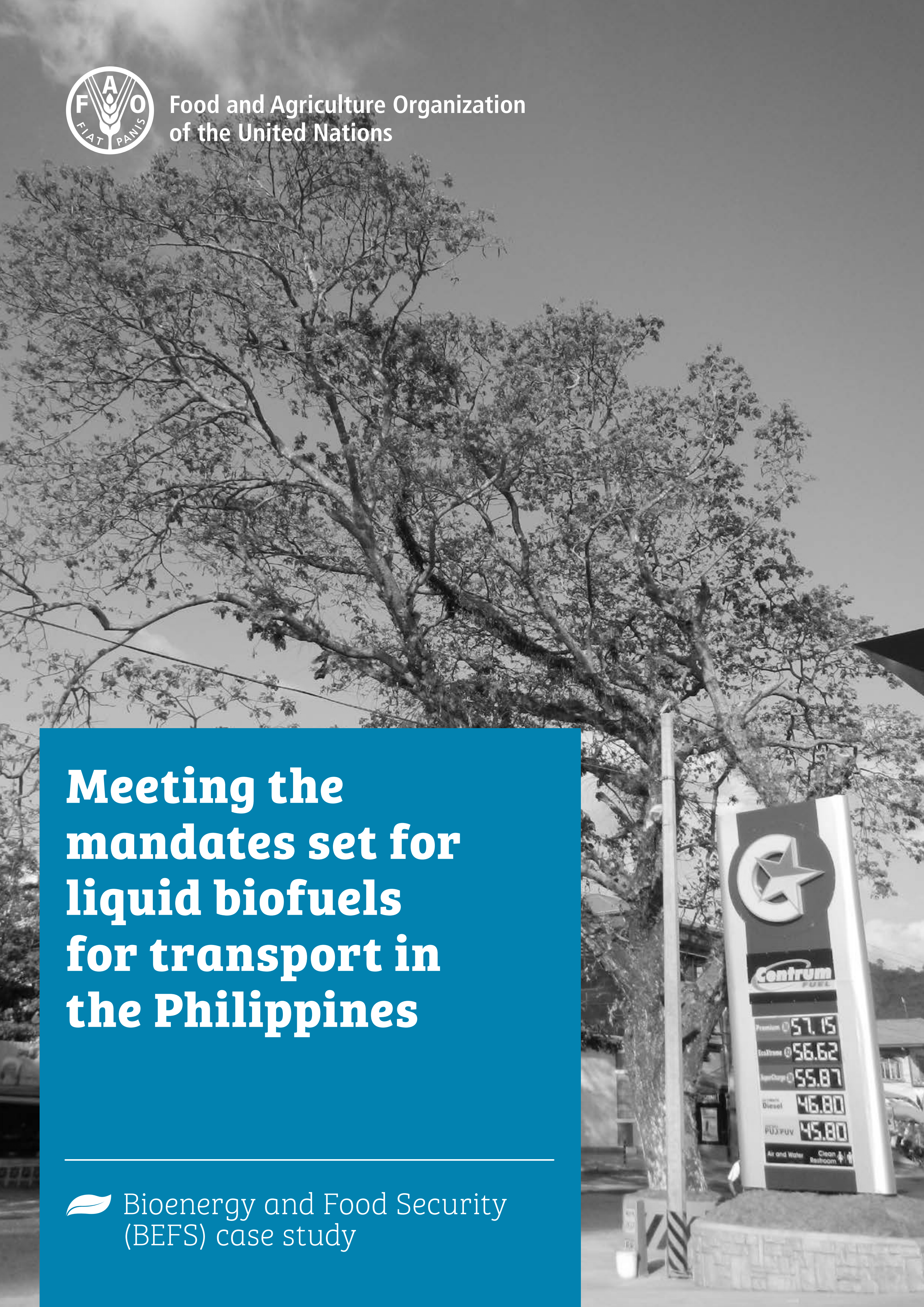
Food and Agriculture Organization
of the United Nations

Meeting the mandates set for liquid biofuels for transport in the Philippines

Bioenergy and Food Security (BEFS) case study



Purpose of the BEFS Case studies

The overall objective of these case studies is to present a range of bioenergy supply chains and look at how to assess the potential within the chains based on the BEFS Approach and BEFS RA tools. The case studies have been developed for training purposes, to illustrate the BEFS approach and tools and how they are applied. They present examples of bioenergy supply chains found in countries where BEFS has supported national stakeholders.

Acknowledgements

The Bioenergy and Food Security (BEFS) case studies were written by members of the BEFS Team; Luis Rincon, Ana Kojakovic, Sergio Rivero and Manas Puri, led by Irini Maltsoglou with inputs from Federica Chiozza and Vicki Romo. The graphical layout was done by Juan Luis Salazar and Christabel Clark provided editorial support. The BEFS team would also like to thank the national experts and institutions that provided input and reviewed the material used. The case studies were developed under the overall leadership of Alex Jones, Director of FAO's Climate and Environment Division (CBC), and Olivier Dubois, CBC's Energy team leader.

Our sincere appreciation goes to those working on the project activities that became the field and background work for the case studies, more specifically our thanks goes to the German Federal Ministry of Food and Agriculture, the national stakeholders in Côte d'Ivoire, Malawi, the Philippines and Turkey, the European Bank for Reconstruction and Development, and the local FAO offices in the countries.

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Coconut tree orchard

Case study focus

Approximately three-fifths of energy in the Philippines comes from fossil fuels, followed by biofuels and waste and geothermal energy, and most of the fossil fuels are imported. The transport sector is the main consumer of fossil fuels in the form of gasoline and diesel. Given this, the Government of the Philippines established the Biofuels Act which sets out targets to produce ethanol and biodiesel to be blended with fossil fuels. This case study presents the biofuel targets, an assessment of selected bioenergy value chains and an overview of what would be required to meet the targets set by the policy. The bioenergy value chains assessed are sugarcane and molasses for ethanol production and coconut to produce biodiesel.

Key elements of the bioenergy supply chain

Feedstock	Technology	Energy end use option	BEFS RA Tools
crops	ethanol from crops and molasses, biodiesel from crops	ethanol and biodiesel for transport	crops tool, transport tool, molasses tool

The case study's bioenergy supply chain

Sugarcane sales

© Thamizhpparithi Maari

Coconuts

© Koshy Koshy

Autogas refueling station

© Robert Brook

Ethanol

Biodiesel

?

2016	2019	2030
E5	E10	E20

Muntinlupa City

© Patrick Roque

2016	2019	2030
B2	B5	B20

?

Glossary

Biodiesel	Biodiesel is called the mixture of esters obtained from the transesterification of triglycerides contained in oleo chemical feedstock such as vegetable oils, tallow and greases. Biodiesel can be used as substitute of diesel fuel.
Bioenergy	Bioenergy is the energy generated from the conversion of solid, liquid and gaseous products derived from biomass.
Biogas	Biogas is a mixture of gases, mainly composed by methane (50-60 percent) obtained from the anaerobic digestion of biomass. In general, most of the organic wastes can be digested (excepting lignin). Among the most common biogas substrates can be counter livestock residues, municipal solid wastes (MSW), water treatment plants sludges.
Biomass	Biomass is any organic matter, i.e. biological material, available on a renewable basis. Includes feedstock derived from animals or plants, such as wood and agricultural crops, and organic waste from municipal and industrial sources.
Biomass assessment	Biomass assessment analysis the production, availability and accessibility of biomass feedstock for energy production. The assessment considers all uses of the potential feedstock, such as their use in maintaining soil fertility, or as feed for livestock before calculating the amount of biomass available for bioenergy production. This is essential to avoid any adverse impact that bioenergy production may have on agricultural sustainability. The result of the assessment is the identification of the main types of biomass feedstock available for bioenergy production as well as their geographical distribution within a specific region or country.
Briquettes and pellets	Solid biofuel obtained by compressing biomass in order to increase density. The primary difference between briquettes and pellets is shape and size. Briquettes are generally bigger than pellets.
Charcoal	A porous black solid obtained from biomass. It is an amorphous form of carbon obtained by the thermal decomposition of wood or other organic matter in the absence of air.
CHP	CHP stands for the cogeneration of heat and power. It is an efficient method for the simultaneous generation of at least two energy forms, including heat, power, and/or cooling.
Combustion	Combustion is the most common way of converting solid biomass fuel to energy. Around 90% of the energy generated from biomass is obtained through combustion, which is traditionally used for heating and cooking. Moreover, biomass combustion technologies are actively used for electricity generation at rural and industrial scales by means of steam.
Crop residues	Plant material remaining after harvesting, including leaves, stalks, roots etc.
Ethanol	Ethanol is a short chain alcohol, which can be directly used as fuel or blended with gasoline. It can be produced through the fermentation of glucose derived from sugar-bearing plants (e.g. sugar-cane), starchy materials after hydrolysis or lignocellulosic materials (e.g. crop residues, Miscanthus) after pretreatment and hydrolysis.
Forest harvesting residues	Forest harvesting residues are parts of felled trees which are not removed from the forest. The rate of removal varies among forests and usually depends on the end product that will be made and the cost-effectiveness of removing the tree. In the case of industrial roundwood, upper logs, branches and different cut-offs are often left in the forest, while stems are removed. Sometimes, stems are debarked in the forest.
Gasification	Gasification is thermochemical process where biomass is transformed into a gas called syngas. This gas is a mixture mostly composed by hydrogen, methane, and nitrogen. Depending on processing technology, conditions and gasifying agent (i.e. air, oxygen or water). The syngas has different composition and as result different fuel qualities.

Livestock residues	Residues originating from livestock keeping. It mainly includes solid excreta of animals.
Roundwood	Wood in the rough. Wood in its natural state as felled, or otherwise harvested, with or without bark, round, split, roughly squared or other forms (e.g. roots, stumps, burls, etc.). It comprises all wood obtained from removals, i.e. the quantities removed from forests and from trees outside the forest, including wood recovered from natural, felling and logging losses during the period - calendar year or forest year.
Sawnwood	Sawnwood, unplanned, planed, grooved, tongued, etc., sawn lengthwise, or produced by a profile-chipping process (e.g. planks, beams, joists, boards, rafters, scantlings, laths, boxboards, "lumber", sleepers, etc.) and planed wood which may also be finger jointed, tongued or grooved, chamfered, rabbeted, V-jointed, beaded, etc. Wood flooring is excluded.
Techno-economic assessment	In the bioenergy context, Techno-economic (TE) assessment facilitates a data-driven decision making about the performance of a bioenergy value chain, in a given context. This methodology is based on understanding the technical (e.g., technology feasibility, biomass supplying) and economic (e.g., production costs, profitability, capital investments) features of these value chains. Depending on the context and objectives, TE assessments can be extended to include socio-economic and environmental aspects.
Wood processing residues	These residues include sawdust, slabs and chips generated as residues during the wood processing. The amount of residues generated in a sawmill depends on the type of technology used and its efficiency. Often, these residues are not fully utilized due to the lack of demand in the immediate vicinity of the processing plant.
Woodfuel	Woodfuels arise from multiple sources including forests, other wooded land and trees outside forests, co-products from wood processing, post-consumer recovered wood and processed wood-based fuels.

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Introduction

Approximately three-fifths of energy in the Philippines comes from fossil fuels, followed by biofuels and waste and geothermal energy. Most of the fossil fuels are imported and the transport sector is the main consumer of these fuels in the form of gasoline and diesel (IEA, 2017). Given the country's rising population, energy consumption levels are expected to continue increasing.

The Philippines developed the Philippines Biofuels Act (RA 9367) in 2007 to promote the use of liquid biofuels in the transport sector by mandating the progressive increase in the blending of biodiesel into diesel and ethanol into gasoline. The Philippine Energy Policy 2016 – 2030 has updated the original targets for the blending mandate. New targets foresee an increase from current levels of 2 percent for biodiesel (B2) and 5 percent for ethanol (E5) to reach a B5 and E10 level respectively by 2019, and a B20 and E20 level by 2030. The aim of the policy is to curtail and potentially displace some fossil fuel imports (Corpuz, 2015a; Department of Trade and Industry and Board of Investments, 2017; Platts, 2016).

BOX

Bioenergy and food security (BEFS) approach

The Bioenergy and Food Security (BEFS) Approach has been developed by FAO to support countries to develop evidence based sustainable bioenergy policies. The approach supports countries in understanding the linkages between food security, agriculture and energy, and building sustainable bioenergy policies and strategies that foster both food and energy security and contribute to agricultural and rural development. A core element of the BEFS Approach is the BEFS sustainable bioenergy assessment component. The assessment covers the whole bioenergy pathway starting from feedstock availability assessment to analysis of energy end use options. The first step in the assessment component is the BEFS Rapid Appraisal (BEFS RA). The BEFS RA consists of a set of excel based tools which provide an initial indication of the sustainable bioenergy potential and of the associated trade-offs. The BEFS RA is divided into three major components: Country Status, Biomass Assessment (Natural Resources) and Energy End Use Options (Techno-economic Analysis). Each major component has one or more excel based tools linked to it.

The steps of the BEFS RA analysis:

Step 1: Country Status
This step collects information on the country status and defines the context, needs and constraints in the key sectors such as agriculture, food security, energy and the environment.

Step 2: Natural Resources: Biomass Potential Assessment
The biomass assessment estimates feedstock availability, considering competing uses and needs. The output is an initial indication of the quantities of feedstock available from crop and livestock residues, forest harvesting and wood processing residues, as well as the potential availability of crops for energy production. Profitability of different crops is also taken into consideration.

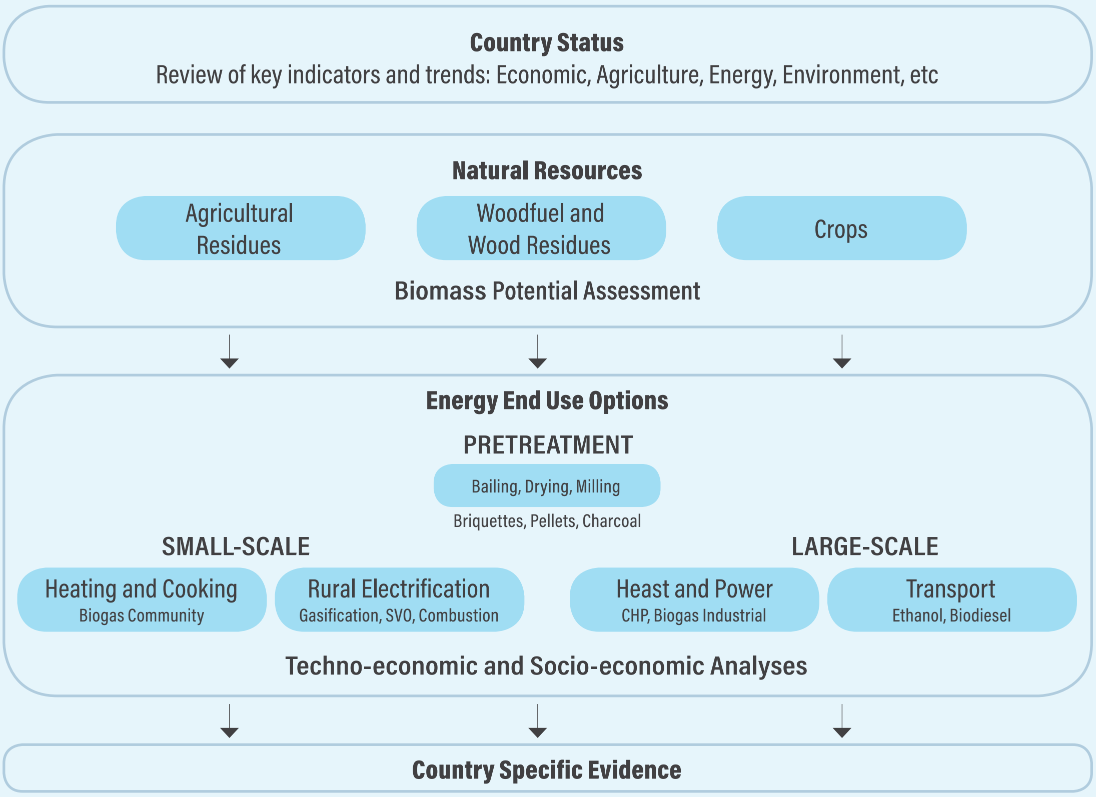
Step 3: Energy End Use Options: Techno-economic Analysis
The energy end use options module evaluates the following bioenergy options:

- ► Intermediate or final products: briquettes, pellets and charcoal;
- ► Heating and cooking: biogas community;
- ► Rural electrification: gasification, straight vegetable oil (SVO) and combustion;
- ► Heat and power: combined heat and power (CHP) and industrial biogas; and
- ► Transport: ethanol (1st Generation, 2nd Generation and Molasses) and biodiesel.

The Biofuels Act mentions the potential crops that could be used as feedstock to produce biofuels. Sugarcane and molasses are used in the Philippines for ethanol production, while coconut oil is the preferred feedstock for biodiesel. The Biofuels Act gives priority to locally produced ethanol over imports, as the mandated blend has historically been met largely through imports. Biodiesel imports are not allowed under the Biofuels Act. In 2016 there were ten ethanol plants operating in the country with a combined annual production capacity of 282 million litres. Additionally, 11 biodiesel refineries with a capacity of 225 million litre were operational (USDA, 2017).

In this case study, the Bioenergy and Food Security Rapid Appraisal (BEFS RA) tools are used to provide a preliminary indication of the sustainable bioenergy potential to produce ethanol from sugarcane and molasses, and biodiesel from coconut oil. The results determine the extent to which these biofuels can fulfil the future blending mandate. An overview of total feedstock requirements is also provided.

Each tool can be used individually but the approach advocates that output from each stage should be used as input into the following steps of the analysis. The tools are excel based and globally applicable. They can be used with limited user defined data and default values are provided. The analysis can be carried out at country or local level and tailored to address the specific needs of countries. In fact, countries can decide to assess a wide spectrum of bioenergy supply chains or, for example, to keep the analysis specific to crop residues for cooking or livestock residues for biogas generation. example.



The context: agriculture, energy and policy in the Philippines

The Philippines is an archipelago in Southeast Asia consisting of more than 7 000 Islands with a total area of 298 170 square kilometres. It has a tropical climate with an average annual rainfall of 2 348 mm. The population in 2016 was 100.7 million and grew at an average annual rate of 1.63 percent between 2010-2015. Although many people have migrated to urban areas, the share of the rural population was about 55.7 percent in 2016 and this percentage has risen steadily since the 1990s. This is due to the annual population increase in rural areas which averaged at about 1.7 percent. In urban areas, the population increased by about 1.4 percent in 2016. The World Development Index data shows that the percentage of people living below the national poverty line decreased from just above 25 percent in 2012 to 21.6 percent in 2015. However in 2015, 13.8 percent of the population was undernourished with a fifth of the country's population living in poverty and given current undernourishment rates, food security remains a national concern (World Bank, 2018).

The Philippines has a total of 119 500 square kilometres of agricultural land which makes up 41.7 percent of the total land area. Just under one fifth (18.8 percent) of this is classified as arable land.

The agriculture sector plays an important role in the Philippine economy: it accounted for 9.6 percent of the gross domestic product and employed about 27 percent of the total labour force in 2015 (Philippine Statistics Authority, 2015).

The main crops produced include rice, corn, coconut, sugarcane, bananas and other tropical fruits (Philippine Statistics Authority, 2017a).

The principal farming systems are traditional smallholder and large-scale production, with the latter producing mainly for the export market. The smallholders produce mainly under rain-fed conditions, while large-scale producers rely on irrigation and modern inputs (Philippine Statistics Authority, 2017b).

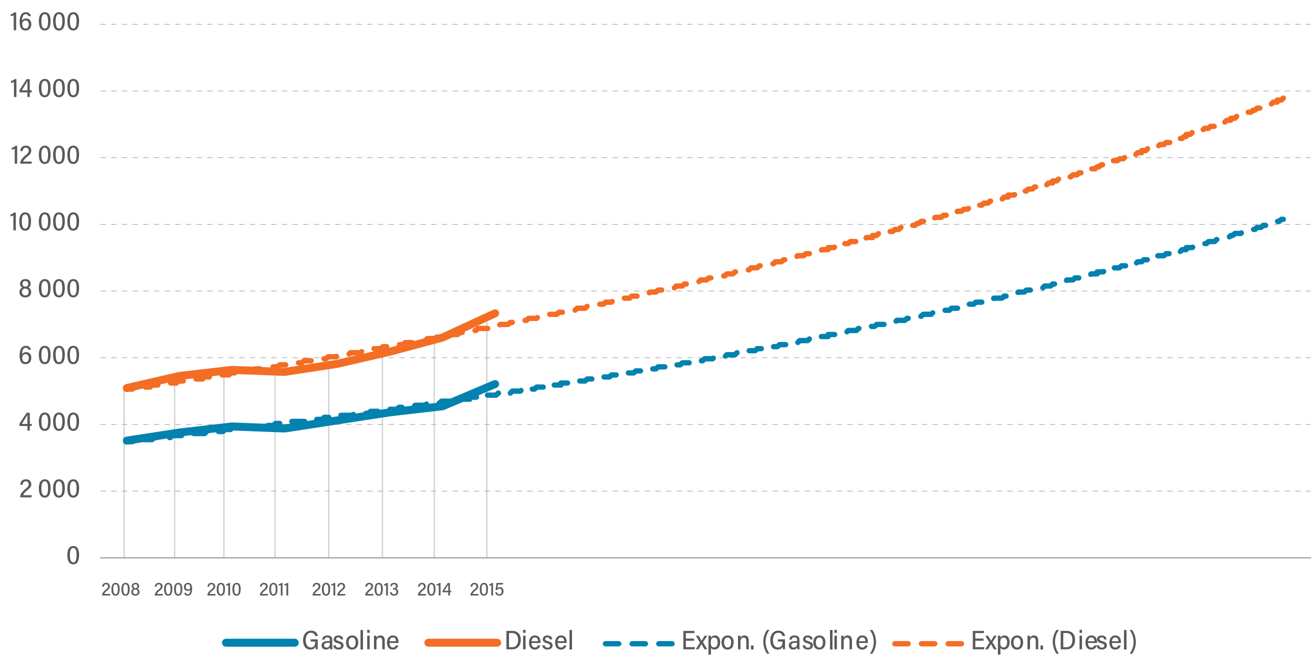
The country's agriculture sector is at extremely high risk of natural disasters (especially the smallholder systems), and this puts stress on capital stock, food security and social development. Moreover, rapid economic growth, a growing population, urbanization and increasing agricultural production have also put pressure on natural resources (OECD, 2017).

The Philippines is a net energy importer and is heavily dependent on crude oil, oil products and coal, which make up around 58 percent of final energy consumption. The country has limited domestic fossil fuel production and thus relies on imports. Biomass is also an important contributor of total energy consumption, accounting for about 17 percent of its energy consumption. Renewables, especially geothermal and hydropower, play a significant role and contributed to about a quarter of electricity generation in 2015. The majority of the population (90 percent) had access to electricity in 2014, in rural areas 83 percent of the population had access to electricity (International Energy Agency, 2017; The World Bank, 2017).

The transport sector is the largest fossil fuel consumer and, with the country's rising population, consumption levels are expected to rise further. The estimated annual demand for diesel and gasoline in 2030 increases all the way to 13 790 and 10 151 million litres, respectively.

Philippines - Key statistics (2015)					
100.7 million population	1 in 5 living below national poverty line	13.5% undernourished	9.65% agriculture sector's share in GDP	27% emloyed in agriculture sector	E10 and B2 ethanol and biodiesel mandates

FIGURE 1. Projected consumption of fossil fuels in the transport sector in the Philippines



Source: *Own projections based on statistical regression with data (up to 2015) from the Philippines Energy Statistics (Department of energy of Philippines, 2018)*

Considering the estimated future demand for diesel and gasoline, imposing B20 and E20 mandates in 2030 would require an annual production of 2 758 million litres of biodiesel and 2 030 million litres of ethanol.[1]

What is the current state of biofuels in the Philippines?

Coconut methyl ester (CME) is derived from coconut oil, which is the primary feedstock used for domestic biodiesel production, while ethanol is currently derived from sugarcane and molasses. As of 2015, the ethanol blending mandate had to be met through imports, due to insufficient domestic production. The B2 biodiesel mandate, on the other hand, has been easily met by local production, as biodiesel imports are not allowed. However, due to concerns about the corrosive effect of CME on engines, complications with storage, handling and distribution along with apprehension regarding the economic impacts due to high domestic prices, a possibility of increasing the biodiesel blending mandate to only B5 is being considered (Corpuz, 2015a; Department of Trade and Industry and Board of Investments, 2017).

In 2007, the Philippines became the first Southeast Asian country to develop a biofuels legislation through the Biofuels Act. This policy set out to promote the use of liquid biofuels in the transport sector, with mandates for both ethanol and biodiesel. The Biofuels Act or Republic Act (RA) 9367 in section five, mandates the use of locally-sourced biofuel and the exhaustion of its supply before importing. Thus, the ethanol and biodiesel production have needed to rely on the already established sugar and coconut industries. Consequently, until now molasses and sugarcane have been the preferred feedstock in ethanol production, while coconut oil (CNO), where coconut methyl ester (CME) is derived, is the preferred biodiesel feedstock (Corpuz, 2015a)(Congress of the Philippines, 2006).

The government also encourages the development, utilisation and commercialization of renewable energy resources for other purposes via the Renewable Energy Law of 2008 (Congress of the Philippines, 2008; Corpuz, 2015a). The Renewable Energy Law aims to triple the 2010 installed power capacity from renewables by 2030 using a mix of sources including wind, solar, biomass, geothermal, hydro and ocean energy. This Law has also setup mechanisms to promote the use of renewable energy in the power sector such as the Feed in Tariff (FIT) and the Net Metering Mechanism. Other remaining policy mechanisms that still need to be implemented

[1] These values were calculated from the projected future demand for diesel and gasoline (based on the Philippine government's goal of mandating B20 and E20 blends by 2030 and the projected future demand for diesel and gasoline given current data in 2015 from the Philippine Energy Statistics).

include the Renewable Portfolio Standard (RPS) and the Green Energy Option which are expected to further boost the share of renewables in the country (DOE, 2016).

The Philippine Developing Plan 2017 – 2022 in line with the country's long-term Vision 2040, has set guidelines to enhance the social fabric, reduce inequality, and increase potential growth. To achieve these objectives the development plan considers energy as part of the foundation, enabling and supporting adequate economic environment to achieve sustainable development. The plan presents strategies to accelerate the development of infrastructure in both the transport and power sectors, to increase the country's self-sufficiency and reduce dependence on external energy sources. In relation to the agriculture sector, the plan has defined strategies aiming to spur growth and support commercialization. For this to happen, productivity in agriculture will need to be raised through collaboration between the science, technology and extension systems in agriculture (NEDA, 2017).

In the agriculture sector, the Philippines centres it's agricultural policy on food security and poverty alleviation, with an emphasis on securing a stable supply of affordable food. After the 2008 global food price crisis, the budgetary expenditure for agriculture increased in order to intensify rice production, the main staple food in the country, through the expansion of irrigation infrastructure and input subsidies (OECD, 2017).

Since 2011, the government has administered the Food Staples Sufficiency Program which focuses on food staples and highlights the importance of extension services and infrastructure in the agriculture sector. In addition to this program there are several agricultural policy instruments in place, including price support measures (mainly for rice and sugar), tariff protection, export controls (on rice, grains, sugar, molasses, etc.) and trade agreements (OECD, 2017).

Biomass assessment

Against the country context and biofuel policy backdrop, this study will now assess the production of biofuels from sugarcane and coconut. The approach taken in the assessment will be to look at options for intensifying the current production of both sugarcane and coconut. The analysis was carried out by utilising the BEFS RA Crop Production tool. This tool helps determine the amount of crop that could be used for bioenergy purposes, while minimizing disruptions to current productions and uses such as food supply[2] etc..

The tool builds upon the Agro-Ecological Zoning Methodology (FAO, 1996) and relies on the data from the Global Agro-Ecological Zones - GAEZ ver. 3.0 (FAO and IIASA, 2012) to estimate the maximum achievable yields of the assessed crops. This is carried out under defined agricultural production levels - namely low, intermediate and high input levels,[3] and under the prevailing agro-ecological conditions in the area assessed.

In this assessment, it was considered that the Philippine policy measures for agricultural production intensification could lead to advanced agricultural practices and increased average yields at national level within a period of 5 to 10 years.

Coconut

Coconut is considered to be one of the most important crops for the national economy. With the annual production averaging 15.1 million tonnes over the last decade (2007-2016), the Philippines is the world's second largest coconut producer after Indonesia (FAO, 2017), and the world's top coconut oil producer and exporter (Corpuz, 2015b). Sale of coconut oil makes up 15 percent of agricultural export earnings (in terms of value) (Philippine Statistics Authority, 2017b).

The climate, soil conditions and environmental conditions in the Philippines are all optimal for growing coconut trees (**Figure 2**). There are around 330 million bearing trees on 3.517 million ha across 68 out of 81 provinces. This means that coconut is produced on 26 percent of all agricultural land (Philippine Statistics Authority, 2017a).

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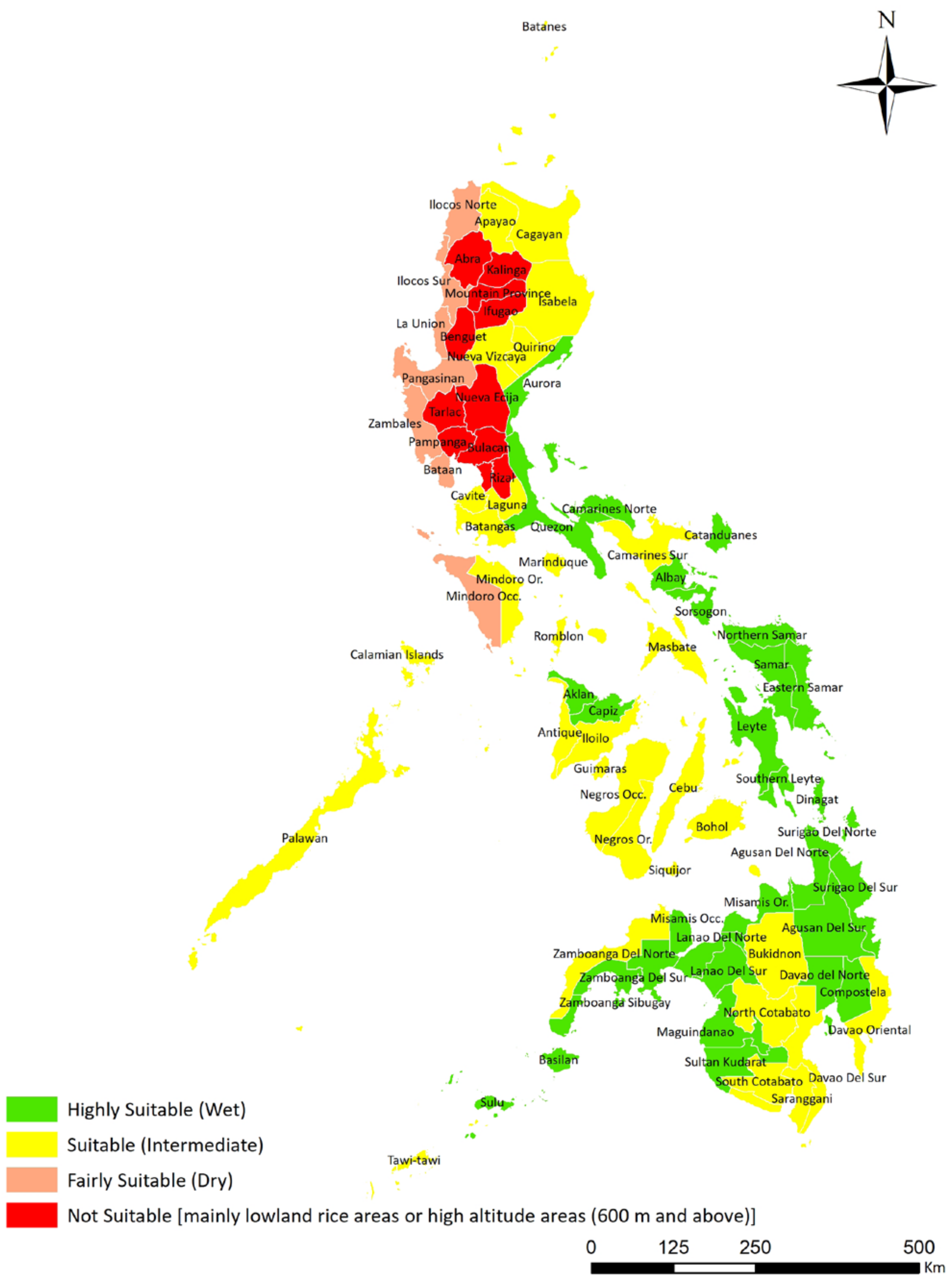
[2] For a full description of this, please refer to the BEFS RA crop tool manual (a full reference can be found in the reference list).

[3] **Low input**: mainly subsistence farming, based on the use of local cultivars and labour-intensive techniques. Agrochemicals and nutrients are not utilised. **Intermediate input**: partly subsistence and partly market-oriented farming, based on improved varieties, manual labour and some mechanisation. Labour is medium-intensive, and some agrochemicals and fertilisers are applied. **High input**: production is mainly market-oriented, it is based on improved or high yielding varieties and is fully mechanised with low labour intensity. Agrochemicals and fertiliser use is at optimum.

FIGURE 2. Coconut growing zones and production suitability of the crop



Source: *Philippine Coconut Authority, 2009*

Coconut tree farm

Coconut is mainly produced on small and medium-sized farms, often as a secondary crop or within intercropping or silviculture systems. According to the 2002 Census of Agriculture, 1.4 million farmers grew coconut on their land, which comprises around 29 percent of all farms. At the time, the average size of a farm was 2.4 ha (Arancon, Jr., 1997). Given the negative trend in average farm sizes from 1991 to 2012, it is likely that the average farm today is even smaller. According to the Agriculture Census, the average farm size shrank from 3.6 ha in 1991 to 2.4 ha in 2002 to 1.8 ha in 2012 (Philippine Statistics Authority, 2015). Coconut production is not only important as an export commodity, but is also an income generating crop for small-scale farmers.

Coconut oil has multiple uses: it is a highly-valued edible oil and in the Philippines it is also used in chemical and cosmetic commodities. To ensure food security, the government requires that the country continue to be self-sufficient in edible coconut oil, while still maintaining its current position in the international market.

With the advantageous agro-climatic and soil conditions, as well as the average coconut yields, it is evident that there is considerable room for increasing production outputs through improved agricultural practices and intensification. The average annual yields in the period 2007 to 2016 have decreased from 4.46 to 3.88 tonnes/ha (Philippine Statistics Authority, 2017a). With an average yield of 4.32 tonnes/ha for this period, the average annual production was 15 106 961 tonnes.

Aiming to improve agricultural practices and increase production, the Philippine Coconut Authority has been implementing a number of different programmes, including integrated soil fertility management, improved fertilization systems and technology, intercropping, and agricultural practices (Philippine Coconut Authority, 2017). Intensification could lead to a significant increase in the supply of coconut oil and, as a result, increased coconut residues which could partly be used as bioenergy feedstock. It is however important that feedstock destined for bioenergy use is not needed for other uses such as food, feed, materials, and contracted exports.

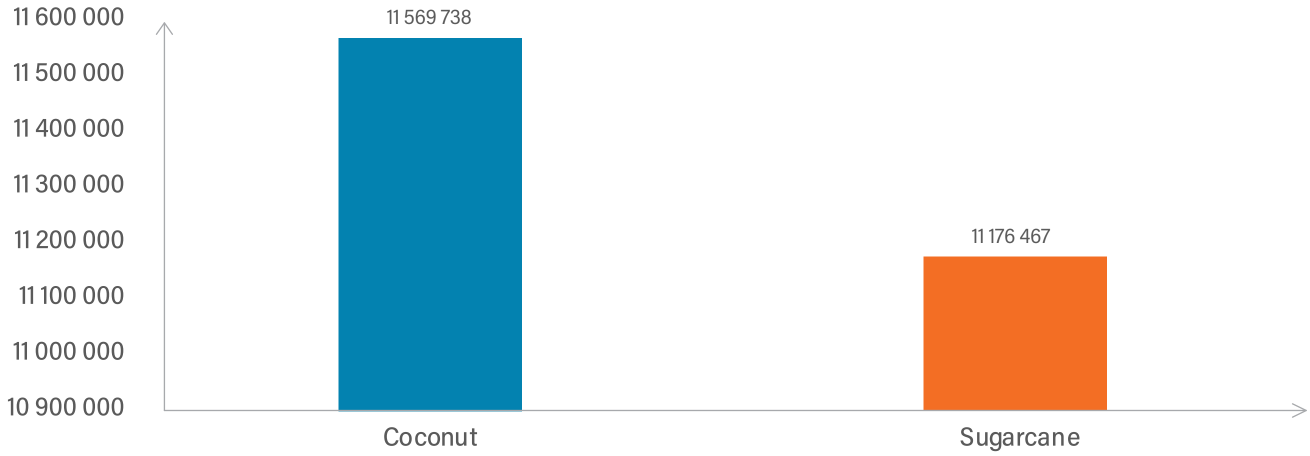
The BEFS RA crops production tool was utilised to estimate the amount of coconut that could be available for bioenergy purposes, under the assumptions that:

- Current production practices would change from low-level to intermediate-level input.
- Intensification measures will be implemented across the country over a 10-year period.

Based on the Global Agro-Ecological Zone - GAEZ ver. 3.0 (FAO and IIASA, 2012), the potential intensified yield (averaged across the country and soil types) is 8.37 tonnes/ha. This value represents the maximum achievable yield that can be reached across the country in rain-fed conditions under an intermediate input level, in terms of farming practices. Given this potential, as much as 29.3 million tonnes of coconut could possibly be produced annually without expanding the production area. If

17.7 of the 29.3 million tonnes/year is allocated for food and other non-bioenergy purposes, then the remaining 11.6 million tonnes could potentially be used annually for biodiesel production (**Figure 3**).

FIGURE 3. Crops potentially available for liquid biofuel under certain conditions (value of production in tonnes/year)



Source: *Results from BEFS RA crops tool*

Sugarcane

The Philippines is a major sugarcane producer - about 410 000 ha are planted with sugarcane and production reached 22.9 million tonnes in 2015 (Philippine Statistics Authority, 2017b). The sugar industry has always been a major contributor to the Philippine economy. The 2015 Sugar Regulatory Administration report states that in the 2013-2014 crop year, sugar sales contributed about USD 2 billion to the national economy.[4] As an industrial crop, sugarcane provides an important source of livelihood through farming, processing, and trading activities (Padilla-Fernandez and Nuthall, 2012). Although most of what is produced is consumed domestically, the country is a net exporter of sugar, accounting for 5.6 percent of the total value of exported agricultural commodities.

Traditionally, sugarcane is produced on small farms across the 19 Filipino provinces. Sugar is primarily produced in the Negros Island Region, as well as in Central Luzon, Western Visayas and in some parts of Mindanao. According to the data from 2009-2010, 89.5 percent of the 62 175 sugarcane farms were smaller than 10 ha. 8.7 percent are medium sized farms between 10 and 50 ha and only 1.8 percent are large scale farms with more than 50 ha (Sugar Regulatory Administration, 2015).

The national average yield of around 60 tonnes/ha is still one of the lowest among sugar-producing countries in Southeast Asia (Padilla-Fernandez and Nuthall, 2012). Thereby, there is strong disparity between large- and small-scale farmers in achieved yields. The yields in small-scale production are highly dependent on weather conditions, and production costs are relatively high. Furthermore, irrigation is also very limited, leaving most of the producers reliant on rainwater. Only around 10 percent of Luzon and Mindanao sugar crops are irrigated, with farms in Visayas faring only slightly better with 15-20 percent of the total planted area used for sugarcane (Oxford Business Group, 2017).

Over the last few years, the Extension Services of the Sugar Regulatory Authority have made considerable

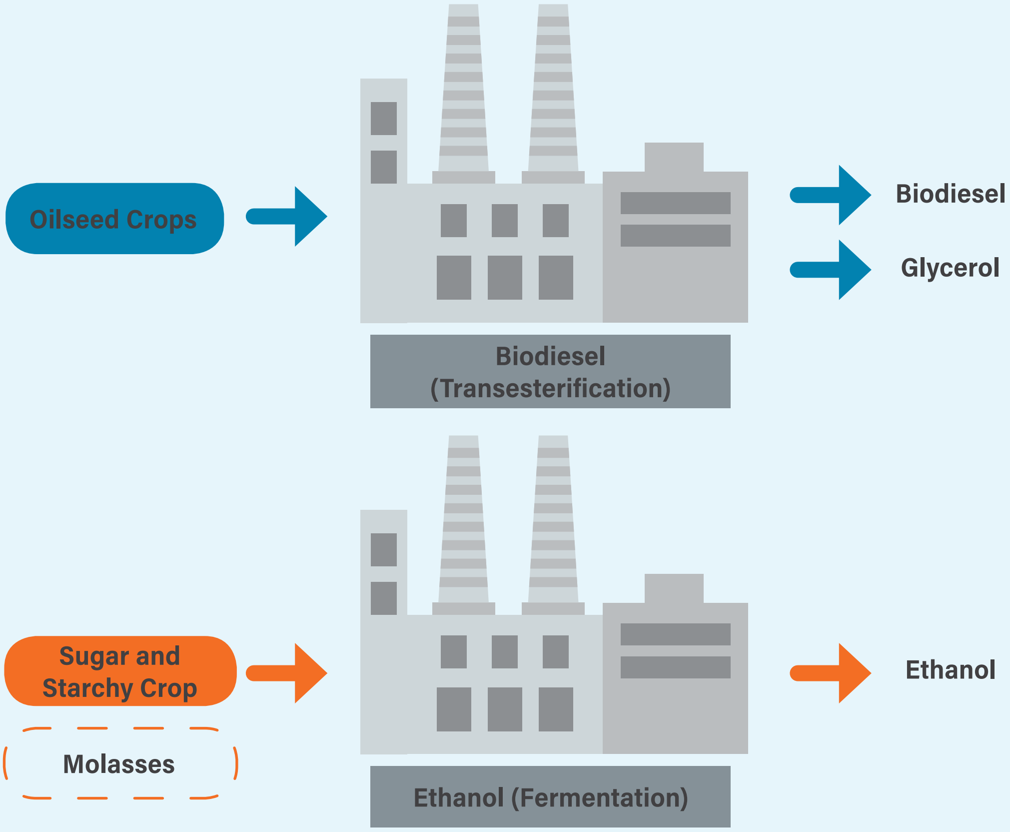
Flowers of sugar cane

[4] 87 billion Philippine pesos (converted to USD with 2013 annual exchange rate average, used: http://www.x-rates.com/average/?from=PHP&to=USD&amount=87&year=2013)

BOX

Technology Box

Liquid biofuels are liquid fuels derived from biomass. The list includes methanol, ethanol, butanol, biodiesel, bio-oil and straight vegetable oil. However, the most commonly produced are biodiesel and ethanol. These are used around the world, pure or mixed with. gasoline and diesel. The policy instrument used to define targets for liquid biofuels in countries' policies are called blending mandates and they operate under various levels with 2 percent, 5 percent or even 20 percent, blended with fossil fuels.



Liquid biofuels are obtained through different chemical and biological pathways according to the main replacement fuel and the level of processing required. Straight vegetable oil (SVO) is the simplest liquid biofuel and is obtained by extracting oil from oilseeds. The oil is then slightly purified to increase its shelf life. This oil is directly used in modified diesel engines either for rural electrification or trucks. Further processing of extracted vegetable oils using a chemical route known as transesterification produces biodiesel, a clean-burning replacement for diesel fuels. Sugar, starchy or lignocellulosic feedstock can be converted through fermentation and, with some additional steps (depending on the molecules' complexity), into ethanol or butanol.

According to the processing level and the feedstock used, liquid biofuels are further classified into either first generation (1G) or second generation (2G) biofuels. First generation biofuels comprises conventional liquid biofuels obtained through well-established processes and bioenergy crops such as sugar cane and sugar beet, starch-bearing grains, such as corn and wheat, oil crops such as oil palm, soya, rape, sunflower and canola, and in some cases used frying oil and animal fats. On the other hand, second generation biofuels includes advanced biofuel production using non-conventional feedstock (e.g. lignocellulosic materials, algae, micro-algae) and alternative termo-chemical routes such as Fischer-Tropsch processing.

OECD/IEA & FAO. 2017. *How2Guide for Bioenergy* pp 78.

Flammini, Alessandro; Kojakovic, Ana; Rincon, Luis; Maltsoglou, Irini; Dubois, Olivier & Puri, Manas. 2017. Energy access: food and agriculture. *State of Electricity Access Report*. Washington, D.C: World Bank Group (also available at http://documents.worldbank.org/curated/en/417941494928698197/Energy-access-food-and-agriculture).

efforts in supporting small-scale farmers to improve their performance. Some of the ongoing projects include reduction of production costs through block-farming practices, establishment of nurseries for high yielding varieties of sugarcane, implementation of farm-schools on good practices and strengthening of links with industry (Sugar Regulatory Administration, 2015). Considering the agro-ecological conditions and potentially achievable yields, these efforts can result in increased sugarcane production. This increase could potentially supply both sugar and biofuel markets, as sugarcane is expected to be the predominant source of feedstock for ethanol production.

The BEFS RA crop production tool was used to examine whether intensification of sugarcane production could support the fulfilment of the national ethanol mandate.

According to the potential values based on the Global Agro-Ecological Zone - GAEZ ver. 3.0 (FAO and IIASA, 2012), improving farm productivity and the efficiency of small/medium scale farms, currently under rainfed and intermediate input level conditions by adding irrigation systems, could increase the yield to 73.29 tonnes/ha. In the case of large scale farms already under an irrigated and high input level production system, improving farm productivity and efficiency, could increase the yield to even 93 tonnes/ha. Such intensified yields would lead to an increase in sugarcane outputs, from the average of 24.8 million tonnes/year for the last five years, to 33.4 million tonnes/year, without increasing the production areas.

The results from the BEFS RA crop production tool show that only a share of this production can be allocated for bioenergy purposes. More than 67 percent would still be needed for non-bioenergy purposes (i.e. food, feed, exports) (**Figure 3**). This is because there is an export quota or an obligation in place in which the Philippines must export a certain amount of sugar to the United States. When there is excess sugar, the country can choose to export to other countries. Additionally, food processing industries, such as the beverage industry, confectionery industry, food service outlets, and households are all major sugar consumers (Sugar Regulatory Administration, 2015).

Techno-economic assessment of producing ethanol and biodiesel

The objective of this section is to determine if the production of sugarcane and coconut oil, once converted to ethanol and biodiesel respectively, can be utilised to fulfil the blending mandate at the forecasted 2030 consumption levels. The feasible production amounts and costs are evaluated using the BEFS RA transport and molasses tools.

What is quedan?

Quedan is an established system in the Philippines in which there exists a sharing agreement between the sugar mill and the farmers. The sugarcane planter designates 30-35 percent of the sugar to the mill as a payment for processing the cane. Once processed, the mill issues a quedan, or warehouse receipt, to the farmer that represents the farmer's 65-70 percent share of the sugar (Ang and Albanese, 2016).

Sugarcane

A techno-economic analysis was carried out considering three scenarios, with the aim to assess three key representative production options in relation to the development of the sugar-based ethanol industry in Philippines. The three scenarios are:

Scenario 1. The sugar mill produces raw sugar and molasses. The sugar mill then sells the molasses to the ethanol factory which converts the molasses to ethanol.

Scenario 2. The sugar mill owns the ethanol factory and produces both raw sugar and ethanol directly.

Scenario 3a. The ethanol factory produces ethanol directly without quedan.

Scenario 3b. The ethanol factory produces ethanol directly with quedan.

The first two scenarios represent current production settings and how ethanol is produced and sold currently. These scenarios are based on molasses. Scenario 3, on the other hand, illustrates the implications of sugar cane production solely dedicated to the production of ethanol. In this scenario the ethanol is produced from the sugar cane juice.

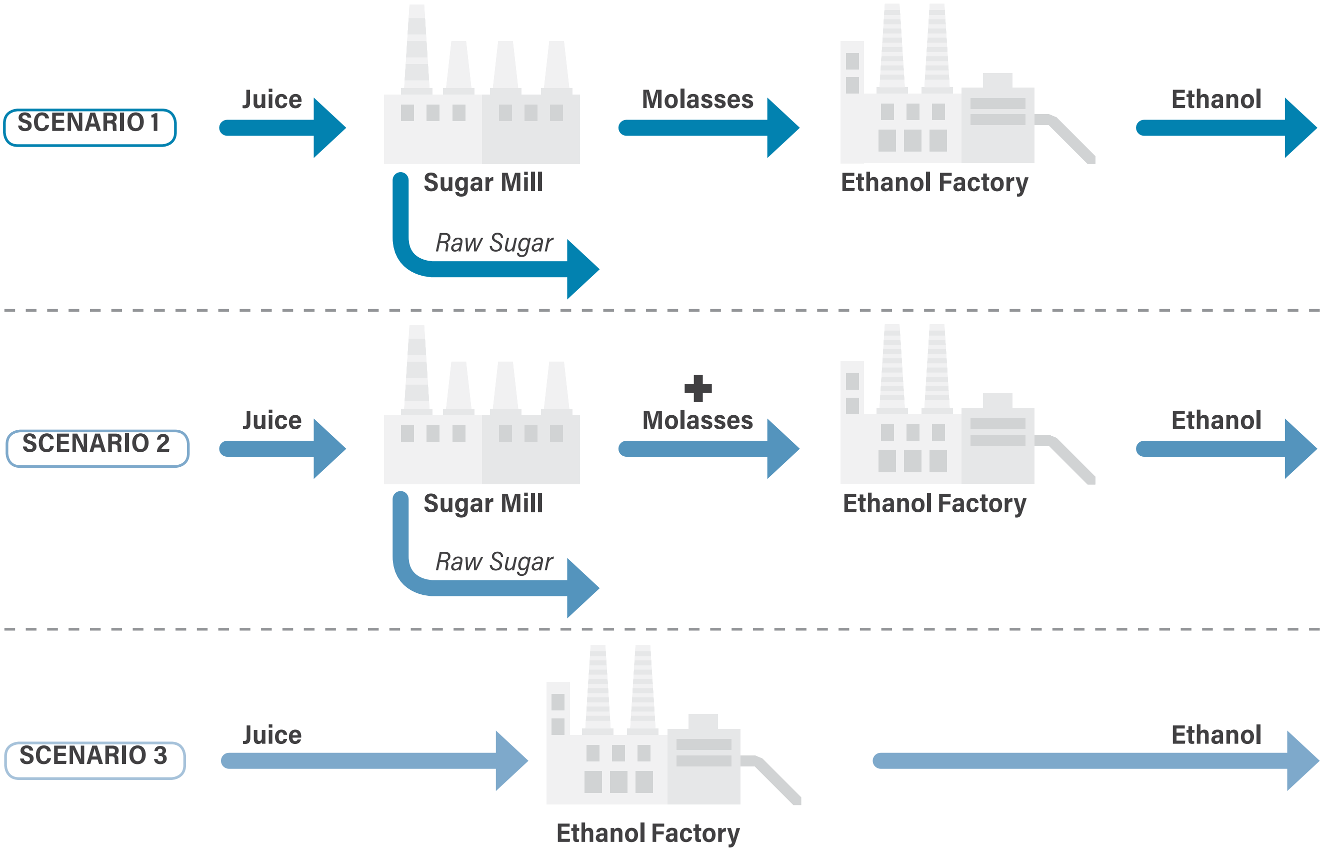
In Scenario 1, the ethanol factory (independent from sugar mills) only needs to invest in the conversion of molasses to ethanol. The potential ethanol production, given the installed production capacity of 182 million litres/year would cover 10 percent of the 2030 E20 blending mandate. However, due to extremely high production costs, and that fact that ethanol factories must buy molasses from sugar mills at an average price of 190 USD/tonne, profitability is negative. This, combined with the fact that the price of ethanol has been decreasing in recent years and the price of molasses has been increasing, leaves little room for profit.

In Scenario 2, the sugar mill only needs to consider the production costs of owning the ethanol factory. The potential ethanol production is the same as Scenario 1. Since production costs are lowered as the price of molasses is no longer a concern, profitability is positive. In comparison to a sugar mill without an ethanol factory, the ownership of an ethanol factory increases revenues for the sugar mills. However, the annual costs (e.g. operating and investment expenses) also increase, causing the total net present value (NPV) to decrease. This economic performance is largely due to the quedan system, as the sugar mill/ethanol factory can only sell 30-35 percent of the products. However, farmers benefit in this scenario as they receive an equivalent higher price (42.86 USD/tonne) for their share (after selling quedan). For sugar mills to become incentivized to invest in a new ethanol plant, the price of ethanol needs to reach 1.29 USD/litre.

For Scenario 3, the results are two-fold. Overall, the potential ethanol production given current conditions is 904 million litres/year, which would cover 48.6 percent of the 2030 E20 blending mandate. The Philippines has enough feedstock available to meet these conditions. In the "no quedan" scenario, no option would be profitable due to the low price of ethanol (0.57 USD/litre) and the 57 USD/tonne payment to the farmers. In the "quedan" scenario, giving farmers the 65-70 percent share of ethanol production in payment for sugarcane caused profitability to increase, but the effect was not large enough to make it positive. The price received by sugarcane farmers in this case would be 32.4 USD/tonne.

Bodisel plant

FIGURE 4. Sugarcane – three scenarios



Source: *Own elaboration*

Overall, the summary of results from sugarcane were:

Scenario 1. Currently the worst scenario in terms of meeting the 2030 blending mandate and the net present value (NPV) and payment to farmers. This scenario could possibly improve with the Regional Comprehensive Economic Partnership (RCEP), a free trade agreement between 16 countries that could open the way for lower-priced sugarcane to be imported.

Scenario 2. This is the best scenario in terms of NPV. However, sugar mills pay for the additional costs of owning an ethanol factory, but the farmers are the ones who receive the benefits from extra revenues.

Scenario 3. This is the best scenario in terms of meeting the 2030 blending mandate and the payment to the farmers when quedan is present.

TABLE 1. Summary of ethanol scenario results

	Scenario 1	Scenario 2	Scenario 3
Percent of blending mandate met	10 %	10 %	49 %
NPV (million USD)*	USD 0	USD 251	USD 0
Payment to farmers (USD/tonne)	USD 0	USD 43	USD 32
** Calculations for an average 50 million litre ethanol plant*			

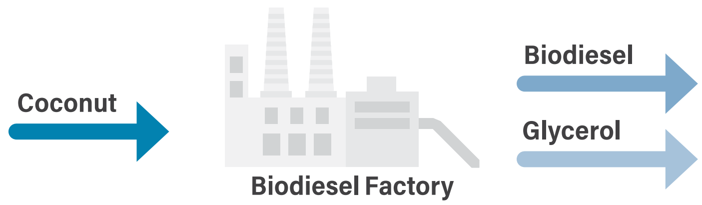
Source: *Own calculations based on results obtained from the BEFS RA transport and molasses tools*

Coconut Oil

The biofuels policy also allows the production of biodiesel from either coconut oil or jatropha,[5] and the government does not allow the importation of biodiesel (Congress of the Philippines, 2006). Overall, biodiesel production, could reach 1 504 million litres/year which would allow to meet 58.1 percent of the 2030 blending mandate (B20). This estimate is based on the amount of coconut production estimated to be available in the biomass assessment section and equivalent to 11.6 million tonnes.

[5] Jatropha is currently under study, but is not currently produced in large quantities for consideration.

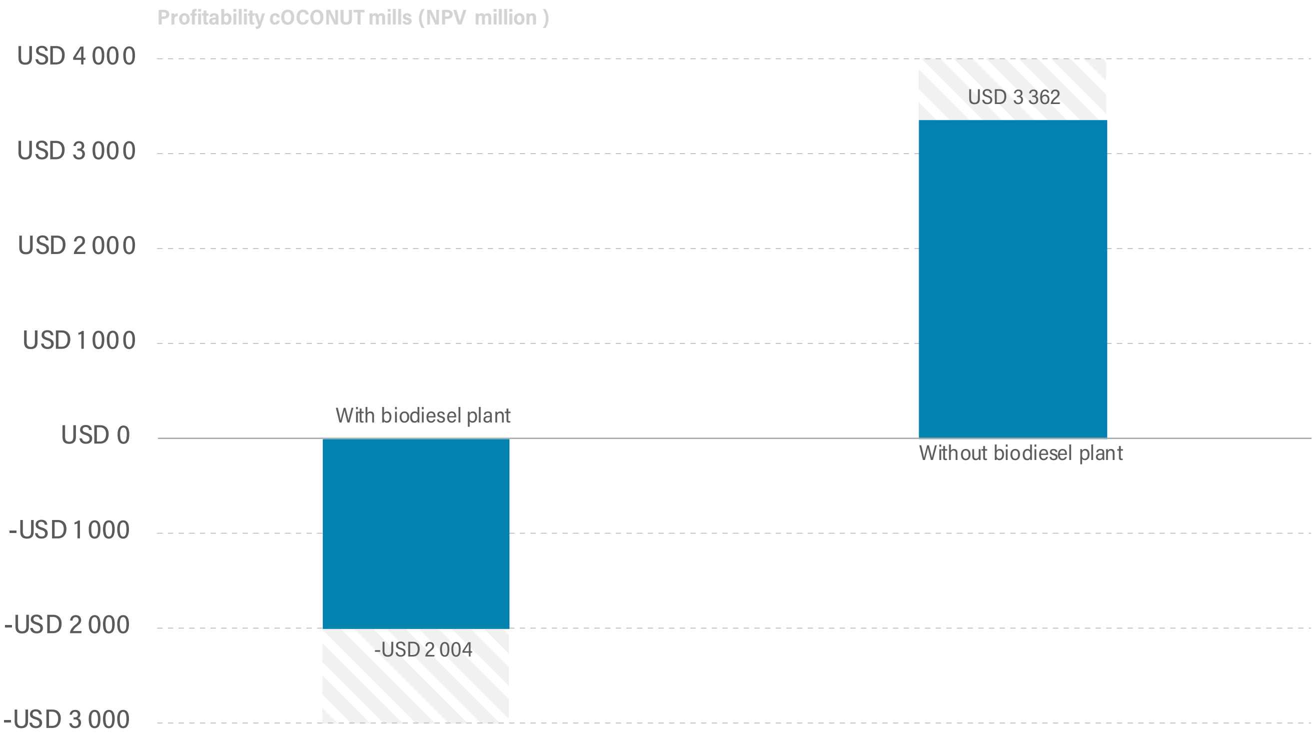
FIGURE 5. Structure of coconut biodiesel



Source: *Own elaboration*

Dried coconut flesh, or copra, is used to extract coconut oil. Current market prices for copra are extremely high at 133 USD/tonne and this greatly impacts coconut oil prices, which were as high as 1 405 USD/tonne in 2016. As a result, the profitability of biodiesel plants suffers and given these current prices, they cannot compete against coconut oil mills. Therefore, only systems in which the coconut feedstock is produced and farmed by the biodiesel producers directly ("own-production scheme") are marginally profitable. These producers would be able to spend up to 34 USD/tonne for copra in coconut production.

FIGURE 6. Profitability comparison for coconut mill with and without biodiesel plant



Source: *Own elaboration based on BEFS RA transport tool results*

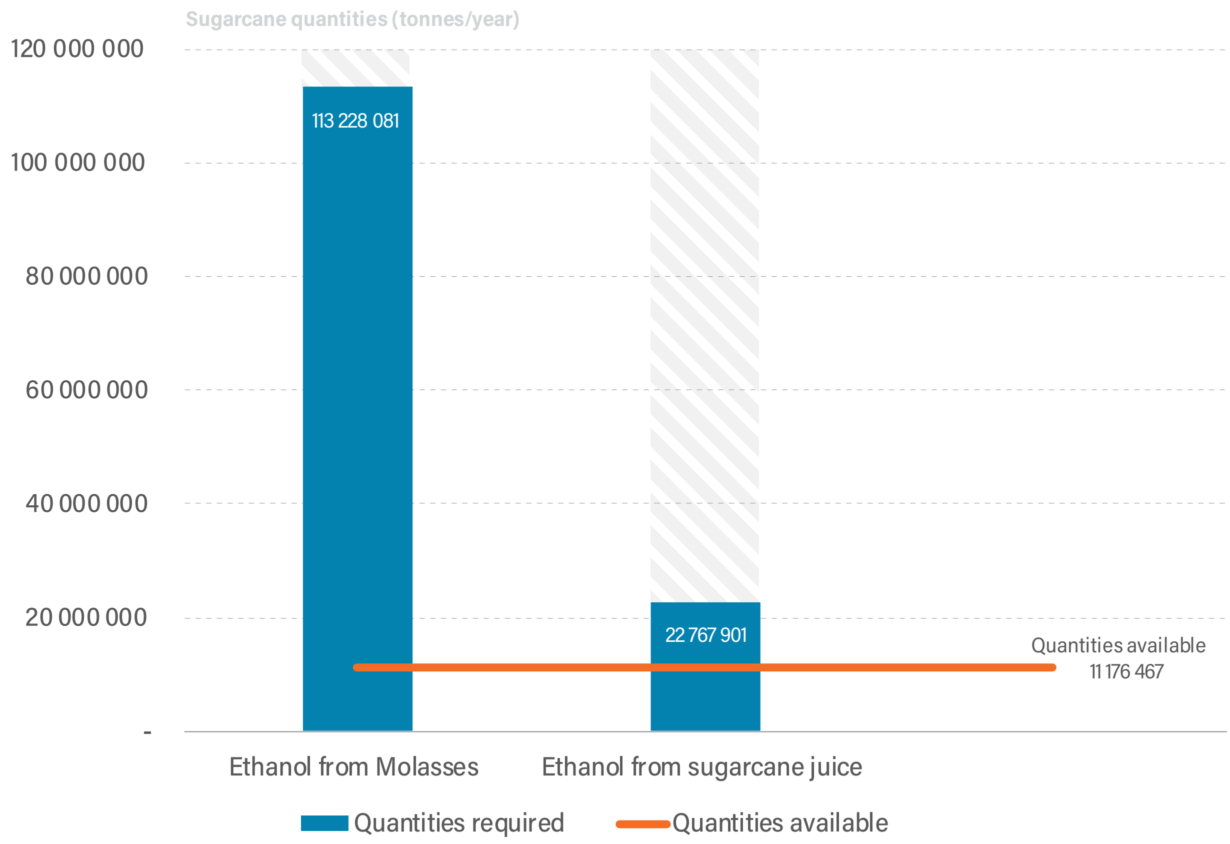
The Philippines happens to be a top coconut oil exporter. Copra prices are therefore high because the final products, coconut oil, produced by mills and copra cake, produced by refineries, are highly valued in the export market. In the domestic market, coconut oil is considered a valuable product used in food, feed and in the industrial market. In the industrial market, oleochemicals from coconut oil are used in the production of laundry detergent, toothpaste, soaps, shampoo, and other products. As a result, this industry is deeply competitive and the price of coconut oil continues to increase. Moreover, the value chain is disconnected as mills, refineries, biodiesel plants and oleochemical plants operate separately, and it is therefore not possible for there to be coordination between all parties.

Under the current market prices for biodiesel and coconut oil, a mill which decides to invest in a biodiesel plant, shifting the main source of income from coconut oil to biodiesel, would end up with negative profit. Therefore, under the current situation, there is little incentive to develop a coconut oil-based biodiesel market in the Philippines. Still, the expansion required to meet the blending mandate targets would require additional support from the government, at least until biodiesel market prices change which would enable profitable production. In the short term, an option that allows sustained, small-scale biodiesel production could be based on the coconut oil ending stocks (the amount of coconut oil left over after all demand has been satisfied). Between 2014 and 2016, these stocks ranged from about 9 to 11 percent of the total coconut oil supply. If this trend continues until 2030, this would allow for an estimated production of 150 million litres of biodiesel, which would be able to supply 6 percent of the blending mandate target.

Production levels required to meet 2030 blending mandate

As was shown in the case of sugarcane, the sustainable sugarcane estimated was not enough to supply the target blending mandate. The next figure shows the estimation of sugarcane production quantities needed to meet the E20 blending target by 2030 for the two ethanol production alternatives analysed in this case study. The production under ethanol from the molasses option would require almost ten times the estimated sustainable availability. Conversely, using sugarcane directly would require two times the sugarcane potentially available. Regarding biodiesel it was found that the estimated coconut availability would need to increase to 8.3 million tonnes/year, to meet biodiesel production for a B20 blending mandate.

FIGURE 7. Target sugarcane production to meet E20 blending mandate

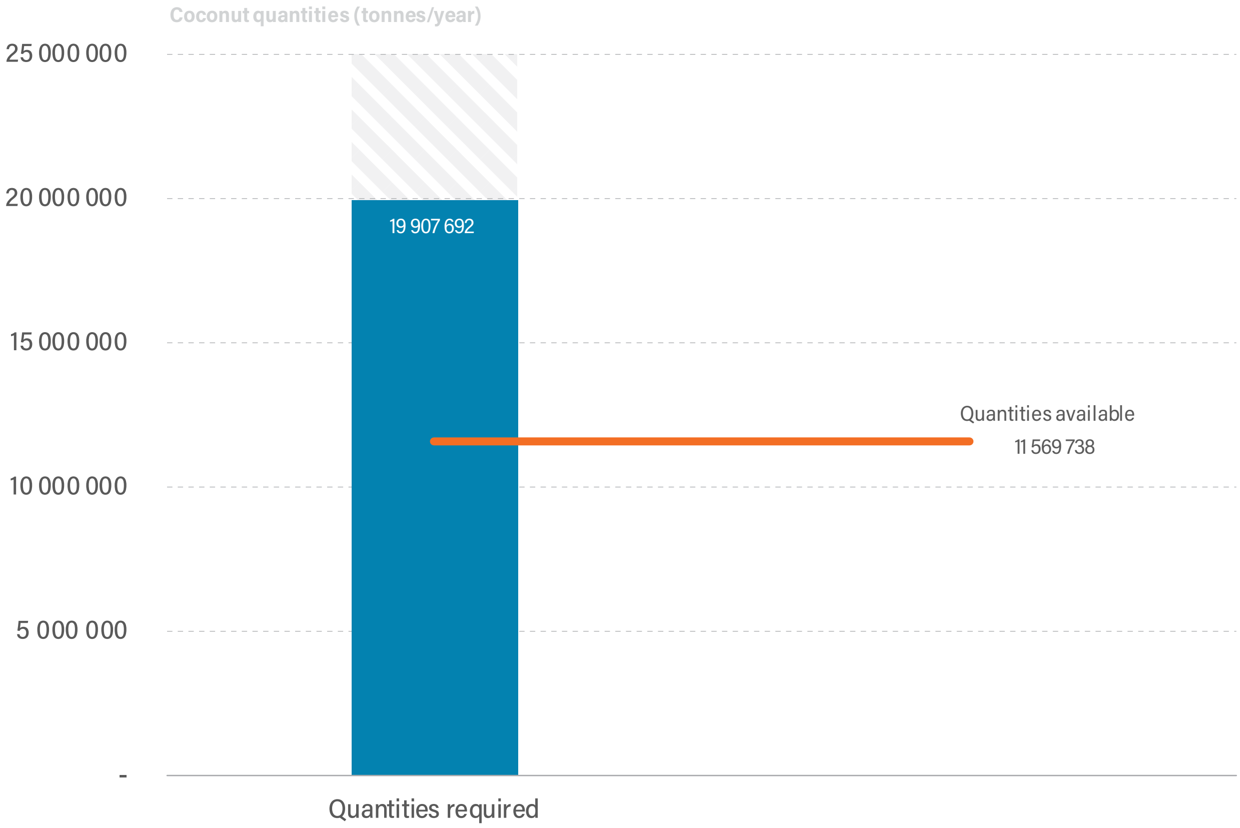


Source: *Own elaboration based on BEFS RA transport tool results*

These results support the discussion on the development of a sustainable blending mandate and liquid biofuel industry in the Philippines. As an example, a quick check of the highest potential yields based on GAEZ for sugarcane in Philippines, indicates that the highest yield under the best possible production conditions (suitable/very suitable lands, high inputs and irrigation) would be 114 tonnes/ha. Even if all yields in the country were to reach this level, total sugarcane production would be stepped up from 11.2 to 47.9 million tonnes/year. In this case, the maximum attainable production but would remain below the production required to meet the blending target from molasses (113 million tonnes/year), but it would be enough to duplicate the sugarcane required meet this target from its juice directly (22.7 million tonnes/year).

Both alternatives would require huge developments and investments in the sugarcane industry to meet the required production levels. Not only at the farm level to reach high input production conditions, but also building new mills and ethanol factories. However, the techno-economic results showed that under the current ethanol prices the direct production from sugarcane (scenarios 3a and 3b) would result potentially unprofitable. Conversely, the alternative molasses based production (scenarios 1 and 2) showed that the additional operating cost for ethanol production in the mills would not be compensated. Therefore, under current conditions, potential investors would refrain from supporting the development of the ethanol industry in the Philippines. Moreover, the above-mentioned yield increments might have adverse environmental effects as a result of the intensive fertilization and mechanization required.

FIGURE 8. Target coconut production to meet B20 blending mandate



Source: *Own elaboration based on BEFS RA transport tool results*

In the case of biodiesel from coconut in the Philippines. The annual coconut production would need to be increased to almost 20 million tonnes/year. This value duplicates the estimated potential availability (11.6 million tonnes/year). Similarly to the sugarcane case, the yield increments and the additional investment required to meet the B20 coconut based biodiesel blending mandate would make difficult for potential investors to take this option. Moreover, as coconut oil is a high-value commodity used in wide a variety of industries, as long as the prices would compensate the additional investments required to produce biodiesel, it will be difficult for an investor to prefer this option.

Conclusion

The Philippines depends on fossil fuel imports due its limited national fossil fuel production. The transportation sector is the largest consumer of fossil fuels and, due to a growing population, total primary energy consumption levels are expected to continue to rise in this sector.

The country developed the Biofuels Act to displace some of the fossil fuel imports in the transportation sector by mandating a blend of ethanol and biodiesel into gasoline and diesel, respectively. This blending is expected to increase steadily until 2030, at which point the government aims to have a blend of E20 and B20 in place.

Following an overview of the agriculture sector, the case study looked at specific cases of sugarcane, molasses and coconut to produce ethanol and biodiesel.

The assessment showed that the mandates cannot be achieved sustainably - there is not enough feedstock available to produce the ethanol required by the mandates and coconut oil has many more lucrative uses.

Regarding ethanol, from a farmers' point of view, the mixed option to produce sugar and ethanol is best (scenario 2) as the farmers receive a higher price for the product. From the mill's point of view, profit margins are lower under this scenario. However, it is important to note that the results are dependent on the price of oil and its effect on ethanol and gasoline prices. When the price of oil increases, producing ethanol becomes more remunerative, although feedstock availability would still be a constraint

With some exceptions, findings show that biodiesel production in the Philippines is not economical under current biodiesel prices. Biodiesel would be competing with pure coconut oil which is a valuable product with many uses in food and oleochemical industries (detergents, toothpaste, soap). The price of coconut oil is much higher compared to biodiesel (1.29 USD/litre = 1405 USD/tonne vs 0.67 USD/litre) and the initial investment is much lower.

Based on this initial level of analysis, meeting the ethanol and biodiesel targets does not appear to be possible. Even in the case of the lower blending mandates, considerable investment would be required to increase agricultural productivity and to build the ethanol and biodiesel plants. A change in crop options was not considered in this study.

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