Feasibility Study for the Utilization of Solar Energy for Sugarcane Irrigation Pumping by Emerging Commercial Small Cane Growers in Eswatini

Small-scale farming and solar irrigation landscape report

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List of abbreviations

CTCN	Climate Technology Centre & Network
ECGA	Eswatini Cane Growers Association
EEC	Eswatini Electricity Company
EIDC	Eswatini Industrial Development Company
ESA	Eswatini Sugar Association
ESERA	Eswatini Energy Regulatory Authority
ESWADE	Eswatini Water and Agricultural Development Enterprise
GDP	Gross Domestic Product
GHG	Greenhouse gas
gpm	gallons per minute
IPP	Independent Power Producer
KDDP	The Komati Downstream Development Project
kWp	Kilowatt-peak
LSG	Large-scale growers
LUSIP	The Lower Usuthu Smallholder Irrigation Project
MSME	Micro, Small and Medium-sized Enterprises
NDC	Nationally Determined Contributions
NDC	Nationally Determined Contribution
NGO	Non-governmental Organization
PPA	Power Purchase Agreements
SACCOs	Savings, and Credit Cooperative Societies
SME	Small and Medium-sized Enterprises
SPIS	Solar-powered irrigation systems
SSEG	Small Scale Embedded Generation
SSG	Small-scale growers

1. Introduction

The Kingdom of Eswatini is a landlocked and mountainous country situated in the South eastern part of Africa with an area of 17,360 km2, bordering South Africa (on the north, west, and south) and Mozambique to the east. The country is a lower-middle income country with a population of 1.13 million people, 58.9% of the population lives below the national poverty line, an unemployment rate of 23.4%, and a Gross Domestic Product (GDP) per capita of 3,415 USD. The country faces numerous challenges such as poverty, food insecurity, and vulnerability to the effects of climate change [1].

The Economy of Eswatini is largely agriculture based, which further increases the country's vulnerability to climate change. Eswatini already faces the impacts of climate change, particularly on the agriculture sector, with an increased intensity and frequency of extreme weather conditions which has affected rainfall patterns causing the frequency of droughts to increase. Regarding greenhouse gas (GHG) emissions, preliminary data indicates that 48% of emissions come from Agriculture, forestry, and land use sectors, while the energy sector contributes to 40% of emissions [2].

The climate change impacts of heavy rainfall and recurring droughts harm agricultural production, particularly smallholder farmers and communities, with more than 70% of subsistence farmers being highly vulnerable [3]. According to the Ministry of Tourism and Environmental Affairs, 14% of the country's population is potentially affected by droughts, this percentage is expected to increase to 33% by 2050 affecting 15% of the country's GDP [4].

Considering this situation, the government of Eswatini, in line with the Paris Agreement and its Nationally Determined Contributions (NDCs), has prioritised climate change adaptation measures, including flood control, irrigation systems and climate resilient infrastructure.

Eswatini's NDC, revised in October 2021 set a target of 14% conditional (to receiving financial support) emissions reduction by 2030, compared to the business-as-usual scenario, or 5% without financial support. The country is also aiming to achieve a 50% renewable energy share in 2030 (relative to 2010). The adaptation and resilience areas considered in the NDC are agriculture, health, water, ecosystems and biodiversity and infrastructure [5].

Within these measures: the promotion of solar-powered irrigation within the sugarcane sector has the potential to contribute towards: i) an increase in the share of renewable energy generation; ii) increasing climate resilience within the agriculture sector and iii) reducing GHG emissions from the agriculture sector. The government of Eswatini has identified sugarcane as a strategic crop to alleviate poverty, and is promoting a series of measures to reduce climate vulnerability and empower farmers [4].

1.1 The sugarcane farming sector in Eswatini

Sugarcane is the main livelihood of most of the people employed in agriculture and a key contributor to the agriculture sector in Eswatini, producing over half of the total annual agriculture-based output. The industry contributes roughly 35% of the private sector employment (Eswatini Sugar Association, 2016) and contributes the majority to the country's GDP. The sugar sector's contribution to the GDP was estimated to be in a range between 12 to 16% [6].

Eswatini is the 4th largest producer of sugar in Africa and 25th in the World. Also, 600 km2 of the entire country's area is used for sugar cane farming. The sugar sector has been described as "the heartbeat of Eswatini's economy" In 2020, the area harvested for sugarcane was 58,523 ha [7], significantly increased from 14,398 ha grown in 1970 [6]. All of this area is irrigated. Most of the area cultivated is managed by large-scale growers (LSGs). However, since the 1990s the role of small-scale growers (SSGs) has grown over time, reaching one third of the cultivated area in 2020 [6]. SSG holdings averaged approximately 75 ha. Data further obtained through stakeholder interviews with the sugar association indicated that 64% of the cane growers are considered large-scale, % medium-scale and 29% small-scale.

Sugarcane farmers are facing increasing costs of production, driven particularly by electricity costs with the majority of farmer-owned sugarcane companies connected to the national grid for electricity supply, which is required for pumping water for irrigation through pressurised irrigation systems. Electricity expenditure accounts for 26% of the total operational costs for smallholder farmers, according to a stakeholder interview with the Eswatini Sugar Association (ESA). Implementing solar irrigation systems has the potential of decreasing these costs while promoting investment in renewable energy technologies and reducing the sector and the country's GHG footprint [8].

The national government, represented by stakeholders such as the Ministry of Agriculture, partnered with the European Union, the Eswatini Water and Agricultural Development Enterprise Limited (ESWADE) and international development partners to support the implementation of farmer managed sugarcane schemes as part of projects, such as the Komati Downstream Development Project (KDDP), the Lower Usuthu Smallholder Irrigation Project (KDDP). These projects have supported the development of rural communities, with over 7,000 families involved in small-scale sugarcane production.

Stakeholder interviews conducted with the Eswatini Sugar Association provided more insights on the role of the sugar industry in Eswatini, the sugarcane industry contributes up to 80% of the crop production in the country. As of 2023, 59,082 ha of lands are harvested for sugarcane, producing 5,690,255 tonnes of sugarcane per year, and contributing to 5% on the national GDP and 6% of the national employment. Sugar production is 673,393 tonnes.

1.2 Solar irrigation systems

1.2.1 Definition and Components

Solar irrigation refers to the use of solar energy to power irrigation systems for agricultural purposes. The main components of solar powered irrigation system (SPIS) are:

- Solar generator, i.e., a PV panel or array of panels to produce electricity.
- Mounting structure for PV panels, fixed, or equipped with a solar tracking system to maximize the solar energy yield.
- Pump controller
- Water pump usually integrated in one unit with an electric motor.
- Distribution system or storage tank for irrigation water.

SPIS can be applied in a wide range of scales, from individual or community vegetable gardens to large irrigation schemes. There are different types of solar irrigation systems including solar powered drip irrigation system, solar powered Centre pivot Irrigation and solar powered sprinkler system.

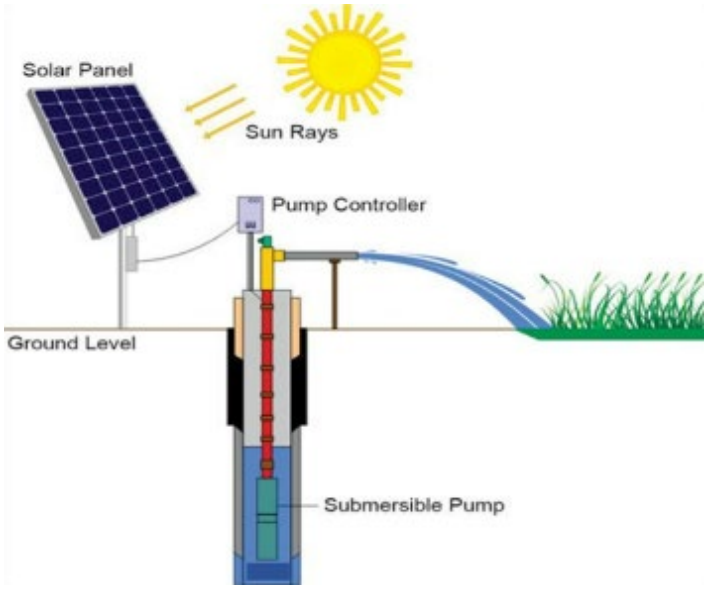

Figure 1. Components of a SPIS [9]

1.2.2 Solar powered drip irrigation systems

In this type of system, the water is pumped and distributed through a network of drip lines. These systems are a highly effective irrigation technique, which delivers water in small, frequent doses directly to the root zone of plants, minimizing water loss from evaporation and runoff. This method is helpful to the remote rural cultivable areas with no access to electricity. This system is used particularly for horticulture (vegetables and fruit trees) and field crops (especially maize).

The advantages are adjustment of water usage, reduction in the soil erosion, increase in the efficiency of fertilizers and reduced water consumption. It increases both household income and nutritional intake, particularly during the dry season, and is cost effective compared to alternative technologies [10]. A small solar drip irrigation system with a flow rate of 0.23 to 0.45 m^3 per hour (0.0631 to 0.1262 litres per second) may require a 100-watt solar panel and a 12-volt DC pump with a power rating of 20-30 watts. A larger system with a flow rate of 1.14 to 2.27 m^3 per hour (0.3159 to 0.6318 litres per second) may require a 300-watt solar panel and a 24-volt DC pump with a power rating of 200-300 watts.

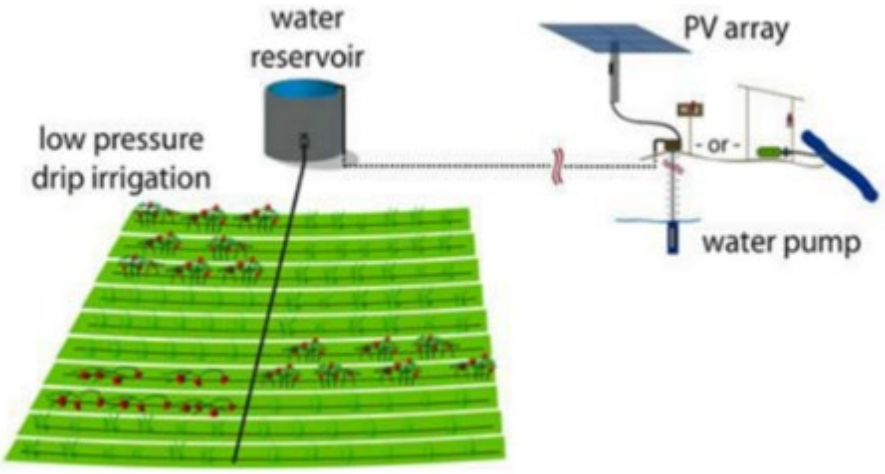

Figure 2. Components of Solar dripped Irrigation system [11]

1.2.3 Solar-powered centre pivot irrigation

This system uses a centre pivot to deliver water to crops in a circular motion. Pivots are capable of applying water, fertilizer, chemicals, and herbicides. The system consists of a centre pivot that rotates around the field at specified rotational speed, side wheel, sprinkler nozzles and control panels. This system can be used to irrigate a wide variety of crops such as soybean, corn wheat and tomatoes.

Some advantages of the system are increased efficiency, improved water distribution, reduction in labour cost and reliability. The system has some limitations such as high initial cost, unsuitability for uneven shape fields, maintenance cost, and non-uniformity due to wind speed [12]. A solar pivot irrigation system , installed in North Africa for an area of 50 ha and with three pump systems that provide a flow rate of 3,300 m^3 per day requires a solar capacity of approximately 105 kWp [13].

Figure 3. Structure of Solar Powered Centre Pivot Irrigation [12]

1.2.4 Solar powered sprinkler irrigation

This system distributes water over a wide area through sprinklers. In this system, water pump pressurizes the water and sends it through pipes to the sprinkler heads. This type of system is ideal in areas where crops are grown in rows or in large open fields or in terrain fields. A wide variety of crops can be cultivated such as sugar beet, potatoes and tomatoes [14]. They are highly efficient in their water usage, reducing water consumption by up to 50% compared to flood irrigation methods.

These systems also require minimal maintenance and can be easily expanded or modified to meet changing irrigation needs. Additionally, these systems are cost-effective, environmentally friendly, as they have direct potential to reduce greenhouse gas (GHG) emissions in irrigated agriculture by replacing fossil fuels for power generation with a renewable energy source, i.e., solar energy [15]. A small solar-powered sprinkler irrigation system with a flow rate of 2-3 gpm (0.1262 to 0.1895 litres per second) requires approximately 150–200-watt solar panel and a 12-volt DC pump with a power rating of 50-70 watts.

Figure 4. Sprinkler irrigation system [16]

1.2.5 Benefits of Solar Powered Irrigation

Solar-powered irrigation technology is gaining interest around the world. In agriculture, solar-powered irrigation has the potential to be particularly successful in overcoming general energy shortages that lead to disruptions in the supplies needed for irrigation water supply and distribution. These systems are portable and can be assembled at any preferred location.

A field study undertaken all over the Punjab and Pakistan [17] in 2021 was conducted to evaluate the socio-economic and climatic impact of photovoltaic-operated high-efficiency irrigation systems. The results showed that the installation of PV systems, along with the adoption of high-efficiency irrigation systems, resulted a reduction in the high operational costs that resulted from the use of old diesel-powered pumping systems; annual savings of 6.6 million litres of diesel; the reduction of 17,622 tons of CO_2 emissions per year, and 41% savings in water usage [18].With the increased utilization of these systems, the costs have decreased substantially, making them an efficient, convenient and cost-effective solution for grid-isolated rural areas.

1.2.6 Comparison between solar irrigation systems

Table 1. Comparison of different solar irrigation systems

	Solar powered drip irrigation system	Solar powered sprinkler irrigation System	Solar powered center pivot irrigation system
Operation	Water distribution through a network of tubes or drips and delivers directly to plant roots.	Sprinkler heads distribute water.	System rotates around a central pivot point, distributing water through sprinkler heads.
Application flexibility	Suitable for small-scale and precision irrigation, suitable for various crops.	Suitable for large and small-scale operations, suitable for various crops and terrains.	Suitable for large-scale operations and uniform water application over long distances.
Maintenance requirements	Low	Moderate	High
Installation Cost	Moderate	Moderate to high	High
Coverage area	Small to medium	Large	Large
Water Pressure	Low	High	High
Required Power (Watts)	100-300	150-450	1,500-2,000

Case Study - The Solar Powered Drip Irrigation for Sustainable Crop Production Project

The Solar Powered Drip Irrigation for Sustainable Crop production project was initiated by the National Disaster Management Agency (NDMA) and the United Nations Development Programme (UNDP) on behalf of the board of India, Brazil, South Africa (IBSA) in Eswatini. This is a two-year project scheduled to end in 2023. The project supports 600 farming households from the regions-Hhohho, Manzini and Lubombo to access water to irrigate backyard gardens and climate-smart agriculture technologies. About 3,000 farming households have already received instruction in effective irrigation techniques, composting, permaculture, and the creation of organic liquid fertilizer using manure and pesticide solutions [19].

The project focuses on smallholders in developing countries, who often lack access to reliable and affordable irrigation systems, leading to low yields and food insecurity. A solar powered drip irrigation system offers an affordable and sustainable solution to this problem as it requires no fuel or electricity and can be easily maintained by farmers.

Eswatini has a relatively abundant solar resource, with a global horizontal irradiance (GHI) of 4-6 kWh/m^2/day. The highest irradiation occurs during the summer months (from December to March), while the lowest irradiation occurs during the winter (June-September). However, it is still adequate for both solar PV and solar water heating [20].

2. Landscape assessment

2.1 Overview of the sugar industry in Eswatini

There are four categories of growers: i) sugar estates owned by the sugar mills; ii) large-scale growers, iii) medium-size growers, and iv) **s**mallholder growers**.** Growers are generally classified by the size of their farms. Smallholder growers have less than 50 hectares, medium-size growers have farms that are between 50-1,000 hectares, and large-scale growers have farms greater than 1,000 hectares. Miller-owned estates contribute the largest share of sugar cane production (51%), followed by smallholder growers (29%), large-scale growers (13%), and medium-size growers (7%).

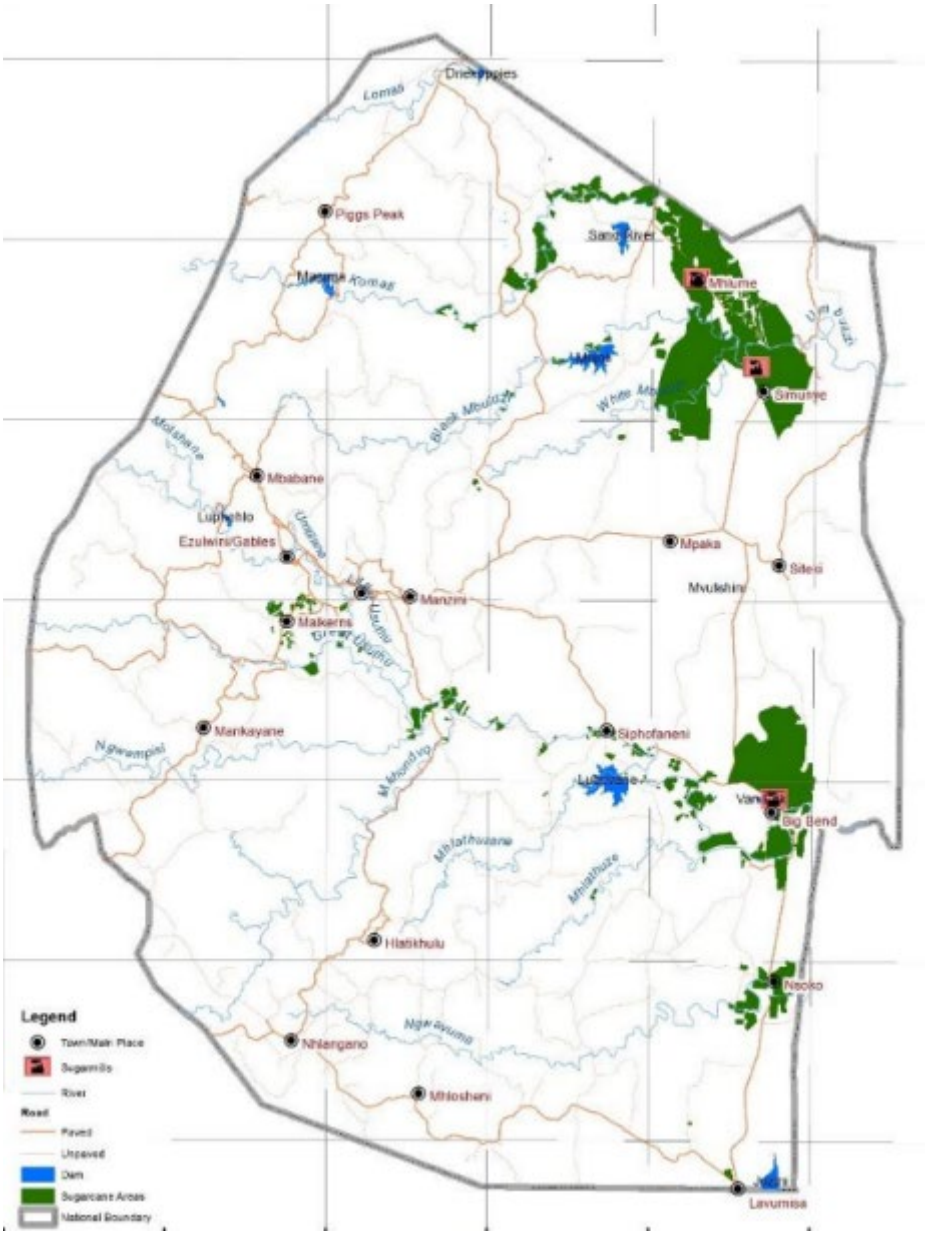

Figure 5. Sugarcane growing areas in Eswatini [21]

Figure 5 above shows the location of the main sugarcane growing areas in Eswatini. The main stakeholders and structure of the Eswatini sugar industry are presented in Figure 6 below. The

Eswatini Sugar Association (ESA) is the highest decision-making authority on common issues for sugar cane growers and sugar millers. ESA provides support services to the entire industry's value chain, which includes marketing of all sugar and molasses, agricultural research and extension, cane testing, warehousing and distribution, industry regulation and policy advocacy. The Eswatini Cane Growers Association (ECGA) represents the interest of all growers excluding miller-owned estates.

There are three sugar mills in Eswatini owned by two companies: The Royal Eswatini Sugar Corporation Ltd (Mhlume and Simunye mills) and Ubombo Sugar Limited (Ubombo mill). The South Africa-based company RCL Sugar Company co-owns the Royal Swaziland Sugar Corporation Ltd, while Illovo Sugar Ltd owns Ubombo Sugar Limited. These mills are members of the Eswatini Sugar Millers Association (ESMA).

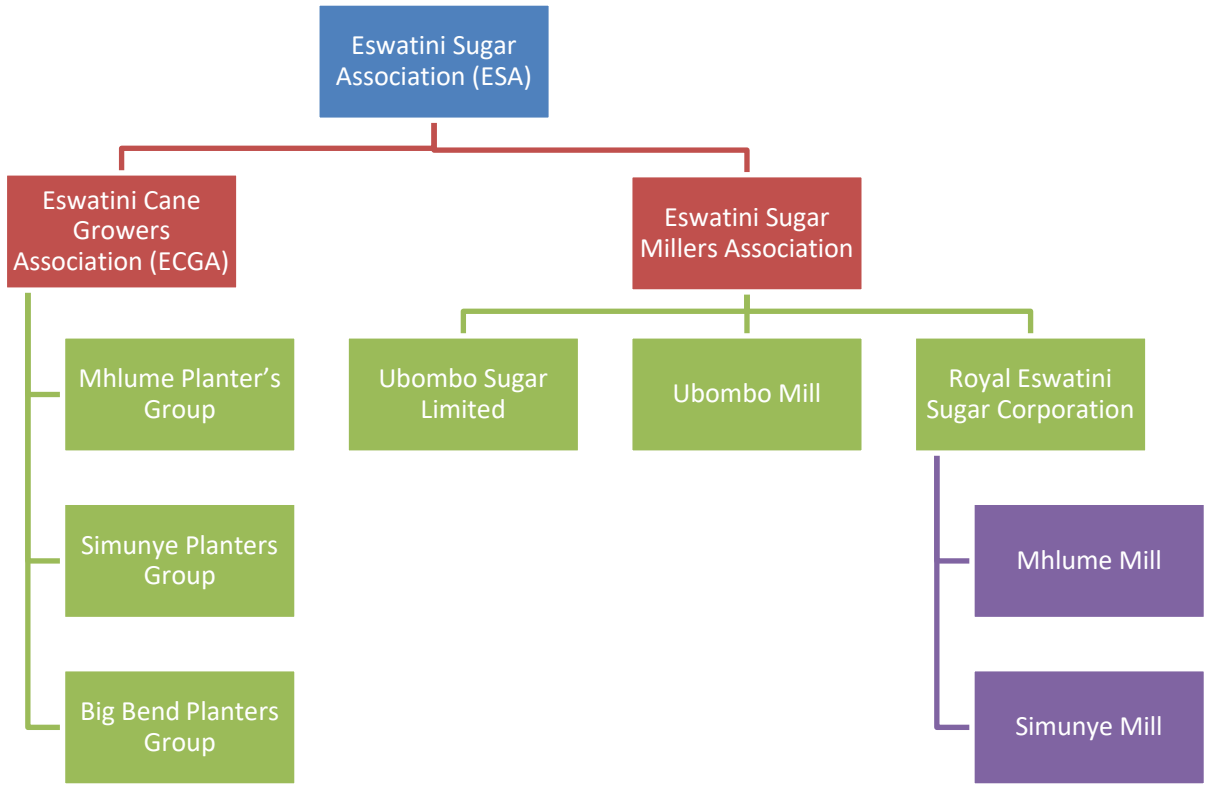

Figure 6. Structure of the Eswatini sugar industry [21]

2.1.1 Royal Eswatini Sugar Corporation (RESC)

The Royal Swaziland Sugar Corporation (RESC) is a sugar producing company based in the Kingdom of Eswatini. It was founded in 1979. In 2020 the Royal Swaziland Sugar Corporation changed its name to the Royal Eswatini Sugar Corporation (RESC). It is the largest company in Eswatini, employing over 2,000 permanent staff and producing two thirds of the country's sugar. It owns and manages over 150 km² of irrigated sugarcane on estate land leased from the Eswatini Nation and manages a further 5 km² on behalf of third parties, delivering some 2 million tons of cane per season to RESC's two sugar mills: Simunye Sugar Mill and Mhlume Sugar Mill. In 1980 the Simunye Sugar mill was commissioned and capable of producing 120,000 tons of sugar per annum initially. The Mhlume Sugar Estate was incorporated in June 1958, with a production capacity of 90 tonnes cane per hour. RESC crushes around 3.5 million tons of cane per year and produces some 450,000 tons of sugar [22].

2.1.2 Other developments

- **The Sivunga Sugar Project**: The Sivunga Sugar Project is a wholly owned sugar estate of Tibiyo and managed by Ubombo Sugar Limited. It consists of four farms measuring approximately 2,6 km² in total which are 100% under irrigation.
- **Sihhoye Sugar Project:** The Sihhoye Sugar Project is a wholly owned sugar cane project of Tibiyo, under the management of Mhlume Swaziland Sugar Company. The estate covers about 1.65 km² of irrigated sugarcane which is delivered to the Mhlume Sugar Mill.
- **Inyoni Yami Eswatini Irrigation Scheme (IYSIS):** The IYSIS is a partnership between Tibiyo (50%) and RESC (50%). It is engaged primarily in the cultivation of sugarcane, livestock rearing and hospitality operations. The cultivation of sugarcane is the single largest contributor to IYSIS's. There are around 110 employees across the company's activities [23].

2.2 Regional assessment of farming areas

In the areas of interest for this project (The Malkerns and KDDP and LUSIP project areas) there are four different locations (Big Bend, Mhlume, Simunye and the Malkerns), with a total of 482 cane growers, distributed as illustrated in Table 2 below. The three key areas of interest for the project will be described in the upcoming sections:

Table 2. Number of cane growers in the interest areas

Area	Number of cane growers
Big Bend	140
Mhlume	310
Simunye & Malkerns	32
Total	**482**

Sugarcane growers in Eswatini use a variety of irrigation technologies, Table 3 below presents the technology shares as of 2020, the technology most commonly used is sprinkler irrigation, with a 37% share, followed by centre pivot with 26%.

Table 3. Irrigation technologies employed in Eswatini

Irrigation technology	Share of adoption among Eswatini sugarcane farmers (%)
Drip Irrigation	19%
Sprinkle (Dragline) Irrigation	12%
Sprinkler (Semi-solid) Irrigation	25%
Centre Pivot Irrigation	26%
Furrow Irrigation	18%

2.2.1 The Malkerns

The Malkerns region lies at the heart of Eswatini' midlevel, midway between Ezulwini and Manzini. In 2013 the region had a population of 9,724 inhabitants [24]. The hills are covered in a mix of grasslands, forests, and agricultural fields, with sugarcane, pineapple, and citrus fruits being some of the main crops grown in the Malkerns Valley. The Malkerns are home to the Royal Eswatini Sugar Corporation (RESC), which is the country's largest sugar producing public company. The fields of sugar cane plants are a common sight throughout the Simunye town and surrounding areas.

The topography has substantial height changes, with a maximum elevation difference of 290 m and an average elevation above sea level of 720 m. The area within 4 km of Malkerns is covered by cropland (76%) and grassland (12%), within 16 km by cropland (44%) and grassland (39%), and within 80 km by grassland (38%) and cropland (35%) [25]. The Mdzimba Mountains are located to the east of Malkerns, rising up to an elevation of approximately 1,300 meters above the sea level [26]. These mountains provide a stunning backdrop for the town and are home to a variety of plant and animal species, including indigenous forests and grasslands.

To the west of Malkerns lies the Ngwempisi River, which flows through the Ezulwini Valley and provides a vital source of water for the region's agricultural activities. The river is surrounded by wetlands and floodplains that support a diverse range of aquatic and terrestrial ecosystems.

Figure 7. Map of the kingdom of Eswatini [27]

The climate in Malkerns is warm, humid and subtropical. The average percentage of the sky covered by clouds experiences significant seasonal variation over the course of the year. The wet season is warm and partly cloudy, and the dry season is comfortable and mostly clear. A wet day is one with at least of liquid or liquid-equivalent precipitation. The chance of wet days in the Malkerns varies significantly throughout the year. The temperature typically varies from 8°C to 27.22°C and is rarely below 5°C or above 33°C [25].

The Malkerns has an annual rainfall of 800–1,000 mm; and an average annual air temperature of 19.0°C with the coldest month in June. The annual rainfall of this site is well distributed from October to February with low coefficient of variation. The Malkerns experiences significant seasonal variation in the perceived humidity. The month with the highest relative humidity is January (80.81 %). The month with the lowest relative humidity is August (57.74 %). The wettest month is December (18.77 days; represents the average number of days in December that received measurable rainfall). The driest month is June (2.97 days) [28].

The soil in the Malkerns is typically deep red loam, sandy clay, and low in organic carbon [29]. In some areas, there may be patches of shallow, stony soils with low fertility, which are more difficult to cultivate. In other areas, the soils may have a higher sand content and be less fertile, which can limit their agricultural potential. Overall, the soil composition of Malkerns is diverse, but the majority of soils in the area are well-suited for agriculture and other land uses.

Sugar Cane Cultivation

The Malkerns is an extremely agriculturally productive area due to its fertile soil. The main crops grown in the Malkerns area are pineapples and a few other crops (e.g., maize and vegetables) but it is mainly dominated by sugarcane. According to Swaziland's State of the Environment Report (2012), 2,5km^{2}of the irrigated cropland corresponds to sugarcane. The cane growing sector comprises approximately 130 registered sugarcane growers farming predominantly in the lowveld, and around Malkerns areas [30].

2.2.2 The Komati Downstream Development Project (KDDP)

The Komati Downstream Development Project was a joint project between the African Development Bank and the government of Eswatini. The project was started in 2002 and completed in 2011 [31]. The aim was to alleviate poverty and improve the standard of living through the provision of portable water supply and irrigation water supply for commercial agriculture in the surrounding communities. The Komati Downstream Development Project (KDDP) consists of three parts,

- Construction of the Maguga Dam
- Development of 7,400 hectares of irrigated farms
- Expansion of the Mhlume Sugar Mill to accommodate an additional 80,000 tons of sugar annually [32].

Beneficiaries

- Around 31,000 people benefited from this project.
- About 27 farming companies are active and established in the area.
- A total of 60.36 km² of land were developed under the project, with 1,482 individuals working for the farmer companies (FCs) on 54.46 km² of sugarcane and 5.90 km² of alternative cash crops.
- Furthermore, 60 km of gravel road were built, 27 crop production tunnels were constructed, and 11 dip tanks were moved.
- A total of nine portable water schemes were deployed, providing clean water to 24,591 people (3,513 homesteads) and sanitation facilities to 28,714 people (4,102 homesteads) [33].

Komati River

The Komati River is a trans-national river system that stretches from west to east entering Eswatini from South Africa where it is joined by the Crocodile River at the border with Mozambique to form the Incomati basin. The river is approximately 480 km long from its source to the confluence with the Crocodile River [34]. The total catchment area of the Komati River is approximately 50,000 km^2. There are two major dams located in the Komati; Maguga in the upper basin and Sand River dam further downstream.

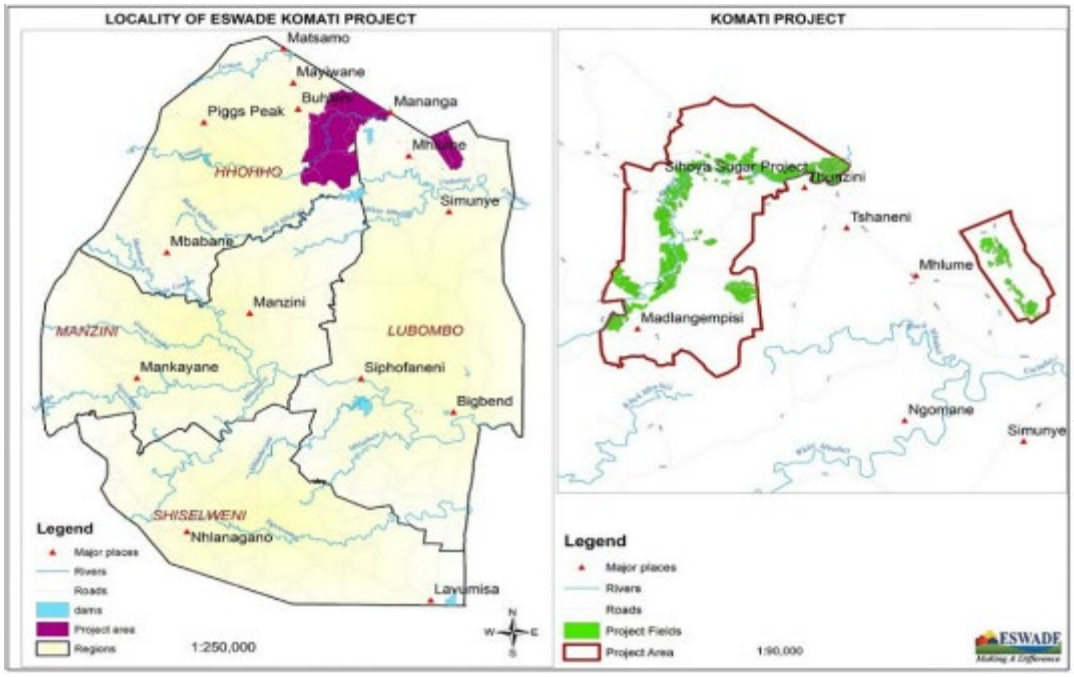

Figure 8. Location of the Komati Project [33]

Figure 9. Komati River [35]

Topography

The topography of the project area consists of hills, foot slopes and undulating plains ranging in altitude from 300 to 600m. The geology is medium to coarse-grained granite with dolerite intrusions and alluvial deposits locally. The granite- derived soils of the project area vary from shallow sandy loams to deep sandy soils with rocky outcrops The total area covered by the Lower Komati catchment is 250 km^2 with about 45 km^2 under commercial sugarcane cultivation. The climate is sub-tropical and semi-arid with a mean annual rainfall of 780 mm.

Summer rains are experienced between the months of October and March, with a cool and dry winter season extending from May until August. Maximum summer temperature reaches about 34.8°C [36], while minimum temperature in winter is about 10°C. The land changes from flat to undulating alluvial terraces to sloping hills as it moves away from the Komati River. The general climate in the Incomati

river basin varies from a warm to a hot humid climate in Mozambique to a cooler dry climate in South Africa in the west. The vegetation of the Komati Landscape consists of predominantly six vegetation types known as Barberton Montane Grassland, Swaziland Sour Bushveld, Granite Lowveld, Kaalrug Mountain Bushveld, Scarp Forest and Northern Mistbelt forest [37].

The most important crops under irrigation in Komati areas are:

- Sugar cane
- Sub-tropical orchards Bananas
- Summer and winter grain
- Summer and winter vegetables Tobacco

2.2.3 The Lower Usuthu Smallholder Irrigation Project (LUSIP)

The LUSIP I irrigation project was funded by the Africa Development Bank (AfDB), the Arab Bank for Economic Development (BADEA), the European Investment Bank (EIB), the European Union (EU), OFID, and the Government of Eswatini. The project is completed with a targeted beneficiary of 20, 479 people and 3,300 households.

The LUSIP irrigation project phase II is funded by AfDB, EIB, Kuwait Fund, BADEA, and the government of Eswatini. The project is currently ongoing and expected to be completed by 2023 with a targeted of 14,279 people and 2,259 households as beneficiaries[36].

The Lower Usuthu Smaller Holder Irrigation Project (LUSIP) is located in the south-eastern part of Eswatini, in the Lubombo Region, in the area between Siphofaneni, Big Bend, and Nsoko, mainly on the southern side of the Usuthu area. The Climate in the Lowveld is semi-arid and warm, with mean annual temperatures in Big Bend of 22°C winter and summer means of 17°C and 27°C with an annual rainfall of 590 mm.

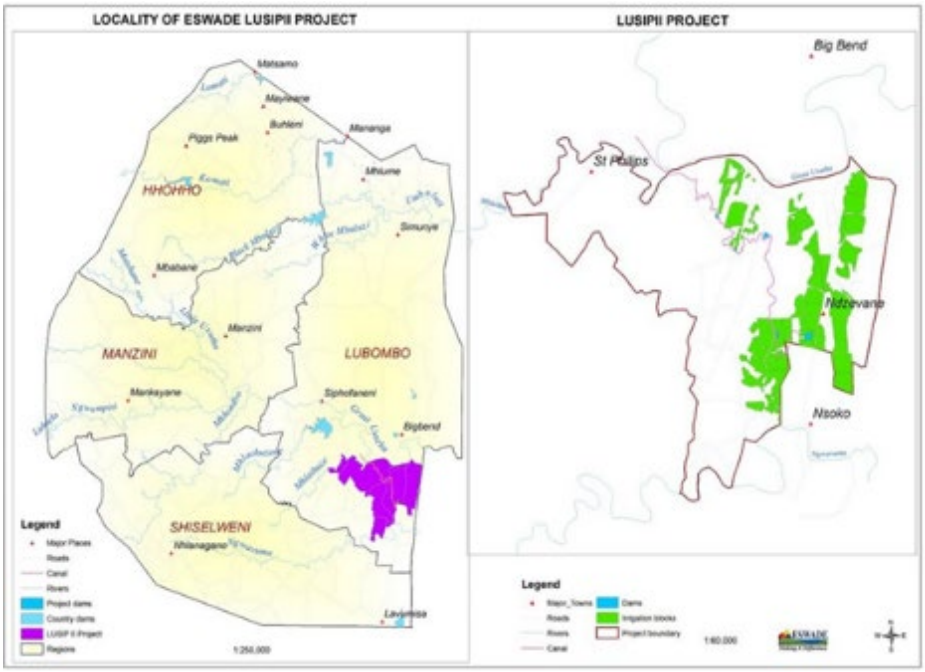

Figure 10. Location of the LUSIP II project

The LUSIP project comprises four main components: Upstream, Downstream, Environmental Mitigation, and Project Coordination and Management. The LUSIP irrigation project involved the construction of three dams to form an off-river storage reservoir to impound 155 million cubic meters of water that will be diverted from wet season flood flows in the Lower Usuthu River. A main canal and distribution system has been constructed below the dam, together with on-farm works designed to irrigate 115 kilometres. [37]

The Lower Usuthu Smallholder Irrigation Project Phase I is made up of 5,044.53 ha for sugarcane and 1,070 ha for alternative crops. The total area of sugar cane harvested for the 2020 season was 4,989.2 ha producing 457,302.20 tons of sugar cane. The average yields for LUSIP Farmers in 2020 stood at 91.7 tons of cane per ha (TCH) (2018: 108.9TCH. The goal of the project was to reduce poverty and sustain improvement in the standard of living of the population in LUSIP through commercialization and growth of agriculture). [38]. This project achieved 100% Portable water in Gamedze, Shongwe, Ngcamphalala, Mphumakudze, Lesibovu Chiefdoms, and KaMamba kingdoms).

Figure 11. LUSIP II - View from the main canal south[39]

(LUSIP) II Extension

The (LUSIP) II Extension Project is a continuation of the Lower Usuthu Smallholder Irrigation Project to improve the standard of living of the population in the project area through an environmentally and culturally sustainable process. The LUSIP II has further improved the standard of living in the Lower Usuthu Basin area of Eswatini. This phase aims to extend the development of the main canal south conveyance system with a net irrigation area of 57 km to deliver water to the Matata area by increasing the efficiencies in the sugar cane value chains.[40]

Additionally, the LUSIP II project aim is to create employment, increase income, enhance food security, reduce soil erosion, and improve access to social and health infrastructure for the rural population by changing subsistence-level smallholder farmers into small-scale commercial farmers with 47 sugar cane Farming Companies (FC).[41]

The LUSIP II project highlighted achievements as follows:[42]

- Resettlement, five (5) homesteads were relocated from the canal servitude, and their compensations were paid accordingly.
- On-farm Environmental Compliance monitoring was developed to audit farmers in complying with environmental requirements stipulated in the Environmental Management Plans.
- A total number of 2,740 Ventilated Improved Pits Latrines (VIPs) were constructed with 20,118 people having access to improved sanitation, bringing the total number of beneficiaries to 99.76%.[43]

2.3 Assessment of available financial institutions and funding mechanisms

Access to finance remains a major challenge in the effort to promote the commercialization and growth of smallholder farmers in Eswatini and a major constraining factor for agriculture development. The FinScope survey of 2016 found that 60% of micro, small and medium sized enterprises (MSMEs) in the start-up stage have difficulty in terms of access to finance.[44]

A small number of farmers in Eswatini borrow money from the banks, nonetheless, they acquire loans from friends, families, and self-help groups to start up their businesses. Farmers also have access to finance through community-based savings and credit Associations (ASCAs) known as Rotating Savings and Credit Associations (ROSCAs) with an interest rate ranging from 0% to an agreed interest rate.[45]

To address the issues of financing MSMEs, the Kingdom of Eswatini established various reforms and programs and prioritised MSMEs in agriculture [46]. Possible finance sources for farmers and MSMEs in the agriculture sector include government development schemes or institutions, including some formal and semi-formal institutions such as microfinance institutions, savings, and credit cooperative societies (SACCOs), Eswatini Finance Corporation (Fincorp), Non-governmental Organisations (NGOs) and other formal sources of credit in Eswatini, including commercial banks, such as First National Bank, Nedbank, and Standard Bank [47].

2.3.1 Financial Institutions

Commercial Banks

There has been a growing interest from Commercial banks to reach out to MSMEs which has increased their participation in financing smallholder sugar cane growers with SME departments that cater to farmers. Some products that cater to farmers are asset financing, overdraft, business loans, and agricultural loans. This financing source requires a series documents and requirements including proof of collateral as a basic requirement to qualify for the credit products, mostly farmers without collateral end up discouraged from applying for bank financing.[48]

A study from Making Access Possible (MAP) shows that Eswatini MSMEs rely heavily on Commercial Banks. However, only 22% of the MSMEs have access to formal credit. The risk perception of MSMEs is due to a lack of collateral and proper documentation of business performance [49].

Eswatini Development Finance Corporation (FinCorp)

FinCorp is a financial institution owned by the Kingdom of Eswatini, its objective is to provide financing to locally owned MSMEs concentrated mainly on agriculture sugarcane production. FinCorp is estimated to have about 2,500 MSMEs under its portfolio.

Sugar cane loans for farmers can either be seasonal loans or capital loans. The capital loan is required to fund the establishment of a new sugar cane project to fund payment of irrigation equipment, seed cane, initial fertiliser, and plant and equipment. Umkantjubovu and Ingungu loans types of capital loans. The seasonal loan is to fund seasonal procurement and operations of the business, Umhhalo and Sivandze loans are seasonal [51].

Industrial Development Company of Eswatini (IDCE)

IDCE is a financial institution with a well-suited product for farmers. The institution provides loans with a repayment period of 3- 5 years to enable farmers to run their farming businesses efficiently and pay loans on time. All farmers including Farmers companies with new farming technologies and energy-saving solutions are considered under this product [52].

Savings and Credit Cooperative Societies (SACCOs)

The Eswatini Farmers' Cooperative Union (ESWAFCU) represents 84 cooperative organisations and 2,500 members, these cooperative groups facilitate the mobilisation of the farmer's groups with a common bond to pool together their savings and subsequently obtain loans that may be used for different purposes. The sole objective is for individual co-operators to benefit and get access to financing. [53]

Microfinance Institutions

There are three Microfinance Institutions in the country, which are the Inhlanyelo Fund, Imbita Women Finance Trust, and the SWEET Microfinance. The Inhlanyelo Fund through the Kirsh Foundation gives a maximum loan of USD 1,765 payable over the period of 24 months and uses the group lending methodology. Agriculture forms a major part of the loan portfolio and beneficiaries do not require a collateral.

The Imbita is a membership-based savings group and has almost the same financial product as Inhlanyelo, although the delivery method is different, the organisation uses Local Management Committees to mobilise the communities.

SWEET Microfinance targets micro-entrepreneurs and currently offers two loan products which are the Emergency loan and the Group's loan.[54]

Eswatini Investment Promotion Authority (EIPA)

The Eswatini Investment Promotion Authority (EIPA) has Agriculture as one of the priority sectors for investment and is therefore known for supporting agriculture enterprises, including SMEs, advising them on available regional and international export opportunities for agricultural produce.[55]

2.3.2 Financing Mechanisms[56]

- **Small-scale Enterprise Loan Guarantee Scheme (SSELGS):** This scheme provides credit guarantees for business start-ups and existing MSMEs. To qualify for a guarantee, the business must be viable and fully licensed with Eswatini majority shareholders and be able to provide 25% security on the required loan.

- **Small Enterprises Development Company (SEDCO):** SEDCO is a government-owned enterprise that offers a range of services to support small–commercial businesses and MSMEs including the agriculture sector in Eswatini. SEDCO does not provide finance to MSMEs, however, prepares project proposals for presentations to financial institutions by MSMEs to access finance.
- **National Agricultural Marketing Board (NAMBOARD):** NAMBOARD works with various farmers providing technical support for transportation and storage facilities and marketing of Agricultural produce.
- **Regional Development Fund (RDF):** The Regional Development Fund enables local communities to access grant funds for the development of community infrastructures such as rural electrification, irrigation supply, and potable water supply. Potential beneficiaries have to be in groups, associations, or co-operatives before eligible for support.

2.4 Review of relevant regulations

2.4.1 ESERA-Independent Power Producer (IPP) Policy

The Eswatini Independent Power Producer Policy (IPP) document was prepared with support from the USAID Southern Africa Trade Hub in close collaboration with the Department of Energy under the Swaziland Ministry of Natural Resources and Energy. A coherent and practical IPP Policy is vital to addressing many of these issues and providing policy guidance to facilitate the growth and development of the power sector in Eswatini. Additionally, environmental sustainability and achievement of the green agenda will be prioritized, while promoting access to affordable and sustainable energy sources to support poverty reduction and economic development.

Objectives of IPP policy

- The goal is to maximise the use of renewable energy resources in Eswatini, which include biomass, solar PV, CSP, wind, and geothermal resources.
- The deployment of IPP capacity can enhance Eswatini´s energy security and reduce dependence on energy imports.
- Embedded generation and mini-grid solutions should be stimulated and enabled to diversify Eswatini's energy mix and increase energy access potential for rural areas.
- To overcome financing constraints, various funding sources should be identified and made accessible for renewable energy and IPP projects.
- The power sector can create employment opportunities for all residents, regardless of gender, both directly and indirectly.
- Promoting environmental sustainability and achieving green goals is a priority in line with the National Development Strategy and National Energy Policy.
- Access to affordable and sustainable energy sources can help reduce poverty and support economic development.

Problem Statement and Rationale

Eswatini relies heavily on power imports from South Africa and Mozambique despite having significant conventional and renewable energy resources. This dependence contributes to the country's current account deficit and exposes it to energy supply risks. Regulatory, economic, and technical barriers

have hindered the development of renewable energy and independent power producers. The SIPP Policy aims to address these barriers and transition towards sustainable energy sources, opening the market to private sector participation through IPPs. The policy is formulated based on guidance from both the national and international policy arena.

Rural Electrification and Mini-Grid Supply

The government is taking steps to support the viability of independent power producers (IPPs) and mini grids by revising pricing approaches and updating tariff methodology. The licensing categories and processes are being reviewed to minimize administrative barriers and costs. Mini-grid projects using preferred renewable energy resources and serving remote areas will be prioritized. A monitoring and verification framework will be implemented to ensure compliance with regulatory provisions, and mini grids will be required to comply with technical standards and the prevailing Grid Code.

Small Scale Embedded Generation (SSEG)

Embedded Generation refers to small or large-scale generation sources that are connected to the distribution network. SSEG typically supplies electricity within the locality of the generator, while larger embedded generation sources can export power onto the transmission grid. SSEG is becoming increasingly important due to the deployment of cost-effective and smaller-scale renewable technologies.

The prevailing provisions in legislation, regulations, and codes cover larger-scale embedded generation, but SSEG warrants aim to specifically focus on supporting the deployment of smaller embedded or distributed generation sources. If distributed solar PV and other SSEG technologies are successful, the distribution grid will need to accommodate higher penetrations of distributed generation on individual circuits. As the use of distributed solar PV and other small-scale embedded generation (SSEG) technologies increases, there is a need for effective screening tools to identify technical concerns that may arise. Penetration-based screens are crucial to limit the size and number of systems that can be interconnected without expensive studies, allowing for a more efficient and cost-effective integration of distributed generation into the distribution grid.

For Eswatini and the region in general, SSEG represents a whole new arena of power generation and it should thus embraced on an incremental basis to ensure that the Eswatini Government shall consider the inclusion of embedded generation projects as part of the overall planning process, recognizing not only the generation capacity added but also the potential benefits to the Transmission and Distribution systems - specifically the ability to defer grid expansion and strengthening, reduction of line losses, reduced network congestion, optimal land use and contribution to overall network stability. This approach will also allow the various stakeholders and government agencies time to develop skills, capacity and experience before locking the country into costly long-term commitments. If distributed solar PV and other SSEG technologies are successful, the distribution grid will need to accommodate higher penetrations of distributed generation on individual circuits.

Mini-grid supply

The high cost of extending grid infrastructure to remote areas coupled to utility funding constraints create an opportunity for mini-grid solutions, which can be more cost effective and efficient than some

larger scale grid expansion projects. Mini-grids and small scale embedded/distributed systems are likely to play a significant role in extending electricity access and in developing the renewable energy and IPP market in Eswatini. The size of the market essentially implies very limited scope for large scale IPP deployments. The licensing process and associated regulatory approvals should make provision for a simplified fast track process but are still required to assess the mini-grid deployment in the context of the integrated resource planning process and associated grid expansion plans to protect customers from potentially signing up to long term high-cost supply or conversely to protect mini-grid developers from investing in assets that become stranded when they need to compete with grid supply.

Mini grids can be a less expensive option for providing access to reliable and affordable electricity compared to central grid extension. This is because the infrastructure required for mini grids has a lower capital cost (depending on distance), and they can avoid transmission and distribution losses, leading to lower supply costs. In regions with power shortages, especially in rural areas, electricity supply through the central grid may not be reliable. In such cases, mini grids can be designed and operated effectively to provide more reliable electricity access and ensure local energy security. Unlike other decentralized energy options like solar home lighting systems and off-grid lighting products, mini-grids (depending on their size) can provide electricity not only to residential loads such as lighting and phone charging but also to smaller commercial and industrial loads like mills and oil presses.

2.4.2 ESERA-Energy master plan [47]

The Energy Department of the Ministry of Natural Resources and Energy is responsible for policies and operational activities related to the energy sector. The government leads the energy planning process with inputs from different energy stakeholders, including government agencies, national utilities, the national regulatory authority, civil society, academia, the private sector, and Independent Power Producers (IPPs).

The Eswatini Energy Master Plan 2034 is the first comprehensive framework for the energy sector to meet short and long-term energy needs in a sustainable manner.

The objectives of the Energy Master Plan aim to ensure:

- Self–sufficiency in energy supply
- Universal access to clean and affordable energy
- Optimal use of domestic resources
- Diversification of the energy supply mix to meet energy security concerns.
- Meeting climate change goals as captured in Eswatini Nationally Determined Contribution (NDC)

The Eswatini Energy Master Plan 2034 seeks to identify and address the country's barriers to the supply of energy on suitable energy sources and technologies.

In 2015, Eswatini submitted to the United Nations Framework Convention on Climate Change (UNFCCC) it intended Nationally Determined Contribution (NDC) towards Greenhouse Gas (GHG)

Emission reduction, out of the four mitigation actions outlined by the country, two are in the energy domain;

- Increasing the share of renewable energy in the primary energy mix to 50% by 2030 and
- Introducing an ethanol blend in petrol of at least 10% by 2030.

Additionally, Eswatini's contribution covers both on-grid and off-grid applications was formulated as follows:

- Implementing small-scale, decentralised renewable energy technologies to improve energy access in rural areas.
- Increasing the use of grid-connected renewable energy technologies fuelled by sources such as waste, solar, bagasse (from the sugar industry), and wood chips.

Furthermore, the implementation of the energy master plan will contribute towards improving universal energy access and security of the supply of electricity in Eswatini.

Eswatini Energy Demand 2015-2034

The overall energy demand of the country is projected to increase from 39.4 petajoules (PJ) in 2014 to 48.5 PJ in 2034. The sugar industry, agriculture, and other industry sectors are expected to see the largest increase in energy demand of all sectors, with a 75% expected growth respectively over the planning period. Electricity demand will increase from 1,270 GWh in 2014 to 2,648 GWh in 2034.

Projections show that the residential electricity demand will increase from 1.2 PJ in 2014 to 3.7 PJ in 2034 and contribute the largest sector share of total electricity demand by 2034.

Table 4. Energy demand by sector and by fuel type in 2034 (In PJ).

Sector	Electricity	LPG	Oil	Wood	Bagasse	Coal	Total
Sugar	2.3	-	0.1	4.7	14.8	2.1	24
Agriculture	1.5	-	0.7	-	-	-	2.2
Industry	1.4	-	0.1	-	-	-	1.5
Mining	-	-	-	-	-	-	-
Commerce	0.6	0.4	-	-	-	0.5	1.5
Residential	3.7	0.6	-	1.7	-	-	6.0
Transportation	-	-	13.3	-	-	-	13.3
Total	**9.5**	**1.0**	**14.2**	**6.4**	**14.8**	**2.6**	**48.5**

Energy demand in the agriculture sector[47]

The growth of the agriculture sector in Eswatini is high and the Gross Domestic Product (GDP) in sugar will stimulate economic growth over the next 20 years. Energy demand in the sugar industry is increasing by more than 2% annually.

Solar PV

Eswatini has relatively abundant solar potential with an estimated global horizontal irradiance of 4-6 kilowatt-hours (kW) per square metre per day. The highest irradiation occurs during the summer months (December-March) and the estimated capacity potential of solar zones would total about 587 MW. Solar PV technologies are the most economical renewable energy source due to the continuous cost decline in the cost of the technology as they become increasingly competitive with conventional sources in Eswatini with the reduction in cost for both utility-scale and decentralised power generation from renewables.

Policy Gaps highlighted from the Eswatini Energy Master Plan [47]

The following policy gaps were identified during the elaboration of the Eswatini Energy Master Plan:

- Eswatini's dependency on fuel and electricity imports remains high while domestic renewable energy sources remain under-utilised. Instruments such as feed-in tariff schemes that drive renewable energy growth such as solar and wind in the power sector should be exploited.
- Government action is required to increase access to clean energy, especially solar power for agriculture. Policy measures are needed to incentivize public and private investments in domestic power generation infrastructure to reduce dependency on imports.
- Solar systems are an opportunity for Eswatini to further increase electricity access and improve energy efficiency. It is necessary to increase awareness among local financial institutions about the commercial viability of this technology, along with the implementation of adequate financial support in the form of dedicated credit lines and guarantees) to utilise this opportunity.
- Development of a standardised Power Purchase Agreements (PPA) to increase the bankability of renewable energy power projects in Eswatini and attract investment and limit elaborate negotiations.
- Generation capacity investments need to match with transmission and distribution infrastructures to enable the grid network to integrate generated power from renewable energy supplies. The transmission infrastructures should be able to grant access to renewable energy.
- Long-term outlook on the implementation of energy efficiency and conservation measures that can be useful to reduce energy consumption in all economic sectors by enforcing minimum energy performance standards for household and industrial equipment through renewable energy mini-grid/off-grid technologies [47].

2.3.2 Other Relevant Policies

- **Electricity Cogeneration:** The Eswatini sugar industry uses bagasse to generate electricity, which is used by sugar mills during peak production periods. None of the electricity generated from the sugar mills is supplied to the national electricity grid due to the absence of appropriate incentives and policy by the state-controlled Eswatini Electricity Company. Eswatini sugar cane growers are currently not compensated for the bagasse used in electricity production, and there have been drawn-out industry discussions to change these terms.

- **Ethanol Production:** There is currently no commercial production of fuel-grade ethanol from sugar cane in Eswatini. It is expected that ethanol production will continue to increase in Eswatini based on the increase in sugar production in the 2022/2023.
- **Sugar Marketing and Sales:** The Eswatini Sugar Association is responsible for *marketing* of all the *sugar* (both raw and refined) produced in Eswatini. The revenue obtained through the sale of sugar and molasses is shared between growers and millers based on an agreed process and formula guided by the Sugar Act of 1967 and Eswatini Sugar Agreement. The Eswatini Sugar Association provides a rebate (discount) to value-adding industries located within Eswatini to encourage and support domestic sugar sales.

3. Stakeholder identification and mapping

Legend

Colour	Indication
	Stakeholders participating in the project's steering committee
	Identified stakeholder
	Stakeholder categories

Figure 12. Stakeholder mapping

Table 5. List of identified stakeholders

Stakeholders	Type of stakeholder
Government of Eswatini	Public sector
Ministry of Natural Resources and Energy	
Ministry of Public Works	
Ministry of Agriculture	

Stakeholders	Type of stakeholder
Ministry of Health	
Ministry of Tourism and Environmental Affairs	
Department of Water Affairs	
Eswatini National Trust Commission (ENTC)	
Eswatini Environment Authority	
Regional Development Team	
Eswatini Energy Regulatory Authority (ESERA)	
Environmental and Downstream Development Management Unit	
Eswatini Investment Promotion Authority	
Eswatini Electricity Company (EEC)	
Eswatini Energy Regulatory Authority (ESERA)	
Eswatini Water and Agriculture Development Enterprise (ESWADE)	Private sector
Eswatini Cane Growers Association (ECGA)	
Eswatini Sugar Association (ESA)	
Mhlume Planters Group	
Big Bend Planters Group	
Simunye Planters Group	
Industrial Development Company of Eswatini	
Savings and Credit Co-operative Societies (SACCOs)	
National Agriculture Marketing Board of Eswatini	
Coordinating Assembly of Non-Governmental Organisations (CANGO)	Non-governmental organisations (NGOs)
Community Development committee	
Renewable Energy Association (REASWA)	
Eswatini Farmers Union	
Climate Technology Centre and network (CTCN)	Development organisations
African Development Bank (ADB)	

4. Insights from stakeholder interviews

In order to validate and further complement the insights from the desk research, a series of stakeholder interviews were conducted both virtually and in person, with the aims of filling the gaps found in the desk research, identify other key stakeholders and provide a holistic view of the sector, the interviews focused mainly on the private sector and financial institutions. The main insights from the interviews are presented as follows:

4.1 Eswatini Sugar Association

Insights on the organization of the sugar industry

- The Eswatini sugar industry is divided into 3 groups namely;
  - The planters' groups (Mhlume, Simunye, and Big Bend) the Eswatini Cane Growers Association
  - Mill group (Mhlume, Simunye, and Ubombo) the Eswatini Sugar Association
  - Millers group (Mhlume, Simunye, and Ubombo) the Eswatini Sugar Millers Association
- The Millers group is responsible for refining and preparing the sugar cane into sugar, the main responsibility of the Eswatini Sugar Association is to look for markets for sugar and pay dividends to each cane grower once sales have been done.
- According to the association, the two major challenges faced by sugar cane farmers are energy and water which are scarce resources. For instance, in 2021 Eswatini was hit by cyclone Eloise which had devastating impacts on the sugar industry and resulted in sugarcane lodging and harvesting inefficiencies. Milers had to extend milling and missing timelines which were necessary for the global sugar markets.
- Sugarcane is a water-reliant crop and cannot be grown without irrigation, irrigation in Eswatini is electricity driven, sugarcane water needs have been estimated as 14,540 m^3/ha.

Insights on opportunities for the solarization of the sugarcane farmers:

- The current electricity supply is carbon rich and contributes to climate change, thus alternative sources of energy are urgently needed as electricity prices have been on the rise in the last 8 years.
- Some farmers have embraced solar energy and have installed in some farms. So far 6.4 MW solar power systems have been installed by 24 grower farms as of March 2023. The savings generated by these systems are yet to be evaluated.
- Over 70% of the growers are interested in switching to solar or other forms of alternative power generation to reduce their electricity consumption from the EEC grid.
- The solar service providers which the 24 farmers have used are;
  - Lumeka renewable energy
  - REPOWE RSA Integrated Energy Solutions
  - Simply Swazi Pty Ltd
- Local financing institutions willing to work with sugarcane growers for the installation of solar energy are:
  - Standard Bank
  - First National Bank
  - Eswatini Bank

- Fincorp

Insights on the current regulatory framework:

- The country has a framework for Embedded Generation (EG) that includes compensation for power exported to the grid and establishes acceptable levels of EG penetration into the national grid.
- The country also has a power wheeling framework that defines the rules, processes and pricing methods for third party transmission and the distribution network.
- Regarding the installation of solar panels, distributors should incorporate EEC embedded generation requirements, while suppliers must comply with the conditions and application processes to become grid-tied embedded in the EEC network.

4.2 Eswatini Cane Growers Association

Insights on the sugarcane industry and the role of smallholder farmers:

- According to the Eswatini Cane Growers Association, sugarcane farming depends entirely on irrigation and is the largest consumer of electricity in the country. Furthermore, electricity demand and costs in the agriculture sector is assumed to continue increasing, electricity costs have increased from 15% to 25% of the overall sugarcane production costs in the last ten years, driven by the increase in tariff, while energy demand is expected to increase by up to 10% within the next five years due to ongoing field expansions estimated above 4,000 Ha.
- Considering the expected increase in the demand, there are prospects for the increase in energy co-generation capacity, especially if there are other forms of renewable energy sources such as solar energy, ethanol, etc.
- In the last decade, the growth of the industry has been led by small-scale growers, these growers have holdings with an average of 75 ha. Currently, smallholder farmers produce over 25% of the sugarcane in Eswatini. However, this segment still faces financial challenges due to increasing costs and inputs for irrigation and other farm management practices.
- Sugarcane production is becoming an area of investment by the private sector and community-based farmers.

Insights on the Eswatini Electricity Company (EEC) and the energy sector:

- Eswatini lacks the security of energy supply. This is due to the fact that the country imports at least 70 percent of its electricity tariffs from Eskom, South Africa.
- The driving force behind the enactment of electricity legislation in Eswatini, adopted in 2003, was to ensure the participation of the private sector in the generation, transmission, and distribution of electricity. Thus, the legislation allows electricity distribution by other private parties (Independent Power Producers), these IPPs are expected to pay wheeling charges to the Eswatini Electricity Company. The energy sector in Eswatini is dominated by hydropower plants, with one diesel power plant and bagasse/coal plants operated by the sugar industry. In the era of renewable energy, long-term energy planning is imperative for the transformation of the energy system in Eswatini.
- The Eswatini energy sector faces challenges, particularly regarding energy security, as there is a trend of continually increasing tariffs for end-users.

- Even though Eswatini has not experienced a total blackout from load shedding, the cost of doing business-using electricity is becoming unbearable and unsustainable, these concerns affect particularly the sugar industry as electricity tariffs continue to increase at household and commercial level, especially for smallholder sugarcane farmers whose crop relies on energy consumption and water usage. In April 2023, electricity tariffs increased a 10.1%, with an additional increase of 8.02% expected for April 2024.
- The prospects of continual escalating tariffs are seen as inevitable, this has forced small businesses to consider other forms of renewable energy [indigenous energy resources to produce and/or compete in the production of electric units.
- Regarding the adoption of renewable forms of energy in Eswatini, Cane growers expressed their concern that clear parameters should be set when considering the renewable model (technology) to be adopted. The technology adopted should be:
    - Low on carbon emissions
    - Friendly to the environment and adaptable
    - Cheaper initial investment cost
    - Cheaper installation and maintenance cost
    - Storage and capacity attributable to the energy system (net metering)
    - Operational life of the technology and disposal

  Furthermore, adopting grid-connected renewable energy (solar, wind, bagasse) solutions has the potential to contribute to small-scale and decentralized renewable energy technologies in rural areas. It is envisaged that all these contributions would improve universal access to energy and provide energy security in the country.
- The sugar industry is one of the major consumers of energy and all developments have a direct impact on the business and profits. As such, the sugar industry sees its role as one of the advocates for the acceleration of a sustainable energy future where the farmer benefits include protection/buffer from an ever-increasing electricity bill and favourable profits by scaling up renewable energy.
- One of the challenges from the regulatory point of view is the development of policies and programmes to promote the introduction of renewable energy sources and that include, cooperation, pooling of resources, knowledge creation and research. Both a net-metering and a power wheeling policy are at a pilot stage in the country, the pilot phase is expected to conclude in November 2023.
- A critical factor is the deployment of tailored solutions for smallholder farmers that are also environmentally friendly and financially feasible.
- The EEC is the main provider of energy in Eswatini has the mandate to lead the process of finding and adopting newer and more user-friendly alternatives to energy provision for the country in general and sugar industry in particular.

Insights on the policy landscape:

- Since the adoption of the Southern African Development Community (SADC) Energy Protocol in 1996, the SADC has enacted several strategic instruments for the energy sector, including the following:
    - SADC Energy Cooperation Policy and Strategies [1996]
    - SADC Energy Action Plan [1997]
    - SADC Energy Activity Plan [2000]
    - Regional Energy Access Strategy and Action Plan [2010]

- The SADC energy policy document is very comprehensive. However, the current conditions differ from those of 2003, so a revision of this document is necessary.
- The farmers in the sugarcane industry particularly have taken matters into their own hands and have provided themselves with alternative indigenous resources to mitigate the high electricity costs. For instance, Tabankulu Estate farms have already installed solar panels for irrigation of the sugarcane plantations. Other individual smallholder farmers have also incorporated solar energy in their farms with varying impacts on profitability.

4.3 Financial Institutions

Representatives from three different financial institutions were interviewed: The Eswatini Industrial Development Company (EIDC), Nedbank Eswatini, The Eswatini Development Financial Corporation (FINCORP), the Eswatini Bank and First National Bank.

4.3.1 Availability of finance for solar irrigation

- Upfront capital financing for solar energy is readily available. However, there is a lack of knowledge and awareness about this technology and this has inhibited the smooth implementation and transition from national grid to solar with incentives.
- Smallholder farmers cannot switch completely to solar due to the lack of clear arrangements between the farmers and EEC on the best way to incorporate solar energy.
- EIDC has al agriculture credit and microfinance options for smallholder farmers, financing both associations, cooperatives and farmers.
- EIDC is cautious to lending to individual producer organizations due to default risks.
- EIDC has built background knowledge on the implementation of solar irrigation. However, there are still some gaps that need to be clarified, including:
    - Return on investment
    - Ensuring the reliability of suppliers and installers
    - Ensuring site installation and an adequate installation
    - Optimal layout of the system and whether batteries are required or not
    - Optimal system size
    - Possibilities of blending finance (EIDC had a partnership with the EU/UNDP for a 50:50 financing of solar pumps.
    - Maintenance costs as disposal.
    - Possibility to fed-in excess energy to the national grid (both technical and regulatory requirements (must be defined along with EEC).
- Nedbank and First National Bank in Eswatini have been involved in sugarcane financing as an agri-business, with a focus on bringing financial solutions to smallholder farmers. Nedbank has been involved in the:
    - Financing of the cane growers in the KDDP, LUSIP I, and most recently LUSIP II.
    - Financing of agro-industries and agro-processing.
    - Dealing with farmer associations as well as with individual farmers.
    - Farmer's leadership/management structure which plays a significant role in their ability to pay off loans.

- FINCORP has provided funding to the sugarcane production operations since 1996, funding farmers across all mill groups, including one group in the Malkerns,
    - FINCORP recently funded the conversion to solar energy through two schemes: The Mavela Farmers Association and Ekuvinjelweni Sugar Limited, commissioned in April 2023, these farms implemented 30 kW and 66kW power of solar energy respectively. However, this is the first stage of a phased conversion to solar energy, the implementation of these systems was financed at 100% debt finance and a 3-year payment period. Preliminary observations indicated up to 70% savings in energy costs achieved. These savings will be used to finance the subsequent phases of converting the farm to solar.
    - FINCORP highlighted the lack of service providers, stating that the providers they have worked with so far are located in Canada.
    - FINCORP states that there is a need to provide trainings and awareness raising to farmers on the operation of solar systems, including:
        - Sunlight period for optimal energy harvesting
        - Assistance to revise irrigation schedules to ensure a maximum utilization of effective daylight time and minimal reliance on the grid, according to FINCORP optimal daylight maximization should be from 7 AM to 5 PM in summer, and from 8 AM to 3:30 PM in winter
        - Explaining that labour overtime required in terms of adjusted irrigation schedule/cycles (a seven day irrigation cycle instead of six days) can be compensated by the reduced energy costs from solar energy
        - Ensuring the farmers have internet connection and know how to use the phone application required to manage the system.
        - Ensure provisions for a system warranty and post installation, including a maintenance agreement.
    - FINCORP expressed concerns regarding the high costs of energy storage and the need to established power purchasing agreements with EEC (which, according to FINCORP, has not happened yet) to ensure that the farmers received discounted energy rates when they feed-in to the grid.
- The Eswatini Bank was the first credit institution to finance smallholder farmers in the sugarcane industry. However, even though the bank has recently received an approval as the Accredited Entity to disburse funding for climate change mitigation and adaptation loans from the Green Climate Fund (GCF), they have not yet received any application by sugarcane farmers. The GCF accreditation opens the possibility to offer discounted loans, grants and co-financing as long as the funding proposals aim to address climate resilience, adaptation and reduction of greenhouse gas emissions. The Eswatini Bank representatives consider that in order to make the financing of solar systems feasible it is necessary to:
    - Clarify the mechanisms through which the costs will be offset, as, according to the bank representatives “they are not yet convinced that there is a system that can operate independently from the national grid”.
    - As per the experience of a farmer that self-financed the installation of solar energy, there are significant infrastructure changes required to install a solar system and “the

farmers cannot completely go off-grid as the pumps need to be started from the grid and then switched to solar energy"

- Solar suppliers are not certain of the number of panels required to ensure an optimal energy supply, which, to the bank representatives, brings uncertainty on the qualifications of the supplier.
- There is a need for the bank to have assurance om system lifetime, warranties, reputability of contractors and the provision of infrastructure insurance. Furthermore, the systems should be tested for efficiency to ensure that the energy output will fulfil the irrigation demand.

- As a positive experience, at the beginning of the KDDP, the government provided the smallholder farmers with sufficient support to ensure that their earnings go to the right place which includes servicing their loans and repay them in due time, along with the provision of technical support.
- Farms with an area of less than 50 ha are considered as less profitable
- The financial institutions consider that there is a lack of knowledge of solar irrigation technologies among the farmers.

4.3.2 Net Metering and interconnection policies

- EIDC identifies the following models as interconnection models/options:
  - Fair withdrawal
  - Net metering
  - Power couriering
  - Mini-grid
  - Battery facility
- EIDC sees net metering as an opportunity for those cane farmers on solar energy who generate extra electricity to get credits against the electricity consumed at night or other periods when they are not irrigating or off-season., while creating a smoother demand curve for electricity and allowing utilities to better manage their peak electricity.
- The foundation for the implementation of solarizing the sugarcane industry in Eswatini is unstable. So far, the farmers seem to be moving on their own because the government is lagging behind and that is a cause for concern.

5. Conclusions

- The deployment of solar irrigation in Eswatini represents an opportunity to:
  - Decrease farmers/farming communities electricity expenditure, which represents a major share of their operating costs (approximately 26% for smallholder farmers, according to ESA)
  - Promote climate change mitigation within the country and reduce its carbon footprint, in line with the NDC.
- The number and importance of small-scale cane growers in the sugarcane (and sugar) production has significantly increased in the last 30 years, reaching 29% of sugarcane production. This means that promoting affordable solar irrigation solutions targeted at small-scale farmers will not only have the potential to reduce their operational costs, but also contribute to a significant impact on the energy consumption and carbon footprint of the sector and the country.
- The regulatory framework in Eswatini is progressing towards promoting renewable energy sources, provisions for feeding-in electricity to the national grid are under development and at a pilot stage, the time for national rollout still requires confirmation. These mechanisms still require enforcement and awareness, for which cooperation between ESERA and independent power producers and other key stakeholders is necessary.
- Arrangements between farmers and the energy provider EEC would help to the farmers to be billed for their 'net' energy usage. Since this is a new concept, the EEC and the renewable energy department need to establish synergies between the current energy consumption and a net metering system.
- Smallholder farmers are already aware of solar irrigation technology and its potential benefits, with 24 solar initiatives with a capacity of 6.4 MW already installed, and a 70% of the smallholders farmers interested in acquiring this technology (as reported by the ESA). However, the benefits of the implementation of these systems have not yet been evaluated.
- There are local financial institutions already active in the agriculture sector and willing to grant finance for solar irrigation systems. However, these institutions perceive a series of significant challenges, particularly:
  - The lack of specific knowledge among farmers on solar irrigation systems
  - The need to validate the sizing and the costs of these systems and to assess whether a system has been properly sized, installed and operated.
  - Additional support for the financing of small-scale sugarcane growers, specifically those with less than 50 hectares of land, as the financial institutions perceive that under this range there is a large risk of default.
- According to financial institution representatives, one crucial factor contributing to the successful implementation of the KDDP and LUSIP projects was the provision of technical assistance to farmers. This support played a pivotal role in ensuring that a portion of the farmers' profits were allocated to loan repayments, among other benefits.

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Annex – List of conducted stakeholder interviews

Organization	Representative	Date and time of the interview
Eswatini Development and Savings Bank	Mr. Mazibuse Khumalo Mr. Bonginkhosi Shabangu	June 27, 2023
Eswatini Cane Growers Association (ECGA)	Dr. Sipho Nkambule	June 20, 2023
Eswatini Industrial Development Company (EIDC)	Mr. Maseko	June 12, 2023
Eswatini Development Finance Corporation (FINCORP)	Mr. Zenzele Dlamini Mr. Emmanuel Shongwe	June 12, 2023
Nedbank Eswatini	Mr M. Khumalo	June 8, 2023
First National Bank	Mr. Mlungisi Simelane	June 6, 2023
Eswatini Sugar Association (ESA)	Dr Nkululeko Dlamini	July 6, 2023