UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

SUSTAINABLE DEVELOPMENT GOALS

Unleashing the Power of the Sugar Industry

Potential of the Sugar Industry for Universal Energy Access in Developing Countries

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Potential of the Sugar Industry for Universal Energy Access in Developing Countries

Côte d'Ivoire

Mozambique

Tanzania

Kenya

Madagascar

Nigeria

COUNCIL ON ETHANOL CLEAN COOKING

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LIST OF ABBREVIATIONS AND ACRONYMS

AIS	Association des Industries Sucrières de Côte d'Ivoire (AIS-CI)
CCM	Clean Cooking Madagascar
CECC	Council on Ethanol Clean Cooking
CER	Certified Emission Reduction
CHP	Combined Heat and Power
CMCS	Malagasy Cane and Sugar Centre
COMESA	Common Market for Eastern and Southern Africa
COP	Conference of the Parties
CSA	Cane Supply Agreement
DNA	National Sugar Distributor
EMD	Ethanol Micro Distillery
EU	European Union
GHG	Greenhouse gas
GWh	Giga Watt hour
ha	Hectare
IGEPE	Institute for the Management of State Holdings
KEREA	Kenya Renewable Energy Association
kg CO_2	Kilogram of carbon dioxide
KPLC	Kenya Power and Lighting Company
KSSCT	Kenya Society of Sugarcane Technologist
ktoe	Kilotons of oil equivalent
KUSPAW	Kenya Union of Sugarcane Plantation and Allied Workers
kWh	Kilowatt-hour
MAN	Manufacturers Association of Nigeria
MIC	Ministry of Industry and Commerce
MICC	Ministry of Industrialization, Commerce and Consumption
MINAE	Ministry of Agriculture and Livestock
MSME	Small-scale Manufacturing Enterprise
MZN	Mozambican Meticais
MWh	Megawatt hour
NBPS	National Biofuels Policy and Strategy
NDC	Nationally Determined Contribution

NGO	Non-Governmental Organization
NISC	National Investment Steering Committee
NSDC	National Sugar Development Council
NSI	National Sugar Institute
NSMP	Nigerian Sugar Master Plan
PPA	Power Purchase Agreement
OXF	West African Franc
SBT	Sugar Board of Tanzania
SRI	Sugar Research Institute
TASGA	Tanzania Sugarcane Growers Association
TCD	Tons of cane crushed per day
TIC	Tanzania Investment Centre
Toe	Tons of oil equivalent
Tons/ha	Tons per hectare
TOSCI	Tanzania Official Seed Certification Institute
TRA	Tanzania Revenues Authority
TSPA	Tanzania Sugar Producers Association
TWh	Terrawatt-hour
UNIDO	United Nations Industrial Development Organization
VAT	Value-added Tax
WACCA	West African Clean Cooking Alliance

Foreword

The global sugar industry plays a crucial role in economies worldwide, with a market supply chain reaching 189 million tons in 2022. Africa, contributing 8% to this market, is emerging as a competitive player. With anticipated 36% growth in production by 2030, Africa's sugar industry is at a turning point. However, challenges remain that must be addressed to realize its full potential.

This report provides a comprehensive analysis of the sugar industry in six African countries: Côte d'Ivoire, Nigeria, Kenya, Tanzania, Mozambique, and Madagascar. It highlights the importance of product diversification to meet Sustainable Development Goals (SDGs). By incorporating circular economy principles, realization of by-products like bagasse, molasses, and press mud, can enhance productivity, profitability and reduce environmental impact, thus aligning the industry with SDGs focused on clean energy, food security, and economic development.

To further enhance competitiveness, the United Nations Industrial Development Organization (UNIDO) is promoting the adoption of clean fuels and technologies in the African sugar sector. This includes upgrading technology and utilizing waste products from sugar mills to meet the growing demand for clean energy in transportation and households sectors.

Despite a promising outlook, significant challenges persist, especially in countries reliant on sugar imports or facing production inefficiencies. Addressing these challenges through advanced technologies, better agricultural practices, and stronger supply chain management is vital. This report offers actionable insights for stakeholders, policymakers, and industry leaders to optimize and maximize contributions of sugar industries to SDGs. With concerted efforts, Africa's sugar sector can become a key global player, addressing food security and climate change while fostering a sustainable future.

Preface

The United Nations Industrial Development Organization (UNIDO) is focused on promoting the adoption of clean fuels and technologies for clean cooking by increasing the competitiveness, productivity, and profitability of the sugar sector in its member countries. This is achieved through advancements in technology, process optimization, and the utilization of waste by-products from sugar mills. The objective is to meet the energy demand in sectors like energy and transportation, while ensuring that households achieve energy security and self-sufficiency. Six African countries were identified for a market potential assessment, specifically Côte d'Ivoire, Mozambique, Kenya, Tanzania, Madagascar, and Nigeria (refer to Figure 1). The studies assessed the performance of the sugar sector, including cultivation, production, and consumption, and its potential to support the energy, household, and transportation sectors. Various opportunities and challenges referred to fulfilling the Sustainable Development Goals (SDGs) and Nationally Determined Contributions (NDC) commitments in each of these countries were also assessed.

The study was carried out between 2022 and 2023, primarily relying on surveys and literature reviews supported by the UNIDO Offices in each respective country. Consultations were done virtually, and data was collected electronically. The UNIDO Project Offices coordinated data collection and stakeholder communications, and provided country-specific insights. This synthesis report presents the consolidated analysis and observations regarding the sugar market across these six countries.

Figure 1. Countries covered in the assessment

1. Introduction

The universal need for sugar and sugar products for residential, commercial, and industrial uses has fetched it a top place among the globally essential food commodities. The sugar sector is one of the key agro-industries with a worldwide market supply chain. The global sugar market reached a volume of 189 million tons in 2022, with South America and Asia accounting for a total of 84 per cent of total sugar production.[1] Global sugar consumption is projected to grow about 1.4 per cent per annum reaching 196 million tons by 2030, driven by rising population and income levels. Between now and 2030, the global average per capita consumption is expected to increase from 22 kg/capita to 23 kg/capita. In general, emerging economies are projected to witness a surge in consumption, while a decline is projected in high-income economies, where markets are mature. The largest contributions to the anticipated increase in demand are expected to come from Asian (66 per cent) and African (30 per cent)[2] economies.

The supply chain of the sugar industry is spread across several sectors, from agriculture to industries, energy, distillery, and transportation, among others. Sugarcane processing generates a significant volume of wastes and by-products. Fortunately, wastes and by-products like bagasse, molasses, and press mud have some commercial value and thus are utilized within sugar mills and other processing industries. Energy demand in sugar mills is met primarily through the use of bagasse, although an excess of it gets accumulated or is discarded around the sugar mill sites. Over the years, the sugar industry has highly contributed to clean energy development, initially by cogeneration and later through the production of bio-ethanol. In consequence, the sugar sector can highly contribute to the SDGs on food security, employment creation, economic development, improved livelihoods, clean energy access, and emission reduction.

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[1] https://www.imarcgroup.com/sugar-manufacturing-plant#:~:text=The%20global%20sugar%20market%20reached,1.64%25%20during%202023%2D2028 (last accessed on October 25, 2023).

[2] https://www.oecd-ilibrary.org/sites/969526b0-en/index.html?itemId=/content/component/969526b0-en.

Africa plays a relatively small role in determining global sugar supplies (around 8 per cent of total global supplies), producing 9.8 million tons from over 1.5 million hectares (ha) of cane cultivation. However, a few of the world's competitive sugar producers are located in Africa, including Uganda, Tanzania, Malawi, Zambia, Swaziland, and Egypt[3]. African countries have also demonstrated high sugarcane yields, equivalent to those of leading producers like Brazil, India, and Thailand. In 2020, South Africa emerged as the primary sugarcane producer in Africa, boasting an annual output of 18 million tons, followed by Egypt with 14 million tons, and Kenya with 6.8 million tons.

The sugar production on the continent is expected to increase by 36 per cent, reaching 15 million tons by the end of 2030, due to the expansion of production in Sub-Saharan countries, which is further enhanced by national and international investments in the sector. This growth is supported by suitable conditions for cultivating sugar crops, including a favourable climate and accessible land. Yet, the African sugar market has to fully explore its potential in contributing to clean energy and aiding the decarbonization efforts of the respective countries. •

[3] https://www.gro-intelligence.com/insights/global-sugar-markets (last accessed on October 25, 2023).

2. Sugar Sector Scenario

Sugar market conditions and its performance vary widely across the assessed countries, from Mozambique being a net exporter to Nigeria being highly dependent on imports. The conditions of the sugar sector in each country are comparatively analyzed and presented below, focusing on aspects such as sugarcane cultivation, sugar production, and the dynamics of sugar consumption and retail market conditions. The demand and supply scenarios, along with the performance of sugar mills, play an important role in the potential for improved utilization of current capacity, future capacity expansion, and opportunities for product diversification.

2.1. SUGARCANE CULTIVATION

All the assessed countries have favourable climate and soil conditions for sugarcane cultivation, which has supported an increase in cane production over the years. In general, cane cultivation is mainly carried out by the estates owned by sugar mills. Farmers residing in and around the estates also participate in cane cultivation through "outgrowers" schemes. Such contribution of local farmers to the country's cane production is high in the case of Kenya (nearly 90 per cent) and the lowest in Côte d'Ivoire (10 per cent).

Box 1. Outgrower systems

The term 'outgrower farming' refers to a contract farming method in which the small, medium, and large-scale farmers supply their sugarcane harvest to a processor or a miller. Outgrowers can participate in the sugarcane production business with as little as one acre of land. However, individual farmers cannot directly sign contracts with sugar millers. They need to associate with a local farmer association, through which they can then partner with sugar mills. A Cane Supply Agreement (CSA) is signed between the company and the farmers' associations, and may be amended during every harvesting season if the need arises. This agreement also comes with a few contractual obligations. For example, millers will buy farmers' harvest and provide them with inputs and training, while farmers commit to supplying products in specified quantities and quality. Landholding size by farmers in the African region ranges from 0.4 ha to 400 ha.

Figure 2 below presents the cane cultivation area, and Figure 3 shows the annual sugarcane produced in assessed countries. Kenya has the largest cane cultivation area among these countries, positioning it among leading producers in Africa. However, cane cultivation and production in Kenya are currently stagnant and experiencing a downward trend due to extensive monoculture practices. The operational failures of large sugar mills like Mumias have heavily affected the local economy. Subsequently, sugarcane cultivation is reported to be decreasing as sugarcane farmers explore other agricultural crops for better yield and revenue. In all other assessed countries, farmers find higher income generation from cane cultivation as a commercial crop when compared to other vegetation. The cane cultivation area is increasing in Tanzania, Côte d'Ivoire, and Madagascar to meet the increasing domestic sugar demand. Mozambique is already surplus in sugar production, and thus growth in the cane cultivation area is more or less stable. In the case of Nigeria, cane cultivation so far is limited to the developed farm areas within existing sugar mills.

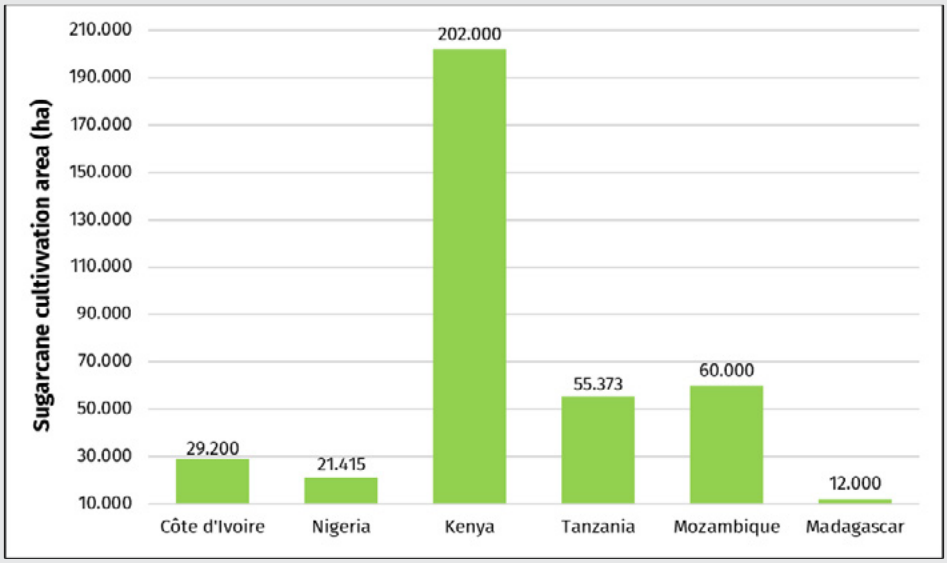


Figure 2. Sugarcane cultivation areas

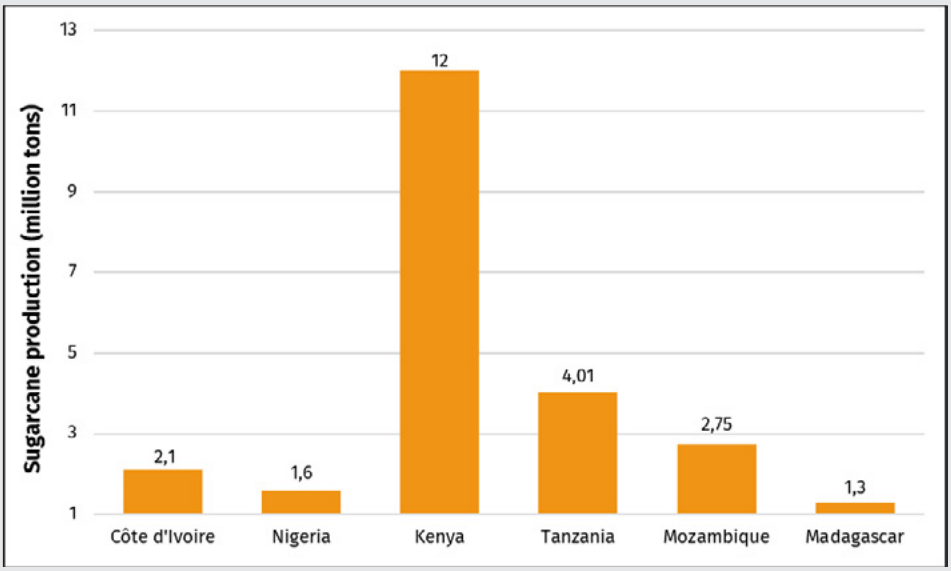


Figure 3. Annual sugarcane production

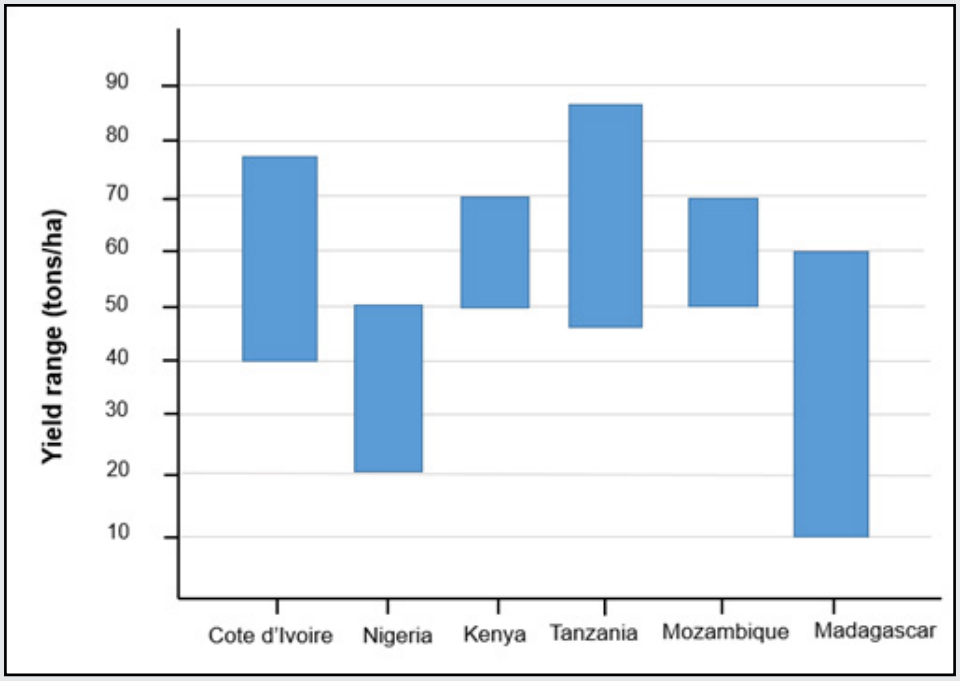


Figure 4. Average range of sugarcane yield

All sugar mills in assessed countries practice mechanized irrigation and modern farming techniques. On the other hand, the majority of outgrowers continue to practice rain-fed irrigation. Harvesting methods also differ: sugar mill estates use a mix of manual (50 per cent) and mechanized (50 per cent) processes, while outgrowers employ a fully mechanized approach for harvesting. Lack of reliable access to energy, roads, and other infrastructure also affects cane farming practices. This leads to around 30 to 50 per cent less yield per hectare by outgrowers when compared to sugar mill estates. Figure 4 presents the average range of yields reported by assessed countries. This shows that there are demonstrated higher productivity levels in African countries comparable to those of other sugarcane-producing nations like Brazil and India. However, these practices are not well disseminated across all sugar mills and outgrowers, as implied by the lower levels of productivity reported in assessed countries.

Cane crop varieties vary from one country to another, and their harvesting period differs from 12 to 18 months. The irrigation systems are advanced in countries like Mozambique, Tanzania and Kenya, compared to those in Nigeria, Côte d'Ivoire, and Madagascar. However, some of the irrigation equipment is outdated and energy-inefficient, requiring frequent maintenance. There is significant potential for improving the efficiency of these irrigation systems to reduce both water consumption and energy use.

2.2. SUGAR PRODUCTION

The harvested sugarcane is used for different purposes, such as the production of refined sugar (both white and brown) at industrial scale, organic/traditional sugar at artisanal or semi-industrial scale, and other local beverages. Among assessed countries, industrial scale sugar mill capacities range from 200 tons of cane crushed per day (TCD) (Zanzibar Sugar Factory Limited, Tanzania) to 11,700 TCD (Xinavane Sugar Mill, Mozambique). The average production capacity in artisanal or semi-industrial scale is around 20 tons of sugar per day. The production of brown sugar (also called table sugar) is widely practised to meet domestic demand. White sugar used for industrial and commercial purposes, particularly

in beverages and food products, is produced on a limited scale or based on demand. Consequently, the majority of countries import white sugar to satisfy both industrial and commercial demand.

Historically, sugar mills and their estates in Africa were installed, owned and operated by the State to generate more employment and boost local economy. However, there has been an increasing trend towards privatization in recent years, aimed at enhancing market competitiveness. Except in Kenya, where few mills are still 100 per cent owned by the public sector, sugar mills in all other countries are under the private sector, with limited to zero public sector share.

Table 1. Sugar mill capacity and operation

Country	Number of sugar mills	Total installed capacity (TCD)	Average annual sugar production (tons)	Average capacity utilization (%)
Côte d'Ivoire	4	12,000	200,600	90%
Nigeria	3	19,500	70,000	Not available
Kenya	14[4]	46,150	690,000	60%
Tanzania	6	15,360	367,700	90%
Mozambique	4	26,500	315,400	60%
Madagascar	5[5]	Not available	90,000	Not available

Table 1 presents an overview of sugar mills and the respective sugar production in assessed countries. It can be observed that sugar mills in Côte d'Ivoire and Tanzania are operating close to their installed capacity. However, capacity utilization is just around 60 per cent in Mozambique and Kenya. As Mozambique has a sugar surplus, capacity utilization is limited by export demand, and market conditions also deter outgrowers' confidence to cultivate and supply sugarcane at constant or higher volumes over the years. In Kenya, the reduced operating capacity is due to business challenges that have led to a lower engagement of farmers in sugarcane cultivation.

In Nigeria's specific case, the sugar sector imports raw sugar (mainly from Brazil), which is then refined as white sugar in sugar mills. The final refined white sugar is supplied to domestic market and exported to neighbouring countries in the region. The annual sugar production mentioned in Table 1 above (70,000 tons) is only the sugar produced directly from cane, not the total refined sugar production. Figure 5 shows the average annual sugar production (cane to sugar) in assessed countries.

[4] Only 12 are in operation, and 2 are closed.

[5] Only 2 are in operation, 1 is under renovation and 2 are closed.

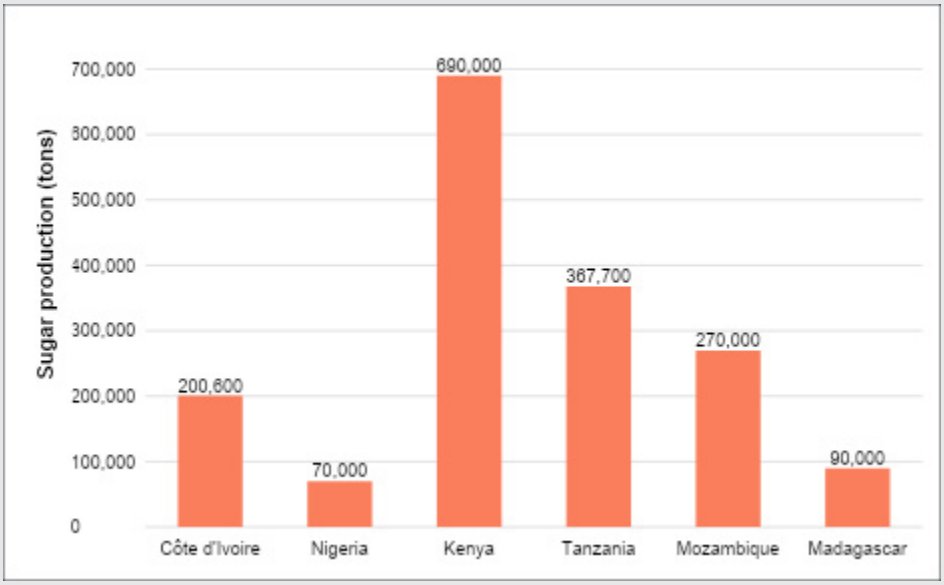


Figure 5. Annual sugar production (cane to sugar)

The operating days of sugar mills (cane processing days referred to as milling season) vary from 150 to 200 days per year. During the remaining days (referred to as off-season), sugar mills are put in partial operations, with staff engaged in cane cultivation activities in the estates or maintenance activities in sugar mills.

In addition to industrial-scale sugar production, traditional and semi-industrial-scale sugar production is also prevalent in a few countries, including Madagascar, Nigeria, and Mozambique. While these small-scale sugar production facilities in Madagascar and Nigeria cater to the domestic demand, organic sugar mills in Mozambique are focused on the export market, mainly Europe and North America. Madagascar is also involved in the production of alcoholic beverages from cane juice, but there is no official record available regarding current production levels. Additionally, commercial rum production plants in Madagascar produce high-quality rums and alcoholic beverages from sugarcane, serving both domestic consumption and exports.

2.3 SUGAR DEMAND AND SUPPLY

Except for Mozambique, all other assessed countries face a sugar deficit, i.e., domestic sugar production does not meet the country's demand for sugar. Figure 6 illustrates the domestic demand, production levels, and the gap in supply that is met with the imports. All these countries expect an increase in sugar consumption in the coming years due to economic growth, and an increase in the consumption of confectionery items, soft drinks, and various beverages.

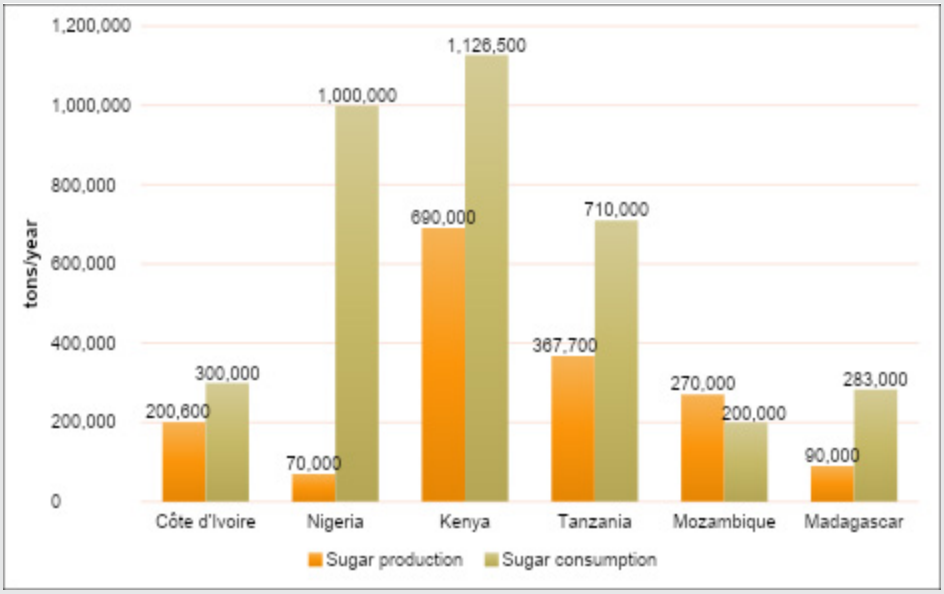


Figure 6. Sugar demand and domestic production

As stated before, the deficit in Nigeria is the highest, as domestic cane-to-sugar production meets only 10 per cent of the demand, and the remaining 90 per cent is imported as raw sugar to be refined in sugar mills. The next highest deficit is seen in Madagascar, where domestic production meets only 30 per cent of the demand, and the other 70 per cent is being imported. Next in line are Tanzania, Kenya, and Côte d'Ivoire, which rely on imports to meet 44, 40 and 30 per cent of their sugar demand, respectively. Table 2 below presents the gap in sugar supply and the import expenses annually incurred by sugar deficit countries.

Table 2. Sugar-gap in supply, and import expenses in assessed countries

Country	Gap in sugar supply (tons/year)[6]	Sugar import expenses ($ million/year)
Côte d'Ivoire	100,000	22[7]
Nigeria	1,000,000	847[8]
Kenya	500,000	150[9]
Tanzania	350,000	151[10]
Madagascar	200,000	57[11]

6 Rounded-off to nearest value for better presentation. Exact values vary based on net stock, domestic demand, and supply.

7 https://oec.world/en/profile/bilateral-product/confectionery-sugar/reporter/civ.

8 https://trendeconomy.com/data/h2/Nigeria/17#:~:text=Imports%20structure%20of%2017%20%2D%20Sugars,pure%20sucrose%2C%20in%20solid%20form.

9 https://nation.africa/kenya/business/kenya-s-sugar-imports-bill-hits-sh24bn-on-low-output-4280156.

10 https://oec.world/en/profile/bilateral-product/raw-sugar/reporter/tza.

11 https://tradingeconomics.com/madagascar/imports/sugars-sugar-confectionery.

Table 3 summarizes some sugar market indicators from assessed countries. In Tanzania, sugar mills produce only brown/table sugar. Thus, all sugar for industrial or commercial consumption, used in baking, confectionery, beverages, and food processing industries, is imported. Kenya procures much of its sugar from the Common Market for Eastern and Southern Africa (COMESA) member states, with duty-free imports to a maximum of 350,000 tons per year.

Table 3. Sugar consumption market scenario

Country	Per capita sugar consumption (kg/capita/year)	Retail price of sugar ($/kg)	Is sugar retail price ceiling regulated by the government?
Côte d'Ivoire	10.5	1.67	Yes
Nigeria	9.0	1.25	No
Kenya	21.6	1.50	No
Tanzania	11.7	1.29	No
Mozambique	7.8	1.18	Yes
Madagascar	7.4	1.00	Yes

In Mozambique, a separate entity known as the "National Sugar Distributor" is responsible for selling sugar in the national market, as well as for coordinating the logistics for exporting any surplus. Further, to protect the domestic market, all sugar products are exempt from value-added tax (VAT). In 2016, the Government of Mozambique legislated vitamin A, E and D micronutrient fortification of several basic foodstuffs, including flour, oil, and sugar, to improve general population's health.

2.4 ENERGY PERFORMANCE OF SUGAR MILLS

In general, sugar mills use electricity and steam as the primary sources of energy for sugar production and processing. The electricity and process steam requirements in a sugar mill are met by (i) conventional cogeneration deploying a bagasse-fired boiler in conjunction with an extraction condensing back pressure steam turbine, or (ii) a double extraction-condensing turbine coupled to an electrical generator. The energy demand of sugar mills depends on the type of technology used for the milling processes and on the efficient operation of the cogeneration systems. Old sugar mills, which are steam-driven, have a process steam demand of 480-600 kg/ton of crushed cane. In the case of modern sugar mills with energy-efficient systems and electric drives, the process steam demand is 350-400 kg/ton of crushed cane. Electricity consumption would vary from 20 kWh/ton of crushed cane for old sugar mills to 35 kWh/ton of crushed cane for modern mills (the increase in consumption is due to the increased use of electric motor drives). In contrast, old mills have lesser additional electricity generation for power export to the grid than modern energy-efficient ones. In traditional sugar mills, the excess bagasse is disposed of as waste. Table 4 below shows a comparison of the tentative energy performance of traditional sugar mills (based on the boiler systems) and a modern one.

Table 4. Energy performance of traditional and modern sugar mills

Aspect	Traditional old sugar mills	Modern energy-efficient sugar mills
Steam pressure (bar)	20-25	60-87
Steam temperature (°C)	260-380	480-520
Steam requirement (kg/ton of cane)	480-600	350-400
Electrical power generation (kWh/ton of cane)	10-20	100-150
Electrical power consumption (kWh/ton of cane)	10-20	25-35

Sugar mills in Africa in general and those in assessed countries have undergone some rehabilitation and upgrade in recent years. However, this has been mainly driven by the business interest of sugar companies, and thus the improvements achieved are reported to be limited. Two critical bottlenecks in switching to higher energy and resource efficiency are (i) the proper management of bagasse, and (ii) the availability of grid export infrastructure.

Traditional low-pressure systems enable burning all bagasse produced, avoiding the need for any additional waste treatment method to handle it. In an energy-efficient system, there will be excess bagasse, which can be used for electricity generation. In the absence of incentives and a conducive grid export environment, the safe disposal of this surplus bagasse becomes a significant challenge; therefore, sugar mills do not have many opportunities to be switched to modern energy-efficient systems. Table 5 presents the potential and actual installed capacity of cogeneration systems in assessed countries (at existing sugar mills' cane crushing capacities).

Table 5. Potential and installed cogeneration capacity

Country	Estimated cogeneration potential (MW)	Installed cogeneration capacity (MW)	Any excess power export to grid?
Côte d'Ivoire	33	Not known	No
Nigeria	Not applicable	Not applicable	No
Kenya	198	116	Yes, but limited
Tanzania	67	59	Yes, but limited
Mozambique	88	20	Yes, but limited
Madagascar	20	Not known	No

SUGAR SECTOR SCENARIO

Among assessed countries, the installed cogeneration capacity is close to optimum in Tanzania. However, it is observed that only one sugar mill (Tanganyika Sugar Mill) has obtained a power export license, and supplies power to the grid. The power export to the grid from sugar mills is limited in Kenya and Mozambique as well, due to bagasse management challenges and the need for supportive grid export policies. As Nigeria is mainly involved in refining imported raw sugar, there is not enough bagasse available for cogeneration. The existing sugar mills depend on natural gas-fired systems for the steam and electricity requirements. As per Dangote Sugar, their Numan sugar plant is expected to generate 6 MW of electricity from bagasse, and supply it to sugar mills and nearby communities.

In the current scenario of limited grid export opportunities, sugar mills in assessed countries are noted to employ the following alternative methods:

- Cogeneration plants also take care of electricity for the staff quarters, irrigation, and energy needs of nearby communities associated with the sugar mills, by operating at current capacity, inefficiently burning all bagasse generated.
- The cogeneration power plant is operated at "under capacity" since there is no power purchase agreement (PPA) and an attractive feed-in-tariff for biomass electricity, which would facilitate the uptake of excess electricity by the grid utility.
- Excess bagasse is used for mulching in sugarcane cultivation lands, or sold in the market as boiler fuel to other sugar mills or industries.

Energy performance details of sugar mills are not available. A specific study to evaluate equipment specifications, modes of operation, and energy efficiency of individual sugar mills could offer deeper insights into their current energy performance and help identify concrete interventions for enhancement.

2.5 SECTOR EXPANSION PLANS AND ONGOING INITIATIVES

The sugar sector in each assessed country is subject to different socioeconomic and political conditions. These have implications for the regulations in the sugar sector as well. Table 6 presents key stakeholders in the market regulation of the sugar sector.

Table 6. Key stakeholders in sugar market regulation

Country	Gap in sugar supply (tons/year)	Sugar import expenses ($ million/year)
Côte d'Ivoire	• Ministry of Agriculture and Rural Development • Minister of Commerce, Industry and SME Promotion	• Association des Industries Sucrières de Côte d'Ivoire (AIS-CI)
Nigeria	• National Sugar Development Council (NSDC), under the Federal Ministry of Industry, Trade and Investment	• Manufacturers Association of Nigeria (MAN)
Kenya	• Sugar Directorate under the Ministry of Agriculture, Livestock, Fisheries and Irrigation	• Sugar Research Institute (SRI) • Kenya Society of Sugarcane Technologist (KSSCT) • Kenya Union of Sugarcane Plantation and Allied Workers (KUSPAW)
Tanzania	• Sugar Board of Tanzania (SBT), under the Ministry of Agriculture, Food Security, and Cooperatives	• National Sugar Institute (NSI) • Tanzania Sugarcane Growers Association (TASGA) • Tanzania Sugar Producers' Association (TSPA)
Mozambique	• Ministry of Agriculture and Rural Development • Ministry of Industry and Commerce (MIC)	• Association of Sugar Producers of Mozambique • National Sugar Distributor (DNA)
Madagascar	• Malagasy Cane and Sugar Centre (CMCS), governed together by the Ministry of Industrialization, Trade and Consumption, and the Ministry of Agriculture and Livestock	-

Côte d'Ivoire

Côte d'Ivoire aims for self-sufficiency in sugar production by 2025. The Government and sugar mills have committed to increase sugar production capacity to match its domestic demand by that year. Both Sucaf and Sucrivoire sugar mills have developed plans to mobilize investments and other resources needed for capacity expansion. As per Sucrivoire estimates, the capacity expansion would cost them around $130 million (OXF 80 billion) to develop infrastructure across the cane production and processing chain. Similarly, Sucaf plans to invest around $396 million (OXF 243 billion) over the next five years to increase its production capacity.

Nigeria

In 2012, the Government of Nigeria approved the Nigeria Sugar Master Plan (NSMP), in order to achieve at least 70 per cent self-sufficiency by 2023. According to the NSMP, 224,000 hectares of land should have been planted to supply sugarcane to 28 sugar factories, where over 112,000 new jobs (both permanent and casual) would be created to reach the target of 1797 million tons of sugar produced. Recently, the Government extended the Plan through 2033 with a framework to address varied implementation challenges, such as perennial disagreements between host communities and investors over land ownership, and other associated infrastructural impediments. Dangote Sugar, BUA Foods, and Golden Sugar have made significant investments with a total combined investment of $1 billion as of 2022. In December 2022, the Government launched a $73 million intervention fund for sugar sector irrigation. The fund aims to boost the development of irrigation infrastructure for sugar plantations and sugarcane outgrower farms. The six beneficiary sugar plantations are in Numan (Adamawa State), Sunti (Niger State), Lafiagi (Kwara State), Bacita (Kwara State), and Toyo and Tunga (Nassarawa State).

Kenya

The Kenyan sugar sector is currently facing several challenges, such as high production costs, decreased yield, high debt, and a shortage in sugarcane supply. In the wake of this situation, the Government of Kenya assigned a Sugar Industry Stakeholders Task Force to assess the challenges and propose directions for future actions. The Task Force submitted its findings report in 2020 with a possible strategy to revitalize the sugar sector. The Government announced that it is fully committed to implementing those recommendations, including the privatization of all five public sugar mills. The important strategies proposed by the report include:

- increasing cane, sugar production, and productivity to enhance sugar industry competitiveness;
- enhancing milling efficiency and competitiveness of sugar and its co-products;
- promoting favourable sugar marketing and trade;
- complying with the Common Market for Eastern and Southern Africa (COMESA) recommendations;
- pricing and funding a mechanism that enhances income to stakeholders;
- enhancing taxation structures in the sugar sector to create incentives for investment;
- executing policy, regulatory, and institutional reforms;
- improving the competitiveness of public-owned sugar mills.

There is an increased private sector investment in the Kenyan sugar sector, as observed by several new mills installed between 2011 and 2018. A few more mills listed below are also under consideration or in the pipeline:

- West Kenya Sugar Company - Naitiri (3,000 TCD)
- South Gem Sugar Company - West Gem, Siaya (1,000 TCD)
- Tembo Sugar Mill - Kisiki (1,500 TCD)
- Seal Sugar Mill - Siaya (1,250 TCD)

Tanzania

Tanzania has a vast range of uncultivated lands across different regions that are favourable for sugar cane farming. Some of the potential regions identified for the expansion of existing farmlands and new cultivation include Kagera, Tanga, Pwani, Kilimanjaro, Arusha, Morogoro, Mbeya, Katavi, Mtwara, Lindi, and Zanzibar. There has been an uptake of block farming practices for improved resource efficiency, productivity and

financial returns in sugarcane farming. Kilombero Sugar Mill has successfully demonstrated these techniques among its outgrowers.

The Government of Tanzania aims to attain self-sufficiency in sugar production by 2025. The Sugar Board of Tanzania (SBT) is planning to build three mini-sugar plants in Kilosa, Kilombero, and Mvomero districts, according to the five-year Sugar Industry Development Plan. A pre-feasibility analysis has been conducted to assess the potential in these districts. The mini-plants are meant to help in the utilization of the surplus canes that remain uncrushed in each season. One potential investor has been identified to set up a 160 TCD sugar mill in Mikumi. As an effort from its side, Kilombero Sugar Mill plans to increase its production capacity as presented in Table 7.

Table 7. Kilombero sugar mill (Tanzania) expansion plan

Aspects	Unit	Current situation	Target condition
Sugar production	tons/annum	127,000	271,000
Sugarcane supply	tons	600,000	1,700,000
Outgrowers numbers	Nos	7,500	Between 14,000 and 16,000
Ethanol production	kilo-litre/day	4,000	16,000

Tanzania's National Investment Steering Committee (NISC) has recently approved some key projects falling under the Government's priority sector of agriculture and industries, including:

- Bagamoyo Sugar Limited, Pwani; developed by Bakhresa Group of Companies (1,400 TCD)
- Mkulazi Sugar Company, Morogoro; promoted by National Social Security Fund and Prison Corporation Sole (1,000 TCD)

Moreover, TARI-Kibaha is promoting research on the best sugarcane seeds that will be able to sustain different climatic conditions to support farmers overcome low yields. The Tanzania Official Seed Certification Institute (TOSCI) is working to develop seed certification standards for sugarcane to enable vital economic crops to be regulated in the country[12]. Currently, the different sugar varieties are imported mostly from South Africa and India.

Mozambique

Though Mozambique is a sugar surplus nation, sugar consumption in the country is increasing, and there is a need to increase sugar production capacity to meet future demands. Traditionally, the sugar sector has been dependent on sugarcane production from the estates owned by sugar mills. The current cultivation area of around 48,000 ha under sugar mills can generate about 3.84 million tons of sugarcane. However, to reach the full capacity of existing installation, the total area of cultivation needed (both sugar mills and outgrowers) is around 66,250 ha, i.e., an additional 18,520 ha of cultivation area needs to be established (for existing sugar mill capacity alone). This marks the importance of outgrowers in the expansion of sugarcane production in the country. Tongaat-Hulett has launched a project to support small-scale sugar farmers budgeted at $4.3 million, which is supported by the European Union (EU) and the Botswana-based ABC Bank.

[12] https://furtherafrica.com/2020/07/09/tanzania-to-develop-seed-certification-standards-for-sugarcane/#:~:text=TARI%20Director%20General%2C%20Dr%20Godfrey,have%20been%20certified%20for%20irrigation (last accessed on January 4, 2023).

The project will enable farmers to achieve yields of 100 tons per ha. Other sugar mills, like Maragra Sugar and Illovo Sugar, are also working with farmers to increase sugarcane production.

Madagascar

The Government of Madagascar launched the "one district one factory" policy in 2021. The focus is to promote investments and private sector participation in medium and small-scale manufacturing enterprises (MSMEs), and one of the priority sectors is that of agro-processing industries. The sugar sector can immensely benefit from the initiative for its various products (sugar, ethanol, rum, electricity), and in terms of contributions to other sectors, such as clean cooking, transportation, and power. In line with this, the Government's focus is to promote semi-industrial scale sugar mills in different regions. There are a few operational mills in semi-industrial scale, such as the PAACO[13]/UGPCSB[14] plant operated by farmers co-operatives. In July 2022, the President of Madagascar inaugurated the Antanamifafy sugar refinery (a semi-industrial scale plant), located in the rural commune of Ambalakida, in the Mahajanga region. The Antanamifafy sugar mill has chosen to make brown sugar of superior quality. It can produce up to 4.5 tons per day, and has a total production capacity of 675 tons per year, a quantity that can cover the needs of the Boney region.

The country has an ongoing Agriculture, Livestock, and Fisheries Sector Programme (PSAEP 2015-2025), which aims to transform Madagascar into the granary of the Indian Ocean, and to reach the goal of zero hunger by 2025. To optimize ethanol production in the country, the Ministry of Industrialization, Commerce and Consumption (MICC) is collaborating with the Ministry of Agriculture and Livestock (MINAE) to increase the production of ethanol feedstock (sugarcane, cassava, sisal, etc.), and to develop areas of industrial nurseries to subsequently increase the transformation of feedstock into bio-ethanol. As part of this, it is important to mobilize the other ministries concerned to set up the institutional framework on ethanol at the country level. There is also an upcoming project in the northern part of the country with a capacity of 80,000 litres of bio-ethanol per day from sugarcane juice.

Earlier studies have identified a potential for establishing sugarcane cultivation zones in different regions. The EU-funded UNIDO project "Support to the semi-industrial processing of sugar cane" was implemented between 2013 and 2022. The project has carried out detailed studies on different sugar sector supply chains and their business potential. It has identified potential cultivation zones and targeted to establish semi-industrial processing units for sugar, rum, and ethanol production. The project has developed two semi-industrial units at Antanamifafy and Mahatalaky so far. Other assistance offered by the project includes capacity building and skill development training for farmers and entrepreneurs, and market and business development support.

[13] Produits Agricoles et Artisanaux de la Côte Orientale (Cooperative of Agricultural and Artisanal Products of the Eastern Coast).

[14] Union des Groupements des Producteurs de Cannes à Sucre Biologique (Union of Organic Sugar Cane Producers Groups).

Box 2. Need for climate-resilient farming practices

The impact of natural disasters and other climate change events has affected sugarcane cultivation in a similar way to other crops. For example, a tropical cyclone that hit Mozambique caused severe floods in the Maputa province, affecting more than 15,000 ha of sugarcane plantations. Damage evaluation indicates that around $15 million (one billion MZN) will be needed to recover the lost sugarcane plantation area. Such damages deter the livelihood of farmers and business operations of sugar mills, leading to a temporary halt of any expansion plans. In the case of Madagascar, the southern parts of the island were hit by prolonged drought between 2018 and 2022, resulting in the loss of over 60 per cent of all crop cultivations. millions of people were affected by hunger and pushed into poverty. These events indicate that there is a need for climate-resilient farming practices in African countries.

One of the success stories from the assessed countries is the "block farming practice" for sugarcane cultivation promoted among small-holder farmers in Tanzania. Block farming enables shared ownership over a contiguous farming area of small farms to take advantage of economies of scale via the collective management of various inputs and infrastructure investments. The lessons learned and best practices in block farming practices in the sugarcane cultivation of Tanzania can be scaled up in other African countries.

3. Potential for Product Diversification

Traditionally, the sugar sector in most developing countries has relied only on one single revenue stream, namely the production and sale of sugar. This has affected the business operations of sugar mills when there are fluctuations in the sugar market prices and demand. Product diversification within the sugar industry can offer a multitude of benefits, including additional revenue for sugar mills, as well as higher price opportunities for farmers' produce. At the economic level, this also translates in the adoption of a circular economy, more job creation, enhanced access to clean energy, and a significant reduction in GHG emissions. The key by-products from the sugar production process are:

- *Bagasse:* It is the dry and fibrous material that remains after crushing. Sugar mills use bagasse as the primary fuel source to generate electricity to meet the electrical demand of the industry through the cogeneration process, and supply the excess electricity generated to the grid.
- *Molasses:* It is the dark, sweet, and syrupy by-product traditionally used as a sweetener and as feedstock for alcohol production.
- *Press-mud:* It is a nutrient-rich organic matter used as a natural fertilizer for agricultural purposes.

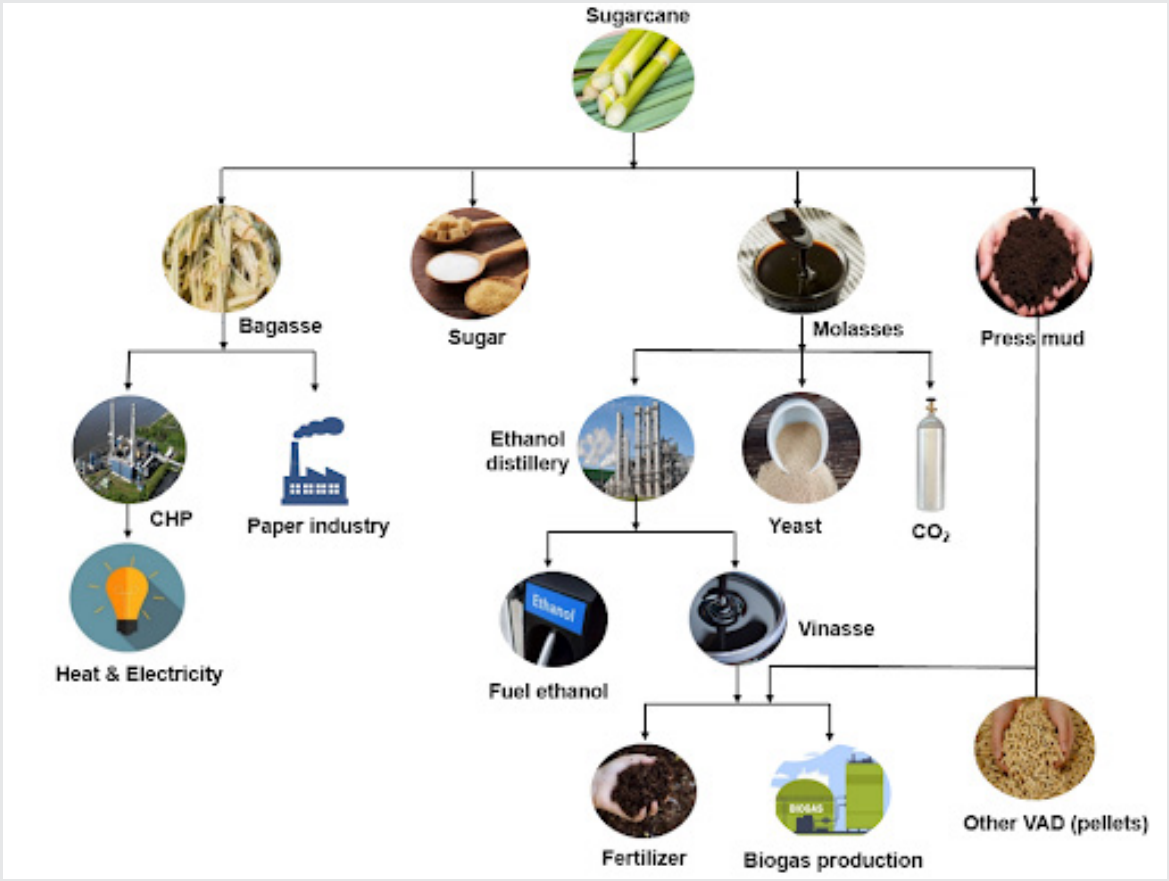


Figure 7. Potential for product diversification in the sugar sector

Note: *CHP: combined heat and power; VAP: value-added products.*

Fortunately, all wastes and by-products from the sugarcane processing have some commercial value, and thus are utilized within the sugar mills and other processing industries. Apart from the bio-energy potential through bagasse and ethanol, other avenues such as paper, fertilizer, and beverage production are practised worldwide as means of diversifying the revenue opportunities for sugar mills. Products such as packaged drinking water, dry yeast, CO_2 bottling, fly ash and bricks, organic fertilizer, bagasse briquettes and pellets, and bottled biogas can also be explored based on market conditions. Figure 7 presents different value-added products from the sugar value chain.

At present, molasses is used in the production of organic fertilizer, animal feed, alcohol, and carbon dioxide for carbonated drinks, and a small quantity is exported as well by assessed countries. Despite such market developments, consistent efforts for improved production diversification are still needed. Except for Kenya and Tanzania, none of the assessed countries seem to have explored these potentials so far. Even in Mozambique, where sugar production is in surplus, none of the sugar mills have installed ethanol distilleries.

3.1 EXPERIENCE IN KENYA

Some of the sugar mills have already taken initiatives on product diversification, such as:

- Mumias sugar mill – Combined heat and power (CHP), ethanol, packaged drinking water
- Kibos sugar mill – CHP, ethanol, paper
- Kwale – CHP, ethanol

Around 70 million litres of ethanol can be produced from the sugarcane currently crushed in Kenya. However, only 40 million litres of ethanol is expected to be currently produced due to poor molasses distribution and improper regulations on the distribution of molasses. The Kenyan ethanol production is handled by individual distilleries and those integrated with sugar mills. The sugar mills having ethanol distilleries are Kibos Sugar, Mumias Sugar, and Kwale International Sugar (KISCOL). The individual distilleries purchase only small quantities of molasses from local sugar mills, and import large quantities from neighbouring countries like Uganda, Tanzania, and Egypt for cost-effectiveness. The individual ethanol distillers in Kenya are Agro Chemical & Food Company (ACFC), Spectre International, and London Distillers. ACFC and KISCOL are the major players in ethanol production, with a production capacity of 60,000 litres per day (lpd) and 30,000 lpd, respectively.

3.2 EXPERIENCE IN TANZANIA

The Kilombero sugar mill in Tanzania has an installed capacity of 12 million litres of ethanol per year (48,000 lpd), and is expected to increase it to 16 million litres of ethanol per year (64,000 lpd). Tanganyika Sugar Mill uses bagasse for electricity generation with a capacity of 20 MW, and exports around 10 GWh to the grid annually after meeting its internal demand.

3.3 EXPERIENCE IN MADAGASCAR

The production of alcoholic beverages from cane juice is widely practised in the country. The traditional rum or "toaka gasy" is produced at an artisanal scale with no specific quality standards. It is of poor quality, and is often fatal to consumers as the methanol produced during the process is not removed. Thus, it is illegal to produce and trade toaka gasy in the market. There is no official record available on its current production levels. However, due to its connection with people's culture, it is widely produced by artisans. Apart from this, there are commercial rum production plants in Madagascar. They produce food quality rums and alcoholic beverages from sugarcane for domestic consumption, as well as for export. Thus, there is an established market for rum production offering job opportunities and promoting tourism.

The lessons learned and best practices from sugar mills in these African countries and the rest of the world, like Brazil and India, can be studied for further replication in the assessed countries.

Box 3. UNIDO's initiatives in Tanzania and Madagascar

Tanzania ethanol-based clean cooking program: Through funding from the Global Environment Facility (GEF), UNIDO has rolled out the ethanol cookstoves program to distribute at least 500,000 stoves in the country within 2025. If implemented, this would generate a demand for around 138 million litres of bio-ethanol per year. A draft standard for ethanol cookstoves is being developed and under review by the TBS.

Madagascar semi-industrial sugar processing project: The EU-funded UNIDO project was implemented between 2013 and 2022. The project has carried out detailed studies on different sugar sector supply chains and their business potential. It identified potential cultivation zones and targeted to establish semi-industrial processing units for sugar, rum, and ethanol production. So far, the project has developed two semi-industrial units at Antanamifafy and Mahatalaky. Other assistance offered by the project includes capacity building and skill development training for farmers and entrepreneurs, and market and business development support.

3.4 MODELLING SUGAR MILL MARKET DIVERSIFICATION

To understand the best-case operation of a sugar mill, a theoretical model of sugar mill operation and potential market diversification is shown in Table 8. For this purpose, three scenarios are considered:

- Scenario A: Business-as-usual sugar production (cogeneration satisfying only sugar mill needs)
- Scenario B: Sugar production + cogeneration with excess power export to the grid
- Scenario C: Sugar production + cogeneration with excess power export to grid + ethanol production

The annual outputs are calculated mainly for sugar, bagasse, molasses, ethanol, and vinasse-based biogas generation. Other products have less economic value (dry yeast: $3.5/ton, CO_2: $27/ton, briquettes: $100/ton, organic fertilizer: $60/ton), and can be subject to wider market fluctuations, therefore not taken for this analysis. It is to be noted that revenue from sugar production is significant in all cases. A 5,000 TCD sugar mill is considered an average size for this analysis.

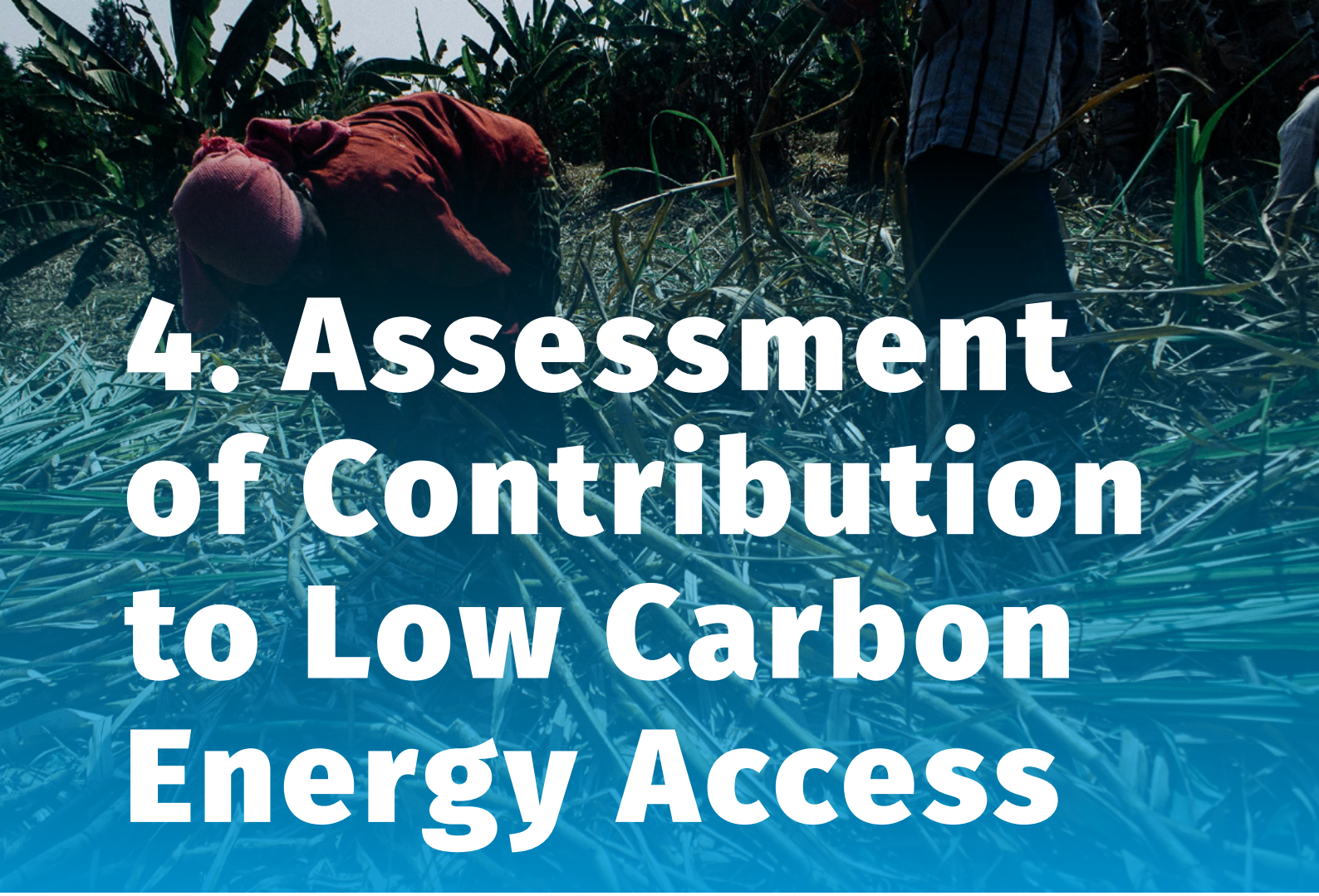
Table 8. Model sugar mill market diversification

Scenario	Scenario A	Scenario B	Scenario C
Capacity (TCD)	5,000		
Annual sugarcane requirement (tons)	1,300,000		
Annual sugar production (tons)	130,000		
Annual molasses production (tons)	39,000		
Annual ethanol production ('000 litres)	NA	NA	12,168
Annual electricity generation (MWh)	34,947	124,810	124,810
Annual electricity export (MWh)	NA	89,863	89,863
Revenue streams			
Sugar (million $) (@ $800/ton)	104	104	104
Molasses (million $) (@ $60/ton)	2.34	2.34	NA
Power export (million $) (@ $0.10/kWh)	NA	8.99	8.99
Ethanol (million $) (@ $1.37/litre)	NA	NA	16.67
Total revenue (million $/year)	106.34	115.33	129.66
Potential increase in revenue	-	8%	22%

Scenario	Scenario A	Scenario B	Scenario C
Emission reduction avenues			
Electricity generation (fossil fuel power plant replacement) (tCO_2/year)	NA	58,816	58,816
Cooking fuel replacement (tCO_2/year)	NA	NA	146,016
Transport fuel replacement (tCO_2/year)	NA	NA	27,976

Revenue from cogeneration facilities is low compared to ethanol stream, but the purpose of cogeneration at the sugar mill complex ensures energy independence and security. The optimal sizing of the cogeneration facility will enhance the operations of the sugar mill complex. Capital and operational costs have high variance, and need extensive analysis: therefore, they are not included here. Regarding environmental benefits, GHG emissions are calculated for various scenarios. The financial benefits from the environmental interventions indirectly help the operations and minimize unplanned shutdowns. GHG emissions considered are mainly from fuel replacement and waste management practices. The highest CO_2 emission reduction is for cooking fuel (charcoal) replacement, followed by fuel replacement for electricity and transportation.

Returns from the milling operation are optimal when the sugar mill incorporates basic elements, like cogeneration and ethanol distillery in its configuration. It is important to highlight that the best financial return could be reaped if the infrastructure has planned to accommodate all these facilities, even if they are implemented in stages. This practice will reduce the financial risks associated with intensive capital requirements. Timing for an upgrade should consider the sugarcane production forecasts and other market factors, like droughts and geopolitics. A detailed analysis of the financial models will yield more accurate insights.



4. Assessment of Contribution to Low Carbon Energy Access

The sugar sector can contribute significantly to the low carbon pathways of assessed countries through three ways: (i) bagasse-based clean electricity generation, (ii) bio-ethanol-based clean cooking, and (iii) bio-ethanol blending in transport fuels. This section shares the results of the assessments carried out for these benefits in each assessed country.

4.1 BAGASSE-BASED CLEAN ELECTRICITY GENERATION

The bagasse is the dry fibrous waste generated in large volumes after sugarcane is crushed to obtain cane juice for sugar production. Bagasse is burned to produce electricity and steam in the sugar mill. Most sugar mills use 50 per cent of bagasse for their steam and electricity demand, and give the surplus bagasse for biogas generator, animal feed, or fertilizers. However, bagasse generation is only during milling season. For electricity generation and export all around the year, bagasse shortage is a major problem, and could be addressed through proper bagasse management by the sugar mills. In addition, sugar mills can look for other biomass feedstock during off-seasons to operate the power plant. Bagasse drying is another notable intervention that could enhance system's efficiency. Table 9 presents the potential for bagasse-based electricity generation in different countries (at full implementation of expansion plans for Nigeria, and 100 per cent of current installed capacity for others). As the grid export may not be feasible in the immediate term in most assessed countries, the revenue from power sales is based on off-grid or mini-grid export and relevant willingness to pay.

Table 9. Bagasse-based electricity generation potential

Aspect	Unit	Côte d'Ivoire	Nigeria	Kenya	Tanzania	Mozambique	Madagascar
Installed capacity	TCY	2,000,000	19,400,000	13,845,000	4,300,000	5,300,000	900,000[15]
Bagasse production	Tons/ year	600,000	5,820,000	4,153,500	1,290,000	1,590,000	270,000
Cogeneration potential	MW	33	277	198	67	88	20.85
Electricity generation	GWh/ year	204	1,706	1,429	413	540	91
Potential for grid/off-grid export	GWh/ year	147	1,288	1,000	297	389	66
Revenue from power sale	million $/year	15	128	60	29	39	16

It is to be noted that almost all these countries currently lack appropriate policies, attractive power purchase agreement (PPA) terms, and transmission infrastructure to encourage excess power export to the grid. Even if grid export is not possible, Governments and sugar mills can explore opportunities with off-grid or mini-grid development, and supply of electricity to surrounding industries and communities. Given that there is a limited national grid network, electricity access in most assessed countries is very low, especially in the rural areas. Even sugar farmers often do not have access to a reliable electricity supply. Under these conditions, bagasse-based electricity generation and export to nearby communities through a mini-grid can be life-changing for rural households.

4.2 MOLASSES-BASED BIO-ETHANOL GENERATION

In general, around 30 kg of molasses would be produced from 1 ton of sugarcane crushed, and 1 ton of molasses can produce around 300 litres of bioethanol. All assessed countries have a high potential for bio-ethanol generation from the molasses produced in sugar mills. It is being practised at a limited scale in Kenya, Tanzania, and Madagascar. However, more information on successful business operations and current performance level of distilleries in these countries is not available. Table 10 shows the available bio-ethanol generation potential in assessed countries.

[15] Based on capacity of operating sugar mills and not sugarcane production.

Table 10. Potential for bio-ethanol generation

Aspect	Unit	Côte d'Ivoire	Nigeria	Kenya	Tanzania	Mozambique	Madagascar
Installed capacity	TCY	2,000,000	19,400,000	13,845,000	4,300,000	5,300,000	1,300,000
Molasses production	tons/ year	60,000	681,400	415,350	129,000	159,000	27,000
Bio-ethanol generation	million litres/ year	19	170	130	40	50	14[16]
Revenue from bio-ethanol sale	million $/year	26	232	178	55	68	20

Bio-ethanol price for the above analysis is assumed to be $1.37 per litre. The imported bio-ethanol may be cheaper than this. But for the initial years of bio-ethanol promotion in these countries, this cost level of bio-ethanol is considered appropriate.

4.2.1 Contribution to the Clean Cooking Sector

The majority of the population in all assessed countries depends on polluting fuels, mainly charcoal, for cooking. Most of the charcoal consumed is produced through informal and uncontrolled supply networks that use low-yield technologies. This has led to a severe loss of woodlands and forestlands. The Governments also have the goal of achieving 100 per cent clean cooking access by 2030, and are promoting several initiatives on this front.

Bio-ethanol cook stoves have been promoted by UNIDO in Tanzania since 2020. So far, around 10,000 ethanol cook stoves have been distributed, and around 200,000 litres of bio-ethanol have been supplied. The project expects to achieve a distribution of 500,000 stoves by 2025.

In collaboration with the Government of Madagascar, the World Bank has targeted to distribute 35,000 ethanol-fuelled cookstoves by 2023. The project will also help train local partners, government and local entrepreneurs in setting up their ethanol micro-distilleries to produce ethanol and sell it as fuel. Around 7,600 stoves were distributed, and one local distillery was built in 2019 under this initiative. The initiative is also expected to generate around 1.1 million certified emission reductions (CERs), and the carbon finance from the sale of CERs will help to provide the cookstoves and ethanol fuel at an affordable price. Under Project Gaia, Clean Cooking Madagascar (CCM), a non-governmental organization (NGO) based in Antananarivo, has called for proposals to start a pilot ethanol micro distillery (EMD) with a capacity of 2,000 to 5,000 litres/day of ethanol production (current status of the initiative is not available). The pilot EMD will serve to meet the demand for 100,000 ethanol cookstoves in the next five years, and will also serve as a training facility to increase the number of EMDs in the country.

[16] From molasses and directly from cane juice in the specific case of Madagascar.

In Kenya, private collaborations like Koko, Moto Safi, and Leocome are actively involved in establishing the infrastructure for bioethanol cookstoves and their associated value chains. For example, KoKo is installing an automatic vending machine for dispensing ethanol. The Kenya Renewable Energy Association (KEREA) has recently published the Kenya Ethanol Cooking Fuel Masterplan (2021), which puts forth several action plans for the promotion of bio-ethanol in the country. Moreover, the Council on Ethanol Clean Cooking (CECC) was launched at the Conference of the Parties 27 (COP 27) in Egypt, jointly by Mali, Ivory Coast, Madagascar, and Kenya, as a multi-stakeholder platform to share information and experience, including best practices to create a sustainable bioethanol industry and associated value chains for clean cooking in member countries. Mozambique and Nigeria are at the initial stage of promoting ethanol-based clean cooking.

Box 4: Need for clean cooking investments in Africa

Though African countries have actively promoted access to improved and clean cooking practices, the rate of adoption remains low. The annual average increase in access in Sub-Saharan Africa is only around 1 per cent when compared to 4 per cent in Asian countries. This access rate is lower than the growth rate of the population in the region. Thus, there will be around 980 million people without access to clean cooking by 2030. As per the IEA estimates, over $8 billion is needed annually for clean cooking programs worldwide, and almost half of this ($4 billion per year) is needed for Sub-Saharan Africa itself. In a 100 per cent clean cooking access scenario by 2030 developed by IEA, biogas and ethanol together are expected to serve the cooking needs of nearly 20 per cent of the population.

Source: A vision for clean cooking for all, IEA, 2023.

4.2.2 Contribution to the Transportation Sector

All assessed countries are experiencing a rapid growth in the number of vehicles, especially passenger vehicles, and they are net importers of petroleum products. The import of petroleum products has been a major expenditure in the State budget. For example, the Government of Madagascar has been offering fuel subsidies since 2019 to maintain the market fuel prices against international oil price fluctuations. It is reported that the fossil fuel market prices are one of the lowest in Africa, and increasing global oil prices result in an increased fuel subsidy budget to the Government. The National Treasury and Planning Cabinet of Kenya highlighted that fuel accounts for 20 per cent of the country's import bill, and the volatile international oil prices expose Kenya's open economy to the risk of imported inflation. The consumption of fossil fuel in the transportation sector also significantly contributes to national GHG emissions.

Kenya has long worked on bio-fuel blending policies and targets. However, it has not materialized them so far due to several challenges. Similarly, Tanzania's first biofuel strategy was introduced in 2009, aiming to enable bioethanol production and promote ethanol blends in the country's transportation sector to lessen the country's reliance on oil. However, the initiative did not take shape due to challenges in feedstock production and technology availability, including no commercial scale demonstration in the region. The focus in the transportation sector regarding fuel has shifted towards the transition to natural gas, and efforts for fuel blending remain halted.

No support scheme has yet been formalized in Côte d'Ivoire for the blending of biofuel in the fuel used in transportation as well as industries. However, the National Action Plan for Renewable Energy (PANER) (2016-2030) has set the target of 5 per cent of biofuel blending in both diesel and petrol consumption.

Mozambique released the National Biofuels Policy and Strategy (NBPS), and the biofuel regulations were sanctioned in 2011 to cover aspects like production, storage, distribution, and sales. The regulations also aim to introduce biofuel blends (E10, B3) into fossil fuels by 2015. Despite these initiatives, the implementation of the biofuel policy has been delayed due to market challenges.

The Nigerian Government implemented the Nigerian Biofuel Policy with incentives in 2007, but little progress has been made since it was released. Another policy named Biofuel Blending Mandate policy from 2013 is still active. This policy aims to develop the domestic biofuels industry and decrease country's reliance on gasoline imports. Its mandates are blending ethanol up to 10 per cent with petrol to achieve the E10 blend, and 20 per cent blend of biodiesel with diesel.

Table 11 presents bio-ethanol requirements of transportation for 5 per cent (E5) bioethanol blending scenarios in petrol consumption in assessed countries.

Table 11. Ethanol requirement for blending

Aspect	Unit	Côte d'Ivoire	Nigeria	Kenya	Tanzania	Mozambique	Madagascar
Petrol consumed	million litres/ year	1,322	1,500	1,770	900	483	150
Bio-ethanol required	million litres/ year	66	75	88	44	24	7.5
Molasses required	tons/ year	211,859	240,400	282,051	142,878	77,503	24,038
Sugarcane required	tons/ year	7,061,966	8,012,800	9,455,100	4,762,000	2,583,440	801,282
Forex saved	million $/year	86	60	115	30	16	4

In Kenya, Mozambique, and Madagascar, current sugarcane production can be sufficient to meet the E5 bio-ethanol requirement. In other countries, all these E5 scenarios cannot be met through sugarcane alone, and other bioethanol feedstock can be explored along with the import of bioethanol.

4.3 VINASSE BASED BIO-GAS GENERATION

The wastewater from sugar processing is fed into the digester to generate biogas. Similarly, the vinasse waste from ethanol production using molasses is treated using an anaerobic digester to produce biogas. The vinasse-based biogas facility will help the sugar industry/ethanol distillery to achieve Zero Liquid Discharge (ZLD) and ensure that the environmental safeguards are followed. Due to its high Biological Oxygen Demand (BOD) (range between 35,000 and 50,000 mg/L) and Chemical Oxygen Demand (COD) (range between 100,000 and 150,000 mg/L), vinasse could be a potential contaminant to the environment when it is not disposed of appropriately.

Table 12. Bio-gas generation potential

Aspect	Unit	Côte d'Ivoire	Nigeria	Kenya	Tanzania	Mozambique	Madagascar
Installed capacity	TCY	2,000,000	19,400,000	13,845,000	4,300,000	5,300,000	1,300,000
Bio-ethanol generation[17]	million litres/ year	19	170	130	40	50	14
Vinasse production[18]	million litres/ year	225	2,040	1,560	482	595	176
Biogas generation[19]	million m3/year	3.37	30	23	7.24	8.93	2.65

Table 12 illustrates the potential for biogas generation from vinasse management. For the purpose of estimation, it is assumed that biogas is only generated from the by-product of bioethanol production (i.e., the vinasse). The biogas generated from the wastewater treatment of sugar mills is not considered in the assessment. The biogas produced can be harnessed for electricity generation using gas engines, for heating needs in ethanol plants and industries, and for cooking purposes for nearby households.

[17] From table 8.

[18] Assumption: One litre of bio-ethanol generates 12 litres of vinasse.

[19] Assumption: One ton of vinasse can generate 15 m^3 of biogas.

5. Key Challenges and Opportunities

Despite the potential for economic development and food security offered by the African sugar sector, there are some key barriers and challenges. These limit the timely achievement of sugar sector expansion plans and the full capacity utilization of existing plants. Inadequate readiness and policy support in energy, clean cooking and transportation fuels sectors also hamper the exploitation of low-carbon energy that the African sugar sector can offer.

a) Availability of agricultural lands for further expansion

It is reported that the outgrower schemes implemented in existing sugar mills have led to land scarcity. Crop farmers raise the concern that the predominance of cane cultivation makes it difficult to find farmlands for other croplands. Also, the attractiveness of the sugar sector makes farmers switch to cane cultivation where other crops, such as paddy, fail as a cope-up mechanism. In the case of Madagascar, one of the world's ecological hot spots, shifting cultivation (also known as slash burn method, or "tavy" in local terms) remains one of the prominent methods of agriculture in the country. The continuous deforestation due to agriculture and cattle pasture is reported to cause habitat loss, and the degradation of soil and water resources.

b) Higher sugar production cost

At present, sugar mills in countries other than Mozambique are unable to meet local demand, both in terms of consumption volumes and competitive production costs. The cost price of local production is higher than the price of imported sugar. Restrictions on sugar import to protect domestic sugar mills tend to penalize local manufacturers, as they need to purchase sugar at a higher cost from the domestic market than imported sugar (which adds to their product price thereby risking loss of price competitiveness). Kenya has the highest cost of sugar production within the Common Market for Eastern and Southern Africa (COMESA) trading block.

c) Ownership of agricultural lands

A large number of farmers do not have any ownership title for the lands they occupy and cultivate. This becomes a major hindrance, as farmers are hesitant to make any additional investment for farming, fertilizers, irrigation, etc., without any assurance of continued possession.

d) Low cane productivity among outgrowers

There are no extension services offered by the ministry or other state agencies to sugarcane farmers and outgrowers. The only assistance they get is through the sugar mills with which they have established a sugarcane supply contract. Sugar mills offer assistance for land preparations, cultivation, fertilizers, and harvesting, among other areas. This also limits the capacity of sugar mills to reach out to a large number of outgrowers for expanding sugarcane cultivation. Outgrowers depend highly on the instructions and guidance of sugar mills for cane cultivation. The economic situation of outgrowers has been deteriorating in recent years. Incomes from sugarcane have declined due to low sucrose levels, and some sugarcane remains unharvested, leading to financial losses and indebtedness in many cases. Other challenges to outgrowers include lack of capital, inadequate agricultural inputs, low quality or duplicate agriculture inputs in the market, and the negative impacts of climate change.

There are no incentives or subsidies for agricultural inputs to encourage farmers to switch to improved agricultural practices. Support schemes on skills, capacity building, and guidance on smart agricultural practices are also missing in order to guide farmers at different stages of land preparation, cultivation, and harvest. This leads to low sugarcane productivity, the use of larger cultivation areas to meet market demand, and an unreliable supply of feedstock for sugar processing.

e) Modernizing sugar processing equipment

Capacity building and skill development are needed at all levels of the supply chain to bring in behavioural change towards improving the energy efficiency of cogeneration systems and ethanol distillers. In addition, adherence to environmental and social safeguard measures becomes challenging in a country like Kenya. The implementation of better bagasse management systems can help address these issues. Sugar companies need access to capital to invest and upgrade the existing cogeneration systems with the energy-efficient ones.

f) Diversification of revenues from sugar sector

Sugar mills must improve energy and resource efficiency, and put the sugar sector by-products to maximum commercial use, so that they can reduce the production cost of sugar to be competitive with the imported sugar. There is a dearth of demonstration plants in Africa from where sugar mills can learn about advanced technologies and best practices.

g) Inadequate regulatory support and uncertainty over policy decisions

In Kenya, it is observed that the Kenya Power and Lighting Company (KPLC) is showing less interest in importing electricity from cogeneration plants, as the energy mix in the grid is already dominated by the RE sources. The terms and conditions of Power Purchase Agreements (PPAs) also seem to be a key challenge to the sugar sector cogeneration power plants. The price offered for power export to the grid is $0.06/kWh, and the penalty for not meeting the export is $0.25/kWh. Since the bagasse supply is subject to seasonal variations and out of control of sugar mill owners, the high penalty (almost three times) for non-supply discourages sugar mills from entering into PPAs with KPLC.

In Mozambique, sugar mills are not ready to invest in ethanol distilleries until they see concrete actions from the demand side (clean cooking or bioethanol blending) for the uptake of their produce.

The sugar industry is also confronted with issues of corruption and mismanagement within its institutions, affecting various aspects such as tendering processes, the issuance of licenses, the activities of sugar importers, milling factories, and traders.

h) High upfront investment and limited access to capital

In general, there is a limited flow of funds from development and climate finance to sugar mills. Sugar companies primarily attract investments from private investors and loans, as well as from the state budget in the case of public-owned sugar mills. This has been a key challenge for semi-industrial sugar mills and micro-ethanol distilleries in Madagascar.

i) Appropriate pricing mechanism for sugarcane

The outgrowers who benefit from the promotion system established by sugar mills have no negotiating power over the sale price at the factory door, and have no mastery of the mechanism used by factories to determine the price. This fact, associated with the absence of a sugarcane reference price and a national-level organization for producers, constitutes an obstacle to the determination of a fair price, and is considered a disincentive for farmers to increase production. Outgrowers have also stated other challenges, such as (i) delays in payment; (ii) limited transparency over determinants of the price paid to them after transportation costs and inputs are deducted; and (iii) failure to inform, before the start of the campaign, of an indicative price for cane. These irregularities do not favour timely planning, and negatively influence the quality of the sugarcane produced.

j) Limited research and development to support innovation

Expenditure on agricultural research and development concerning high-yielding seed varieties, improved land preparation, farming practices, and irrigation systems remains limited and inadequate. Sugar mills actively engage with universities to obtain the research and development support needed in the sugar sector.

Sugar mills in Africa have adopted best practices in cane cultivation. Tanganyika sugar mill in Tanzania has recorded a sugarcane yield as high as 140 tons/ha, the highest in Africa and third highest in the world. However, this needs to be disseminated across African countries, amongst millers and outgrowers. •

6. Investment Needs and Expected Benefits

The actions and investments needed in the sugar sector of each country depend on its current market priorities, readiness of policy frameworks, and regional scenario. The countries in Eastern Africa —Kenya, Tanzania, and Mozambique— have relatively competitive regional markets with well-developed sugar markets. The countries in Western Africa —Nigeria, and Côte d'Ivoire— have less significant sugar production. The island nation of Madagascar has limitations to market access, and is not aiming for self-sufficiency shortly.

6.1 COUNTRY PRIORITIES AND INVESTMENTS NEEDED

Table 13 presents a summary of priorities and investments needed in each country.

Table 13. Country-wise priorities and investments needed

Country	Sugar sector priorities	Investment needed
Côte d'Ivoire	• Expanding sugar production capacity to attain self-sufficiency • Improving outgrower engagement for increasing sugarcane cultivation • Encouraging climate smart-agriculture practices • Modernizing sugar processing equipment for resource efficiency • Introducing bio-ethanol policies to create market demand	• $700 million to achieve self-sufficiency and business competitiveness for sugar sector development • $90 million for the mobilization of ethanol distilleries
Nigeria	• Increasing sugarcane production and attaining 70 per cent capacity utilization • Improving outgrower engagement for increasing sugarcane cultivation • Assisting in implementing the 2012 Nigerian Sugar Master Plan (NSMP)	• $2,160 million for implementing 28 sugar mills as per NSMP
Kenya	• Increasing sugarcane production and attaining 100 per cent capacity utilization • Modernizing sugar mills to reduce production costs • Encouraging climate-smart agriculture • Assisting in implementing recommendations from the Sugar Industry Stakeholders Task Force	• $500 million for boosting the sugar supply chain to attain 100 per cent capacity utilization
Tanzania	• Supporting expansion plans of the sugar sector to achieve self-sufficiency • Improving outgrower engagement for increasing sugarcane yield and cultivation • Diversifying ecosystems around sugar mills, such as cogeneration, ethanol distillery, and other associated products • Developing ethanol distilleries to support bio-ethanol-based clean cooking market and blending targets	• $1,300 million to increase the installed capacity of sugar mills by over 13,000 TCD • $300 million for the development of ethanol distilleries and related supply chain

Country	Sugar sector priorities	Investment needed
Mozambique	• Increasing sugarcane production and attaining 100 per cent capacity utilization • Improving outgrower engagement for increasing sugarcane cultivation • Modernizing sugar processing equipment for resource efficiency • Promoting bio-ethanol generation and its use • Encouraging climate-smart agriculture for reduced risks of floods	• $450 million for the modernization of existing mills, expansion of cultivation area, and development of organic sugar production and climate-smart cultivation practices • $75 million as an investment for the mobilization of ethanol distilleries
Madagascar	• Organizing key stakeholders (farmers, sugar producers, vendors, labourers) into a formal market • Promoting semi-industrial units along the sugar supply chain • Boosting the performance of existing industrial-scale sugar mills and their possible capacity expansion • Contributing to other markets of clean cooking, beverage production, and rural energy access	• $400 million to improve existing mills' energy efficiency, establish new sugar mills, and modernize processing technology and sugarcane cultivation practices • $100 million to double the ethanol production capacity and serve the industry, cooking, and transportation sectors for developing ethanol distilleries

6.2 SOCIOECONOMIC BENEFITS

In Mozambique, the sugar sector currently offers employment to around 34,000 people, the second largest industry to offer job opportunities next to the public sector in the country. The Madagascar sugar sector currently employs around 150,000 people directly. This includes around 100,000 farmers, 5,000 employees, and 45,000 workers involved in agricultural labour and traditional rum production. The sugar sector of Kenya contributes to food security, employment creation, regional development, and an improved livelihood for more than 8 million people. According to the Sugar Taskforce report (2020), the sub-sector employs over 400,000 small-scale farmers, who supply over 90 per cent of milled cane. Tanzania's sugar sector currently employs around 75,000 people, both directly and indirectly. This includes around 20,000 farmers, 5,000 sugar mill labourers, and 5,000 contract labourers. In Côte d'Ivoire, Sucaf sugar mill engages nearly 7,000 workers, including 865 permanent workers, 2,578 temporary workers, and 3,000 service providers throughout the sugarcane production and processing season. Similarly, Sucrivoire has 7,400 employees, including around 650 permanent employees.

A summary of tentative estimations that were carried out to explore the socioeconomic benefits that the above-presented investments can deliver to the respective countries in terms of job creation, poverty alleviation, better health, and clean energy access, among others, is illustrated in Table 14.

Table 14. Summary of expected socioeconomic benefits

Unit	Aspect	Unit	Côte d'Ivoire	Nigeria	Kenya	Tanzania	Mozambique	Madagascar
1	Expansion of cane cultivation area	ha	8,000	236,000	-	67,000	20,000	40,000
2	New farmers adopting cane cultivation	Nos	4,000	-	200,000	67,000	10,000	50,000
3	Job opportunities for women and youth	Nos	5,000	171,010	50,000	7,000	20,000	20,000
4	Number of households benefitting from ethanol-based clean cooking	Nos	46,390	-	500,000	500,000	168,000	100,000
5	Population served with electricity through mini-grids	Nos	29,700	-	500,000	2.14 million	58,350	1.10 million
6	Forex saved (for diesel replacement for electricity)	million $/year	85	-	140	61	224	19
7	Forex saved (transport fuel replacement by ethanol blending)	million $/year	7.34	-	70	30	22	4

The improved resource efficiency and capacity expansion of the sugar sector will generate new green job opportunities in rural and agricultural communities. Considering the sugar sector's impact on other sectors, like clean cooking and transportation, it can support most SDGs of the respective countries and directly contribute to the following:

- SDG3: Reduced deaths and illnesses from household pollution
- SDG7: Universal access to affordable, reliable, and modern energy services
- SDG9: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation
- SDG13: Accelerated decarbonization of the energy sector

6.3 CLIMATE BENEFITS

The GHG emissions from sugar industries encompass the entire supply chain of sugarcane, from its cultivation through to the final products, which include sugar and biofuel, as well as their subsequent disposal. Among all the agricultural practices, the major source of emission comes from farming activities, including residue burning, fertilizer use, and fuel/electricity consumption. Open burning leads to CO_2 emissions, but it may not be considered due to regrowth over a subsequent period. However, there are non-CO_2 emissions (CH4, CO, N2O, and NOX) that are originated during biomass burning, which are important to estimate in national inventories. Fertilizers (calcium silicate slag, dolomite, nitrogen, phosphate, potash, and micronutrients) and soil conditioners (dolomite for liming application) are other sources of GHG emission. In addition, fuels and electricity consumption involved in irrigation, soil preparation practices, and transportation are also minor emission contributors. As per research findings, the GHG emissions from sugar production in Southern Brazil and Eastern Thailand were 0.24[20] and 0.55[21] kg CO_2e/kg of sugar, respectively. There is no proper research and/or literature on GHG emissions from sugarcane cultivation in African countries. In general, the bulk of emissions (73 per cent) occur in the agricultural cultivation phase (due to fertilizer inputs, and residue burning), followed by processing (21 per cent), and transportation[22].

Bio-ethanol is a carbon-neutral fuel, since the carbon captured from the atmosphere during sugarcane growth is only released back when the bio-ethanol is burned. The emitted carbon also goes through this carbon capture process during the next sugarcane plantation. Bio-ethanol is also bio-degradable, and thus less toxic in case of spillage or mishandling. The environmental benefits associated with bio-ethanol use depend on the fossil fuel supply chain, from raw material extraction, processing, and transportation. The production of petroleum fuels generates a lot of hazardous wastes, wastewater, and emissions all along its supply chain. By replacing biomass-based cooking, bio-ethanol-based cooking also helps reduce deforestation. Unlike firewood and charcoal, burning bioethanol does not generate any particulate emissions. Reduced production and usage of firewood and charcoal will help mitigate these harmful emissions to the global environment. Blended bio-ethanol is also expected to reduce the release of cancerogenic pollutants from the combustion of fossil fuels.

Assuming that the countries implement these proposed clean energy access contributions from the sugar sector in a timely and phased manner (i.e., if bioethanol potential is split and utilized in cooking, while the remainder is directed towards transportation, and the surplus bagasse is used for electricity generation), the GHG reduction potential in different sectors is estimated by 2030; this is illustrated in Table 15.

[20] de Figueiredo, E.B., Panosso, A.R., Romão, R., La Scala, N., 2010. "Greenhouse gas emission associated with sugar production in southern Brazil". *Carbon balance and management 5, 3.*

[21] Yuttitham, Monthira, Shabbir H. Gheewala, and Amnat Chidthaisong. "Carbon footprint of sugar produced from sugarcane in eastern Thailand." *Journal of Cleaner Production 19 (2011): 2119-2127.*

[22] Peter W. Rein, "The carbon footprint of sugar", *Zuckerindustrie*, Vol. 135(7), July 2010.

Table 15. GHG emission reduction potential

Country	Through bio-ethanol-based clean cooking (tCO_2/year)	Through diesel replacement for electricity generation (tCO_2/year)	Through bio-ethanol blending for transport fuel (tCO_2/year)	Total GHG reductions (tCO_2/year)
Côte d'Ivoire	153,000	129,000	12,500	294,500
Nigeria	1.25 million tCO_2 per year collectively from all measures			
Kenya	668,000	420,000	40,000	1,128,000
Tanzania	360,000	200,000	29,400	589,400
Mozambique	554,000	254,000	45,500	853,500
Madagascar	86,500	62,500	7,100	156,100

The Nationally Determined Contributions (NDC) of assessed countries have set GHG mitigation goals where energy and transportation are the key sectors. Meeting the NDC targets requires the mobilization of climate finance, the judicial utilization of natural resources, and the cessation of forest land degradation, among other related actions. The sugar sector can contribute to all of these focus areas of intervention. In addition to mitigation benefits, there are also adaptation benefits for vulnerable groups, such as youth, women, and remote communities, through improved lifestyles, reduced household pollution, and better job opportunities.

7. Recommendations

A consolidated list of key recommendations relevant to all assessed countries is provided in this section for the interest of relevant stakeholders. These are focused on the medium-term basis (next 4 to 7 years) from the development assistance point of view. The appropriate measure for a specific country may vary slightly based on market conditions.

a) Sugarcane cultivation

The following recommendations are made to **increase yield/ha, expand cane cultivation areas, and overcome climate change risks:**

- Evaluate current and expected climate risks in sugarcane cultivation in the country or region, and identify climate change adaptation measures to address them, including indigenous solutions.
- Analyze gaps in existing agriculture and sugar sector policies and regulations to enable the faster adoption of climate-smart agricultural practices by sugar estates and individual farmers for cultivation, irrigation and harvesting.
- Study the available arable land area, traditional crop cultivation area, and potential conflicts in different regions, as well as explore expansion viabilities of sugarcane cultivation area and farmers in different regions.
- Assess the lessons learned and/or best practices in block farming, and scale up technical and financial support for increased uptake by outgrowers.
- Retrofit, rehabilitate, and build logistics to access roads and warehouses in and around sugarcane cultivation areas for better access to modern farming services. This will in turn reduce the collection and delivery time of harvested cane to the sugar mills.
- Develop schemes to extend reliable electricity access to cane farmers using renewable energy (solar pumps), mini-grid technologies, grid extensions, etc., to support sustainable irrigation.
- Build capacity, knowledge, and skills of farmer's associations in streamlining their operations, articulating their needs/concerns, and improving farmers' and sugar mills' participation.

- Strengthen public and private agencies or NGOs to deliver extended agricultural services (soil fertility-based guidance, crop rotation, weather information, fertilizer use, disease control, etc.) to cane farmers.

b) Efficient production processes and technology upgrade

The following recommendations are made **to increase operating efficiency, reduce sugar production costs, and increase domestic sugar production capacity:**

- Assist existing sugar mills in technology upgrades, and process optimization in sugar production using high-pressure boilers, turbines, modern distilleries, and biogas systems.
- Assess, identify, and implement additional revenue opportunities in existing sugar mills by converting waste streams like bagasse, molasses and vinasse into value-added products, especially for bio-ethanol generation.
- Demonstrate best practices in quality-based payment to outgrowers, and develop facilities for accurate testing of sucrose levels.
- Conduct techno-economic feasibility studies for establishing new sugar mills/ethanol distilleries, or the expansion of existing ones taking into account the availability of cane, infrastructure, and market supply and demand.
- Explore the feasibility of exporting electricity to the mini-grid or national grid, contributing to increased rural electrification.
- Offer technical and resource mobilization assistance to adopt green harvesting technology through international financial institutions by channelling climate funds.
- Support the establishment of effluent treatment facilities at the sugar mills, and promote concepts of zero liquid discharge practices wherever possible.
- Create a roadmap for industrial-grade refined sugar production to achieve self-sufficiency to serve the demands of the African region.

c) Sugar supply chain

The following recommendations are made **to create a conducive market environment for sustained growth of the sugar sector and contribute to other national priorities:**

- Enable frequent interactions between agricultural and industrial research institutes and mainstream agricultural, industrial, and business practices to bridge gaps in adopting modern technologies and sustainable practices, by upgrading infrastructure and facilities at those institutions.
- Prioritize actions on increasing local bio-ethanol production to serve the existing demand in the market by revamping the existing installed capacity at the public and private sugar mills and ethanol distilleries, thereby reducing import.
- Revisit the bioethanol blending market opportunities in the transportation sector and recommend required policies to reduce fossil fuels dependency and promote energy security.
- Incentivize private sector investments in biomass-based mini-grid development, ethanol distilleries, clean cookstove manufacturing, ethanol dispensers and fuel blending, biogas bottling plants, etc., through tax benefits, production-linked grants, marketing support, etc.
- Offer business development assistance to entrepreneurs, technicians, and intermediate market players, such as traders of bagasse, bioethanol, farm equipment, clean energy services, etc., in creating a stable and mature market environment.
- Develop the capacity of regulatory agencies to enforce stringent measures to contain illegal sugar dumping and smuggling of low-quality sugar.
- Revise and/or update standards for bio-fuels, bio-fuel packaging, and retailing. Also prepare handbooks for production, transportation, and end consumption in different sectors.
- Set up an information and learning centre (I&LC) to serve as a central repository of all sugar and bio-ethanol-related knowledge and practices (climate, financial and technical) in the country.

8. Conclusion

The sugar sector in Africa is witnessing an expansion as the demand continues to grow. Out of six countries assessed in this report, all countries except for Mozambique are not self-sufficient, and depend on imports to cover domestic sugar demand. The sector is focused only on sugar, and has not reaped the benefits of product diversification available in sugar processing. To expand in capacity and position itself in the African market and beyond, the African sugar sector must invest in expanding sugarcane cultivation through outgrower schemes, improve yields in current farming areas through climate-smart agriculture, modernize existing sugar mills, install new sugar production units, and diversify operations through electricity and heat generation, ethanol production, and other valuable products. There must be parallel developments in other associated sectors to generate the future market demand for these value-added products, like electricity (in the power sector) and bio-ethanol (in the transportation and cooking sectors). The ongoing initiatives by the country governments and sugar mills in assessed countries are aligned with these strategies.

The ongoing initiatives from the countries can be accelerated through international development and climate finance, which is currently limited in the sugar sector of assessed countries. These initiatives can also help achieve low-carbon development in the cooking and transportation sectors. Though there have been initiatives in the past to promote bio-fuels, their efforts have failed considerably to create a sustainable market environment. In general, there is an urgent need for the mobilization of financial and technical resources to the sugar sector in order to overcome current market and climate challenges.

With an appropriate action plan and coordination, the assessed countries have a high potential to transform their sugar sector into a self-sufficient one, and achieve their 2030 goals of inclusive economic growth, and climate commitments under NDCs. •

Annex 1. Key Socioeconomic Status of Assessed Countries

Aspect	Côte d'Ivoire	Nigeria	Kenya	Tanzania	Mozambique	Madagascar
Population (million)	29	213	49	63	33	29
Community	Economic Community of West African States (ECOWAS)	Economic Community of West African States (ECOWAS)	The East African Community (EAC)	The East African Community (EAC)	Southern African Development Community (SADC)	Southern African Development Community (SADC)
Currency used	West African CFA Franc (XOF)	Nigerian Naira (NGN)	Kenyan Shilling (KES)	Tanzanian Shilling (TZS)	Mozambican Metical (MZN)	Malagasy Ariary (MGA)
Economics status	Lower middle-income country	Lower middle-income country	Lower middle-income country	Lower middle-income country	Least Developed Country (LDC)	Least Developed Country (LDC)
GDP ($ billion)	71.71	472.62	109.8	69.23	18.41	14.64
Clean cooking access (%)	31.8	15	19.5	4.5	5.1	1
Electricity access rate (%)	64	60	75	37	42	25
Poverty rate (%)	39.4	37	27.2	43	61.9	75
Country climate vulnerability index rank	52	53	41	45	50	20
Official language	French	English	Swahili and English	Swahili	Portuguese	Malagasy and French

Annex 2. Identified Key Stakeholders in Assessed Countries

Country	List of sugar mills	Key ministries	Others
Côte d'Ivoire	• Sucrivoire (Borotou-Koro and Zuénoula) • Sucaf (Ferké 1 and Ferké 2 sites)	• Ministry of Commerce, Industry and SME Promotion • Ministry of Agriculture and Rural Development • Ministry of the Environment and Sustainable Development (MINEDD)	• Sugar industry association - Association des Industries Sucrières de Côte d'Ivoire (AIS-CI)
Nigeria	• Savannah Sugar Company Numan, Adamawa state – Dangote Sugar • Sunti Golden Sugar Estate Ltd, Sunti – Niger state – Nigeria Flour Mills • BUA Sugar Company Lafiagi, Kwara state	• Federal Ministry of Trade and Investment (FM &TI) • Federal Ministry of Agriculture and Rural Development (FMA& RD) • National Sugar Development Council (NSDC)	• Sugar Cane Outgrowers Farmers Association • Savannah Sugar • Oyo Sugar-cane Processor

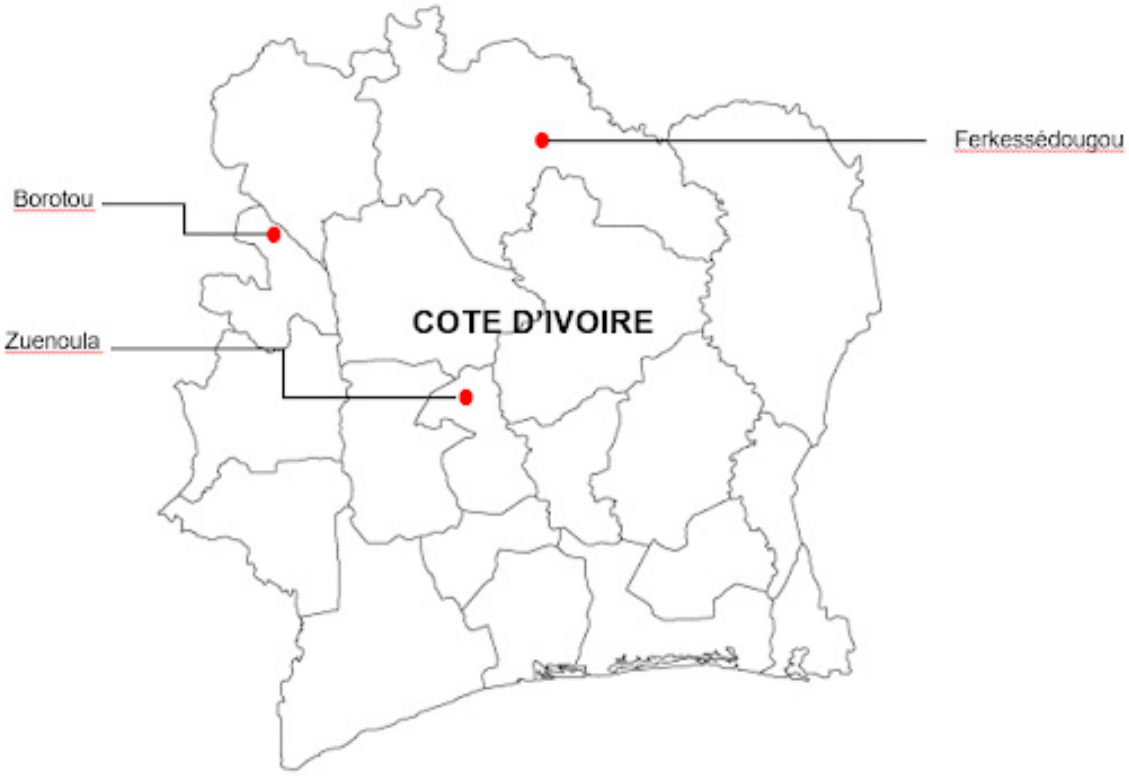
ANNEX 2. IDENTIFIED KEY STAKEHOLDERS IN ASSESSED COUNTRIES

Country	List of sugar mills	Key ministries	Others
Kenya	• Miwani sugar company • Muhoroni • Chemelil sugar company • Mumias sugar company • Nzoia sugar company • West Kenya sugar company • Sony Sugar Company • Kibos Sugar & Allied Industries Limited • Butali Sugar Mill Limited • Transmara sugar company • Sukari sugar company • Kwale International sugar company • Ole Pito sugar company • Busia Sugar Company	• Ministry of Agriculture, Livestock, Fisheries and Irrigation (MoALFI) • Sugar Directorate • Ministry of Energy and Petroleum • Energy and Petroleum Regulatory Authority (EPRA) • Ministry of Industry, Trade and Enterprise Development (MITED)	• The Kenya Renewable Energy Association (KEREA) • Kenya Industrial Research and Development Institute (KIRDI) • Sugar Research Institute (SRI) • Kenya Society of Sugarcane Technologist (KSSCT) • Kenya Union of Sugarcane Plantation and Allied Workers (KUSPAW)
Tanzania	• Kilombero Sugar Company Limited (KSCL) • Tanganyika Planting Company (TPC) • Kagera Sugar Limited (KSL) • Mtibwa Sugar Estate Limited (MSEL) • Manyara Sugar Company Limited (MSCL) • Zanzibar Sugar Factory Limited	• Ministry of Energy • Energy and Water Utilities Regulatory Authority (EWURA) • Tanzania Investment Centre (TIC) • Small Industries Development Organizations (SIDO) • National Environmental Management Council (NEMC) • Tanzania Trade Development Authority (TanTrade)	• Tanzania Sugarcane Growers Association (TASGA) • Tanzania Sugar Producers' Association (TSPA) • Tanzania Renewable Energy Association (TAREA) • Sokoine University of Agriculture (SUA) • University of Dar-es-Salaam (UDSM) • Tanzania Agricultural Research Institute (TARI) • National Sugar Institute • Tanzania Agricultural Development Bank Limited (TADB)

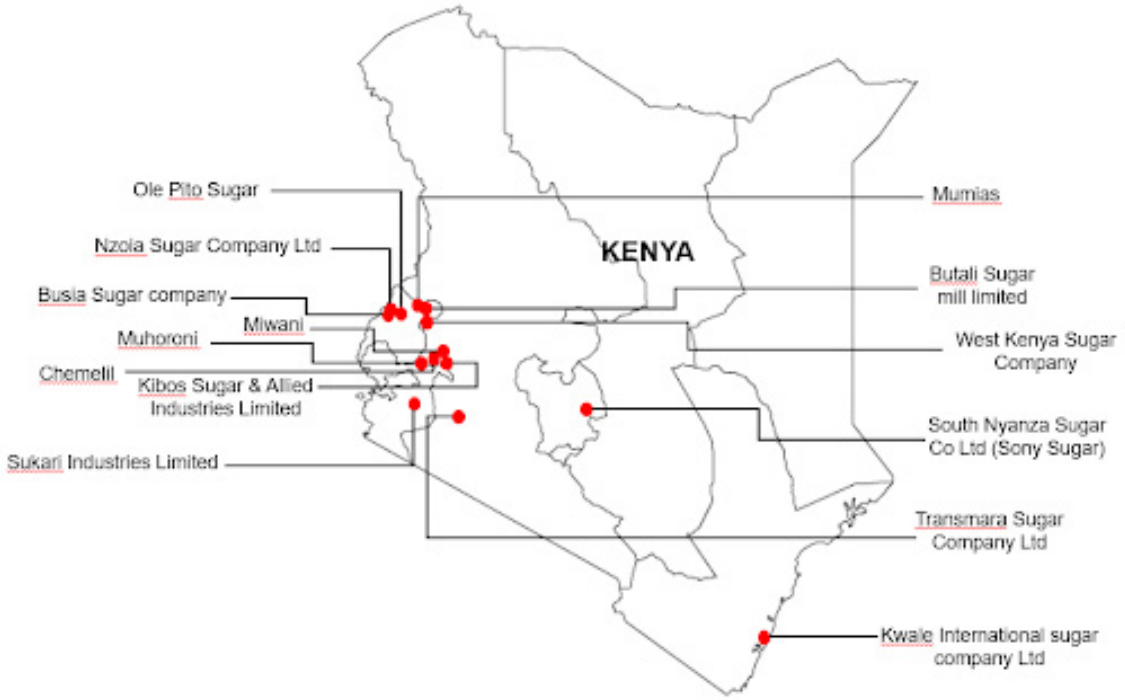
ANNEX 2. IDENTIFIED KEY STAKEHOLDERS IN ASSESSED COUNTRIES

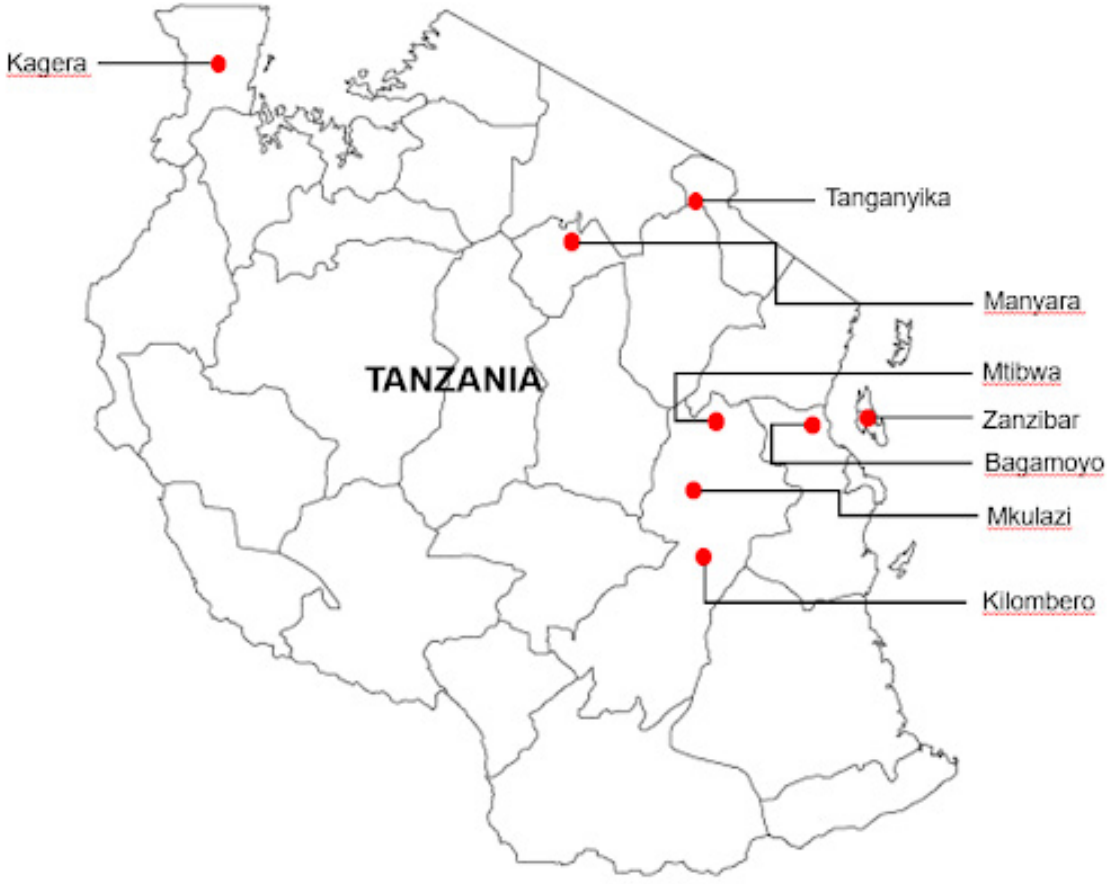
Country	List of sugar mills	Key ministries	Others
Mozambique	• Mafambisse • Xinavane • Maragra • Marromeu	• Ministry of Agriculture and Rural Development (MADER) • Ministry of Industry and Commerce (MIC) • National Sugar Distributor (DNA)	• Association of Sugar Producers of Mozambique (APAMO)
Madagascar	• Ambilobe • Nosy-Be • Antanamifafy • Namakia • Morondava • Brickaville	• Malagasy cane and sugar centre (CMCS) • Ministry of Industrialization, Trade and Consumption (MICC) • Ministry of Agriculture and Livestock (MINAE) • Ministry of Energy and Hydrocarbons (MEH) • Ministry of Environment and Sustainable Development • Economic Development Board of Madagascar (EDBM)	• University of Antananarivo

Annex 3. Sugar Mill Locations in Assessed Countries

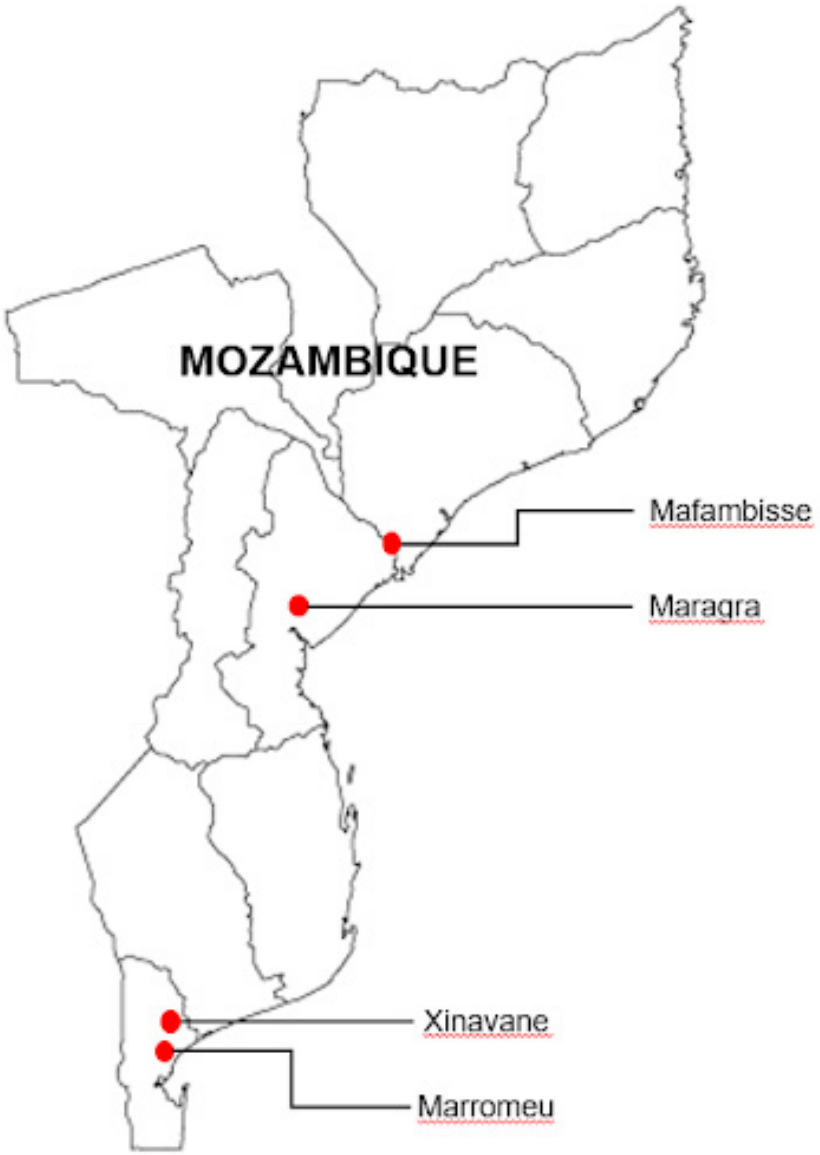


ANNEX 3. SUGAR MILL LOCATIONS IN ASSESSED COUNTRIES

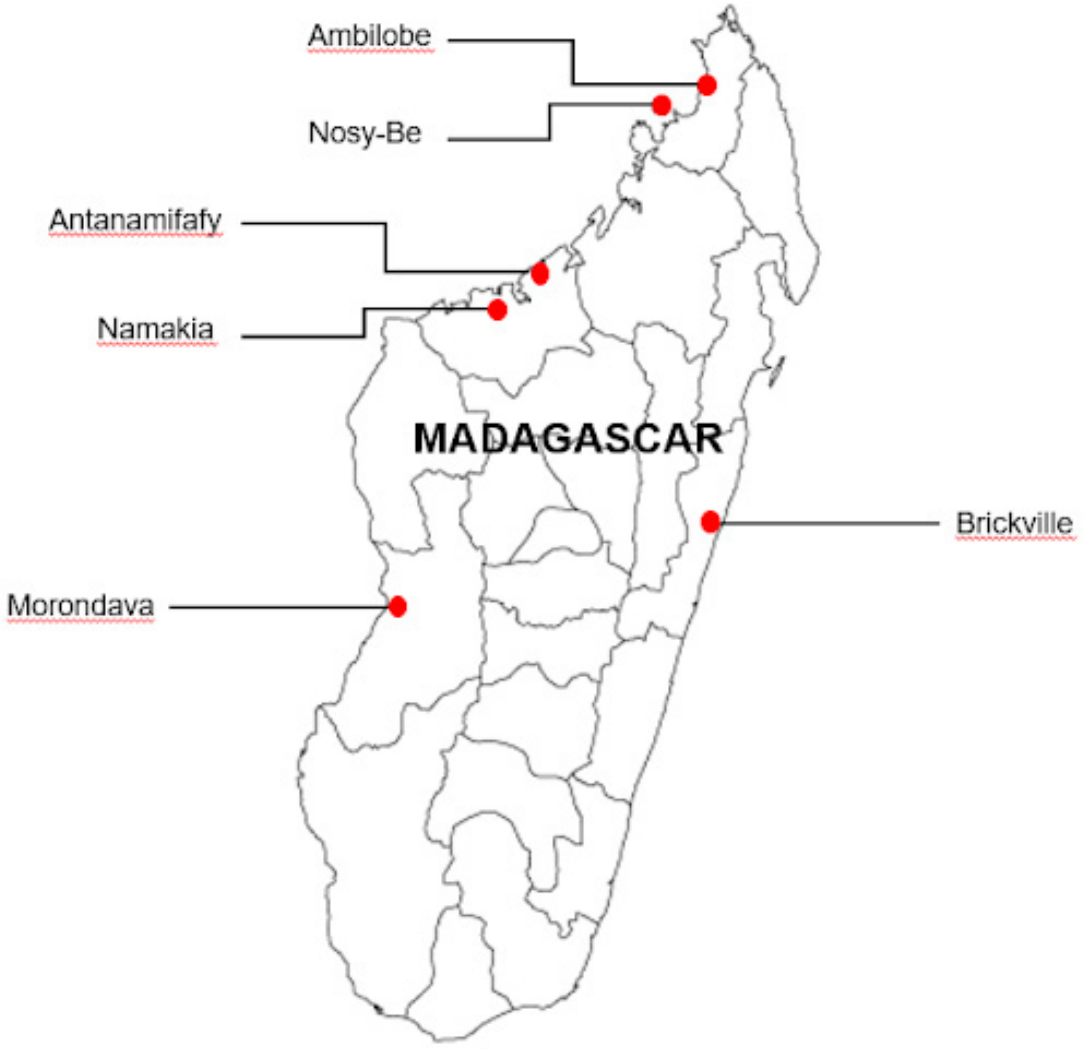




ANNEX 3. SUGAR MILL LOCATIONS IN ASSESSED COUNTRIES



ANNEX 3. SUGAR MILL LOCATIONS IN ASSESSED COUNTRIES



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