHANOL

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

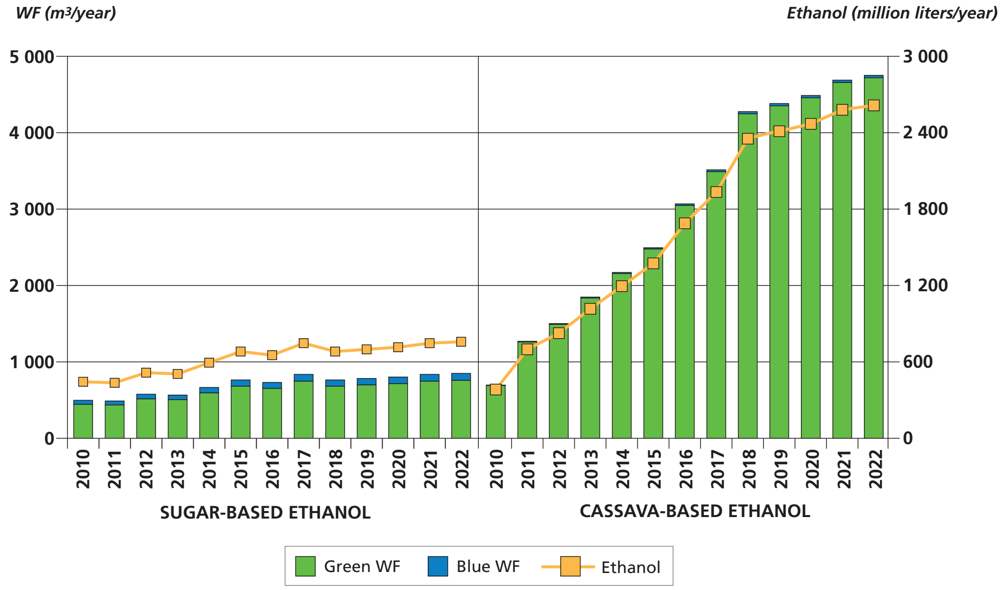
Thailand is estimated to have around 444 billion m^3 of total renewable water resources (TRWR). Increases in biofuel production in line with the AEDP targets will have some impact on these resources. As discussed in Chapter 2 and Chapter 3, cassava is expected to become the main biofuel crop for Thailand's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