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

Report on infrastructure, energy use profiles and needs of interested small-scale sugarcane growers

Deliverable D1.3

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List of abbreviations

Abbreviation	Definition
GHI	Global Horizontal Radiation
LUSIP	Lower Usuthu Smallholder Irrigation Project
PV	Photovoltaics
ECGA	Eswatini Cane Grower Association
ESA	Eswatini Sugar Association
KDDP	Komati Downstream Development Project
kW	Kilo-Watts
MW	Mega-Watts
W	Watts

1. Assessment of small-scale cane growers

Data from a total of 66 sugarcane farmers were assessed for this study, 42 of them do not have yet a solar irrigation system, while the remaining 24 have already installed solar systems. This data was provided by the Eswatini Sugar Association (ESA) and the Eswatini Cane Growers Association (ECGA). The data was analysed in two sections: sugarcane growers without solar systems and sugarcane growers with solar systems, as discussed below.

1.1 Farmers without solar irrigation systems

General information

Location

The location of a site affects many aspects, including the available solar resource in terms of solar irradiation, as well as the angle and orientatation in which the panels should be set to optimize the production of energy. Knowing the location of the site will help in understanding the position of the sun and the optimized angle for energy production throughout the season.

For the purposes of this asssessment, the sugarcane growers in Eswatini were divided into three regions, as per the project requirements:

- The north, where the farmers are located in the vicinity of the Komati Downstream Development Project (KDDP), these farmers deliver their produced sugarcane to the Mhlume mill for processing, 20 farmers were assessed in this area, in collaboration with the Eswatini Sugar Association (ESA) and the Eswatini Cane Growers Association (ECGA).
- The south, in those farms located around the Lower Usuthu Smallholder Irrigation Project (LUSIP) and whose production is delivered to the Big Bend mill for processing. 19 farmers were shortlisted from this group as possible candidates.
- The center, in the Malkerns region, where the farmers deliver their production to the Simunye mill, where three farmers were selected as possible candidates. Out of the three regions of interest, this region has the least area dedicated to sugarcane growers, furthermore, the growing area is located far from the milling, resulting in less cases available for assessment.

Error! Reference source not found. below presents the distribution of assessed farmers across the t hree regions of interest.

Global horizontal irradiation

The estimated solar energy that is accessible for power production and other energy purposes is summarized in this solar resource map. It represents the Global Horizontal Irradiation's average daily/yearly sum (GHI). The estimated solar energy that is accessible for power production and other energy purposes is summarized in this solar resource map. It represents the Global Horizontal Irradiation's average daily/yearly sum (GHI). The most crucial factor in calculating energy yield and evaluating the effectiveness of flat-plate photovoltaic (PV) technology is GHI.

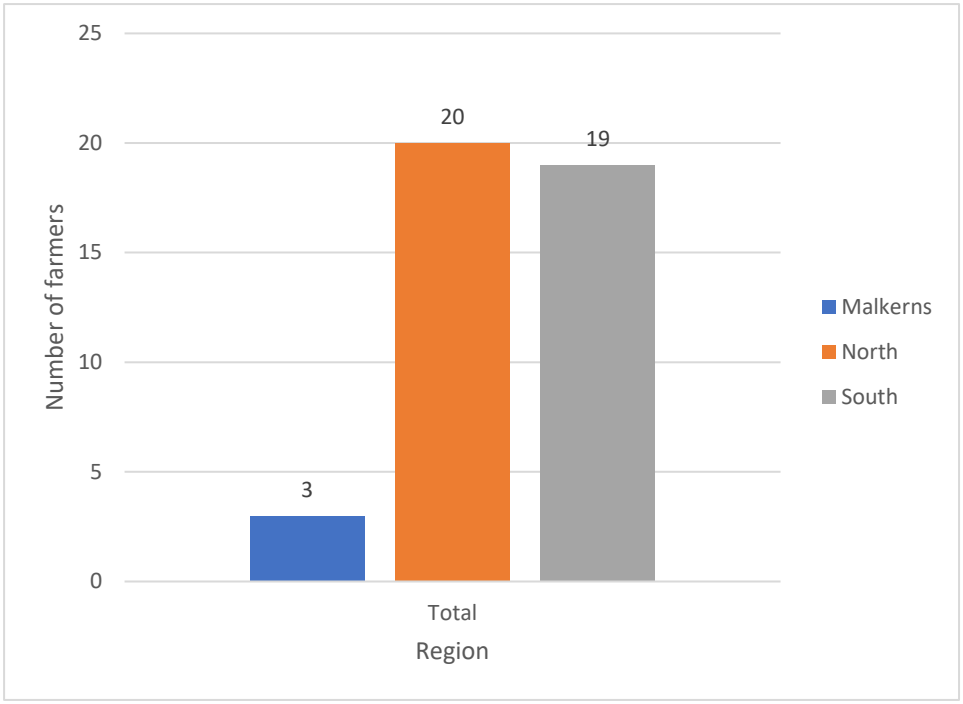

Figure 1- Number of Farmers in the Eswatini Region.

The estimated solar energy that is accessible for power production and other energy purposes is summarized in a solar resource map. The maps presented below show the Global Horizontal Irradiation's average daily and yearly (GHI). The GHI is crucial factor in calculating energy yield and evaluating the effectiveness of flat-plate photovoltaic (PV) technology. The western portion of the country is the Region with the largest global horizontal radiation. Solar-powered irrigation systems are already in use in the western region, the second-highest radiation level in the nation is found in the Central Malkern region. In both the southern and northern regions of the nation, the GHI and photovoltaic potential are comparable. as depicted in Figures 2 and 3 [1].

Photovoltaic Power Potential

A review of the potential for solar photovoltaic (PV) generation is shown in Figure 2. It depicts the average daily and annual output of electricity from a grid-connected, 1kW-peak solar PV power plant. Among the three regions of interest, the largest photovoltaic potential is located near the Malkerns, followed by the northern region closer to Komati Dam and the southern region.

In terms of water resources, these are abundant in the Northern region because of the Komati Downstream Development Project (KDDP). Lower Usuthu Smallhole Holder Irrigation Project (LUSIP) is a water resource in the south [1].

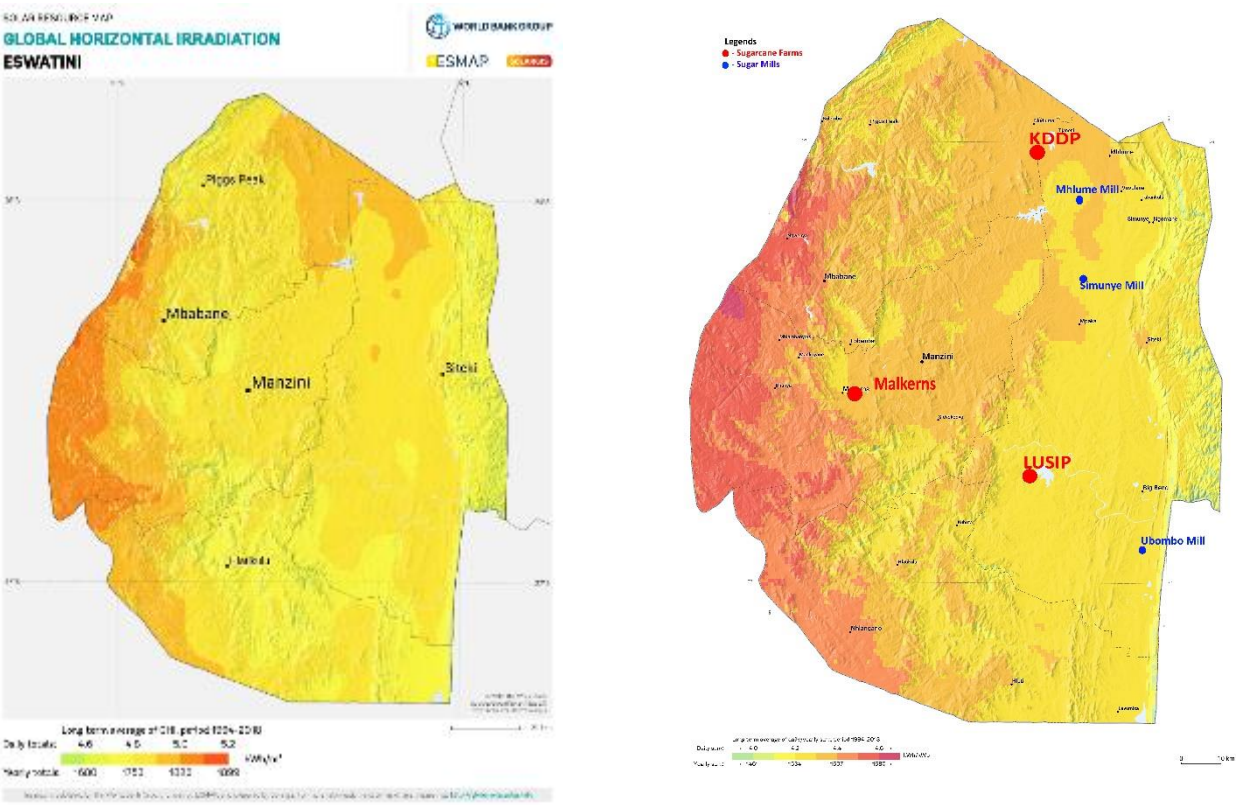

Figure 2 – Global Horizontal Irradiation and solar potential in Eswatini

Farm size

The size of the farm is related to the production of sugarcane, along with irrigation and electricity demand, which will affect the size of the solar power irrigation systems. Depending on the size of the farm parameters such as the irrigation area, energy requirements, and water sources must be considered for sizing the solar irrigation system.

The shortlisted farmers have areas between 41.15 and 630.75 ha. For further analysis, the farmers were divided based on the farm size (in ha) into three groups.

Small farms: A farmer with an area size of 10–100 ha falls under this category. Ten of the shortlisted farms fall into this category, and the average size within this group is 64.9 ha. The grower from the Central Malkern region, Mbetseni Farm, has the largest farm size in this criteria at 90ha. The smallest grower in this criteria is Asibebahle Mbabala Investment, at 41.15 ha, situated in the southern region of Eswatini. As can be seen in Figure 3 below.

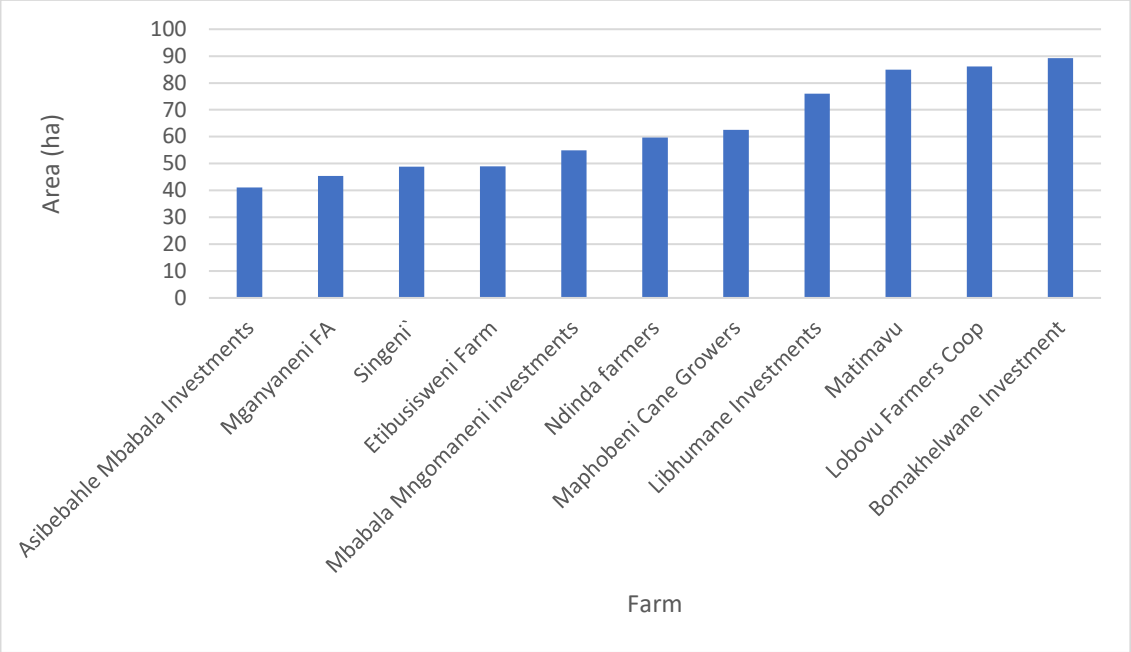

Figure 3. Area of small farms (ha)

Medium-sized farms: "Medium farm size" refers to areas between 100 and 300 ha. This group includes a total of 22 sugarcane farmers. The farms in this category have an average size of 167.07 ha. The grower with the smallest area is in the south and accounts for 104.5 hectares. The largest farm, which has a surface area of 264.3 ha, is situated in the central Malkern region known as Umbane. Figure 4 below compares the medim-sized farms.

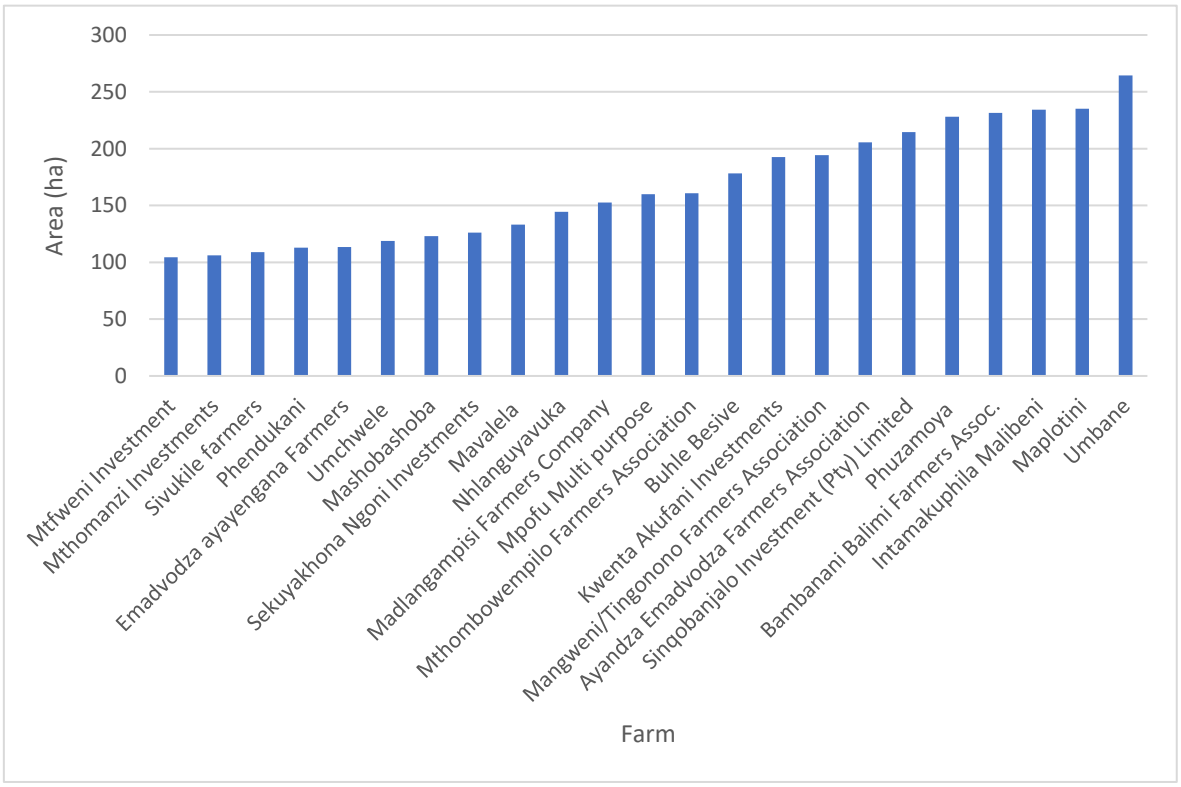

Figure 4. Area of Medium size farms (100-300 ha)

Large farms: A "large farm" was defined as one that grows sugarcane on more than 300 ha of land, seven farms assessed fulfill this criteria. The average size of the farms in this category is 415.14 ha. The majority of them are found in the north. However, the largest farm, with 630.75 ha, is located in the south, Lomdashi Investment. The northern region's Bambanani Maliba Farmers Association, with a total area of 302.568 hectares, has the smallest area in this category. Figure 5 below shows the graphical representation of the Large Farms.

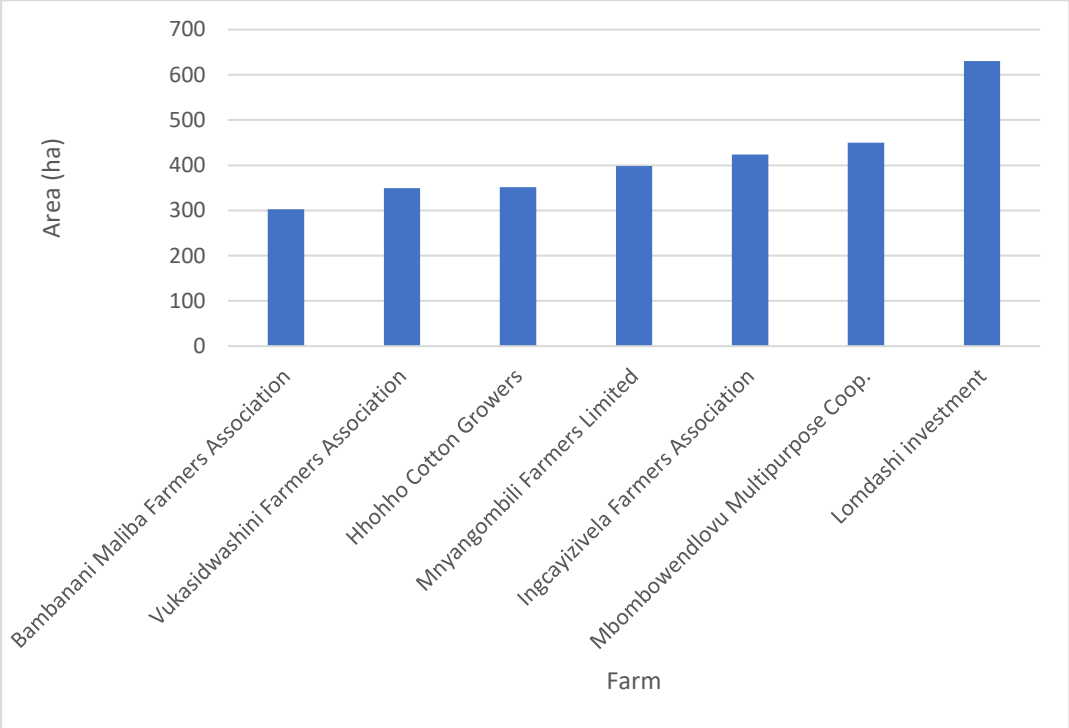

Figure 5. Area of large farms

Larger farms frequently have more land available and therefore more space for a solar irrigation system. However, larger farms will also have a larger energy demand for irrigation and more complex requirements for water distribution.

Available water sources

The quantity and quality of the available water supplies have a considerable impact on the installation of solar irrigation systems, as they are determinant factor on the pumping needs and the power requirements required from the system.

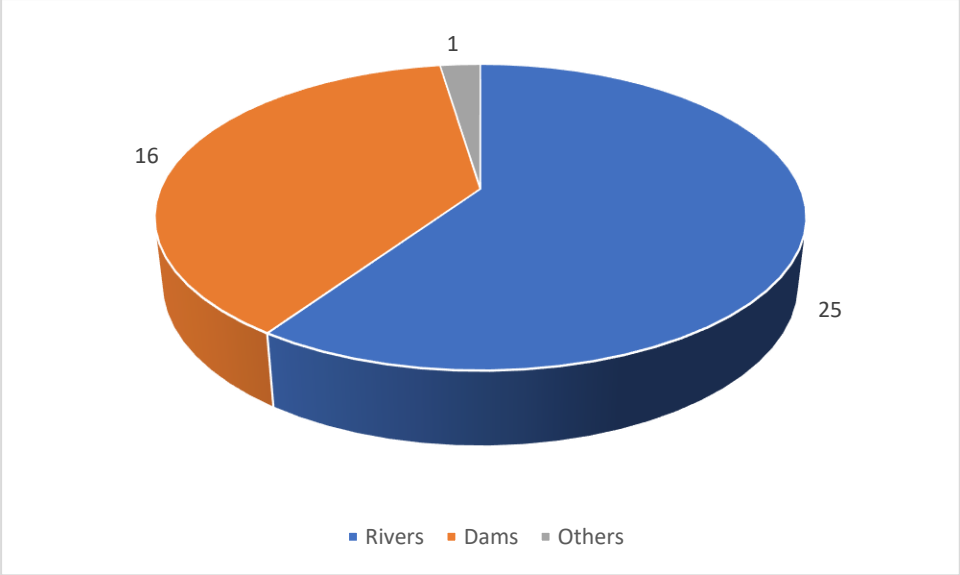

Figure 6. Water sources from assessed farms.

Among the assessed farms, 60% of growers use river's water supply for irrigation. Additionally, 38% of sugarcane farmers use dams for irrigation. 2% of farmers make use of canals and other waterways. The LUSIP dam serves as a source of water for the southern region's sugarcane farmers, while rivers provide a source of water for sugarcane farmers in the Malkerns and practically the entire northern region. The **Error! Reference source not found.** demonstrates that medium-sized f arms and large farms choose rivers as their supply of water. Small farmers prefer dams as a source of water.

Irrigation patterns

Sugarcane farmers in Eswatini typically undergo a 6-day cycle for the irrigation system. The water supply rate is 52 mm/cycle. During the wet season, irrigation is only required three days a week. The most used irrigation method used among the assessed sugarcane growers is sprinkle irrigation. The dry season is typically from October to February.

From April through December, larger farms comply to a harvesting program. Before the start of harvesting, the months of May and June are for drying off. All of the crops can be harvested at once by the small farms. During the winter time, a lower water loss due to evapotranspiration reduces the irrigation needs. Additionally, medium- and large-sized farms can properly manage their water demand throughout the year by adhering to a timetable based on the dry-off and harvest program, ensuring that water is delivered equally and efficiently.

Irrigation system

Figure 7. below shows the type of irrigation systems used by the sugarcane growers assessed. The semi-solid sprinkler irrigation system, which is a typical sprinkler irrigation system, is the most commonly used irrigation method in these farms. This irrigation technique is used by around 60% of sugarcane evaluated. This method is followed by the sprinkler and pivot irrigation system. Only six farms use the irrigation techniques associated with drip irrigation, floppy systems, dragline sprinklers, and drip and pivot systems.

These less popular irrigation techniques are frequently more expensive to install and operate, which may account for their slow uptake among farmers. Additionally, the capacity of semi-solid sprinklers and pivot systems to evenly distribute water over large areas is what makes them popular. This ensures that crop growth and yield are maximized. Small and medium-sized farms typically use the sprinkler and pivot system and the spherical sprinkler system.

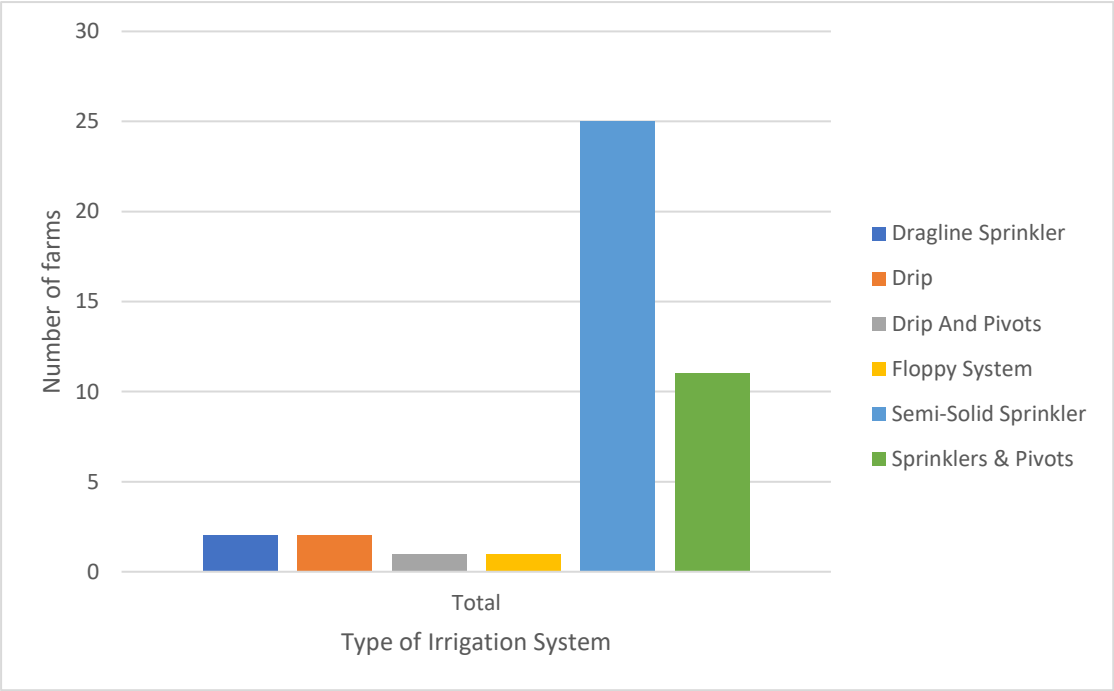

Figure 7. Type of irrigation systems used by shortlisted farmers

Pump sizes and number of pumping stations

In solar irrigation systems, the power generated by the solar panels is fed to the water pumps, which are used to irrigate water from the source to the fields. Therefore, the number and size of the pumps will provide a good indication of the amount of power required for irrigation, while the number of pumping stations indicates the distance between the water source and the crops that require irrigation, the higher these parameters, the larger will be the required solar power irrigation system. The assessed farmers employ a total of 178 pumps for their irrigation system. For the crops to have a consistent supply of water, these pumps are necessary.

The pumps have an overall power requirement of 13,837 kW to operate. The power consumption of the pumps highlights the significant energy demand of the irrigation system, emphasizing the importance of sustainable energy sources for long-term agricultural practices.

For the cultivation of sugarcane, each farmer requires an average of 329 kW of power. The size of the pump station has no bearing on the grower's power usage. The maximum number of pumps installed amoing the growers is 16, for a power requirement of 1,137 kW of power. The largest power requirement is 1,365 kW of power at maximum output for eight pumps. The power consumption of a grower is not solely determined by the number of pumps they have but also by other factors, such as the efficiency of their irrigation system.

Small farms (10 -100 ha): The Bomakhelwane investment has the highest number of pumps in this category with three pumps to irrigate an area of 89.2 ha. They are in Eswatini's southernmost region and obtain water from the LUSIP dam. The power required to run the three pumps is 135 kW, which helps run the semi-solid sprinkler irrigation system. The Asibebahle Mbabala Investment with an area of 41.15 ha located in the southern region and consuming the water from the MPOFU requires 55 kW of power; the Mbabala Mngonami Investment with an area of 54.94 ha located in the southern region and using LUSIP dam for irrigation purposes consumes 45 kW of power; the Singeni Investment with an area of 48.8 ha located in the northern region and using the river for irrigation purposes requires 90 kW of power; and the Mganyaneni FA with an area of 45.4 ha located in the southern region and consuming the water from LUSIP dam for irrigation purposes requires 75 kW of power. All of these sugarcane growers only have one pump for their cultivation. The Average power consumption by the growers in this sector is 125.5 kW, while the total number of pumps used in the small farms is 18. These results can be seen in Figure 8 and Figure 9 below.

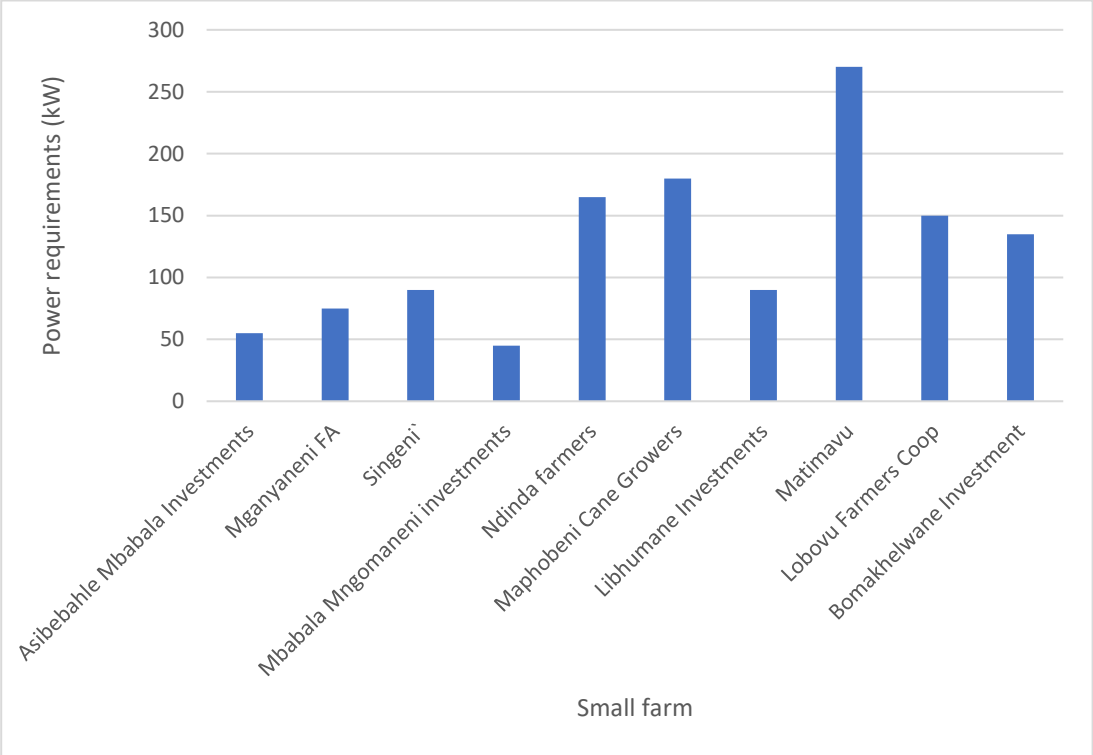

Figure 8. Power Consumption by small farms

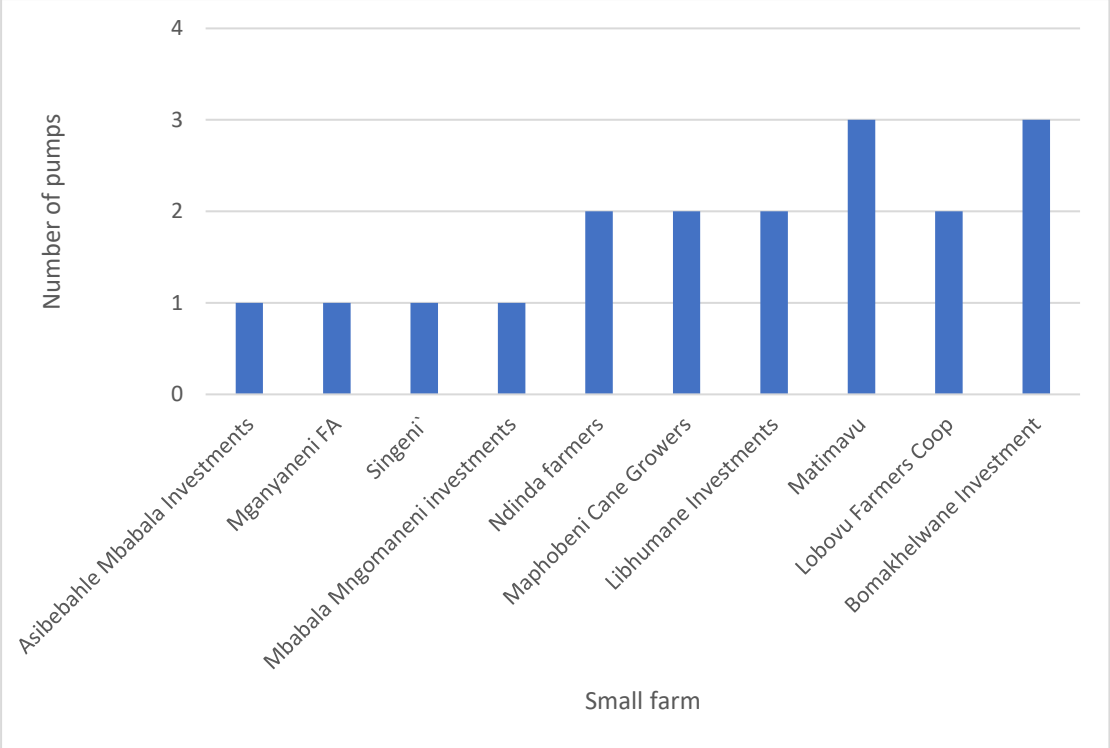

Figure 9. Number of pumps used by small farms

Medium-sized farms (100 – 300 ha): Within this group, the Mangweni/Tingonono Farmers Association, with an area size of 194.4 ha, uses the largest number of pumps, with nine, to power their 344 kW sprinkler irrigation, this farm is located in the northern region of Eswatini and uses river water for irrigation. The smallest power consumption within this group is in Emadvodza ayayengana farm with only one pump used to irrigate their 113.35ha of land and consuming 110 kW of power to run their semi-solid sprinkler system, this farm is situated in the northern region of Eswatini and uses river water as a resource. The category's average power is 265.47 kW. The farmers within this group use an overall number of 90 pumps used. These results can be seen in Figure 10 and Figure 11 below.

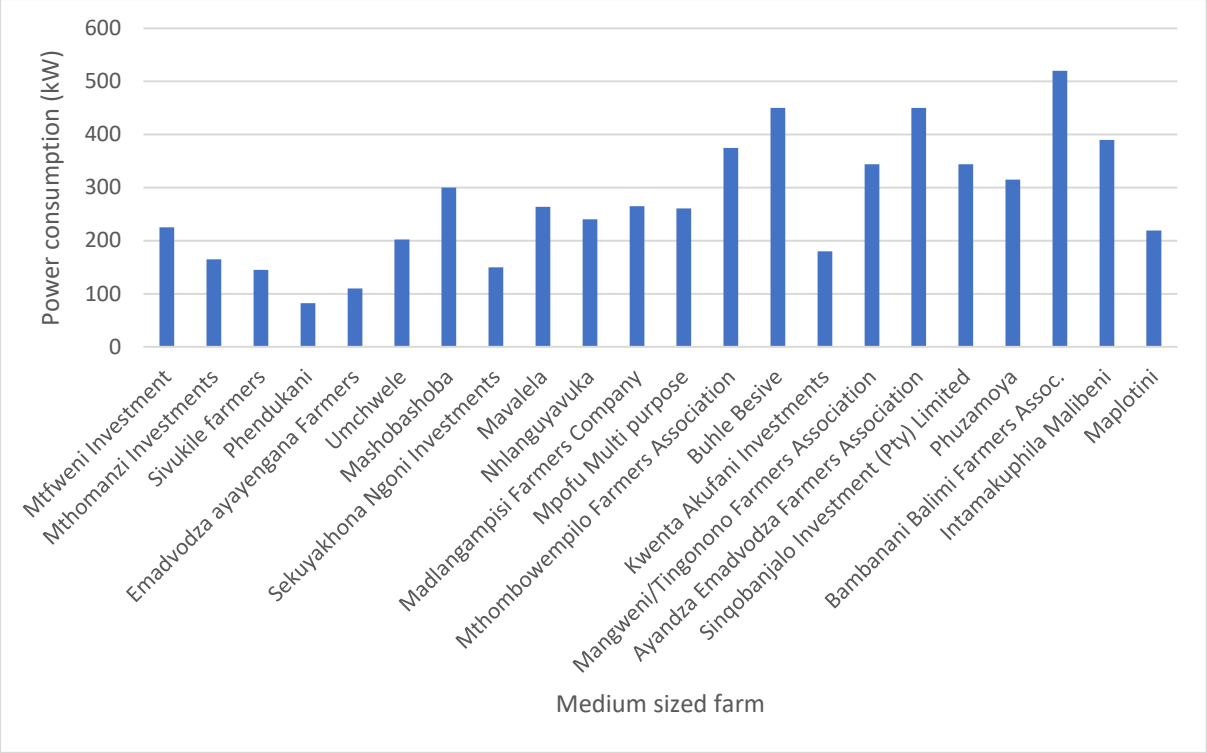

Figure 10. Power consumption in medium-sized farms

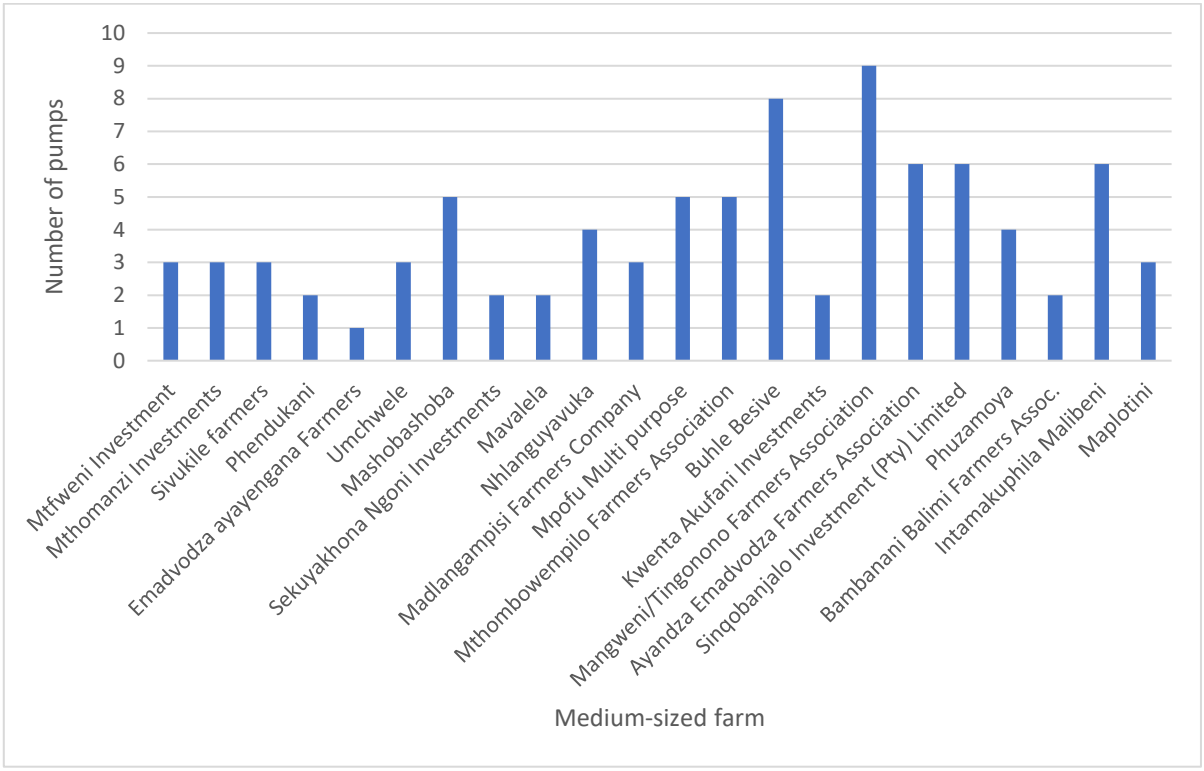

Figure 11. Number of pumps used by medium-sized farms.

Large farms (Above 300 ha): Among the large farms, the Lomdsahi Investment far, the largest farm among the ones assessed, utilizes 16 pumps to irrigate a 630.75 ha area using a Sprinkle & pivot irrigation system which consumes 1,137kW of electricity, the water source of this farm is the LUSIP dam. The smallest power requirements among this group is found in the Bamanani Maliba Farmers Association, using five pumps to extract river water for sprinkler and pivot irrigation systems, with

power requirements of 450 kW of electricity, this farm is localted in Eswatini's northern are. Among the farms in this group a total of 66 pumps, with an average power consumption of 867.42 kW of power per farm. These results can be seen in Figure 12 and Figure 13 below.

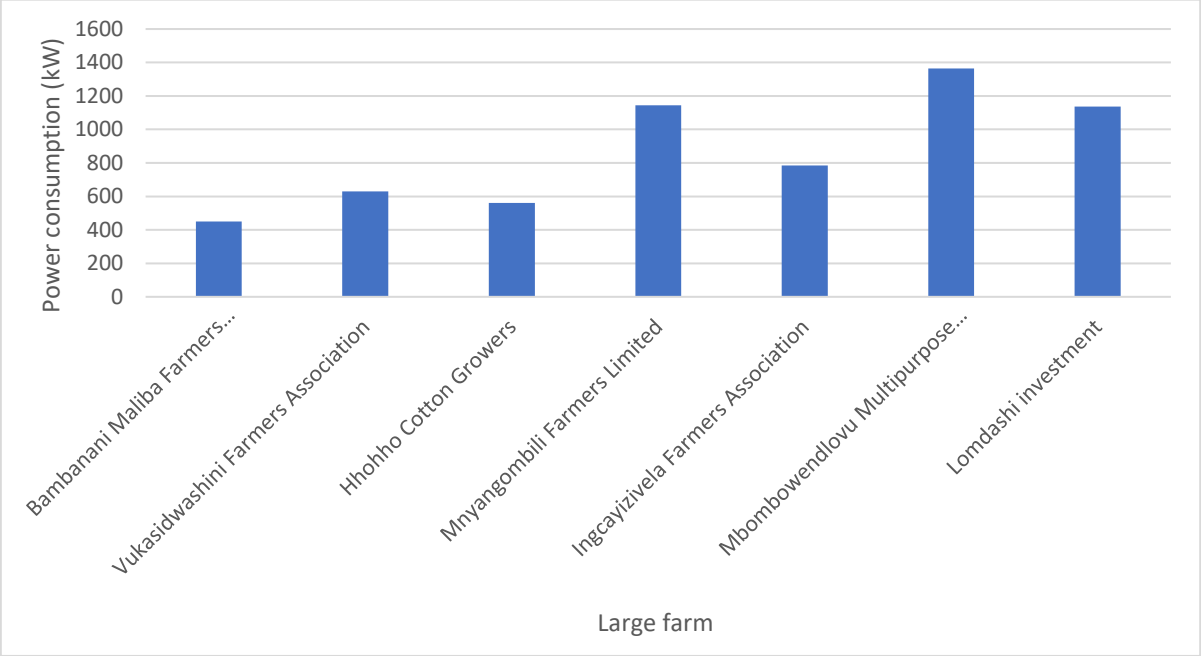

Figure 12. Power consumed by large farm-size grower

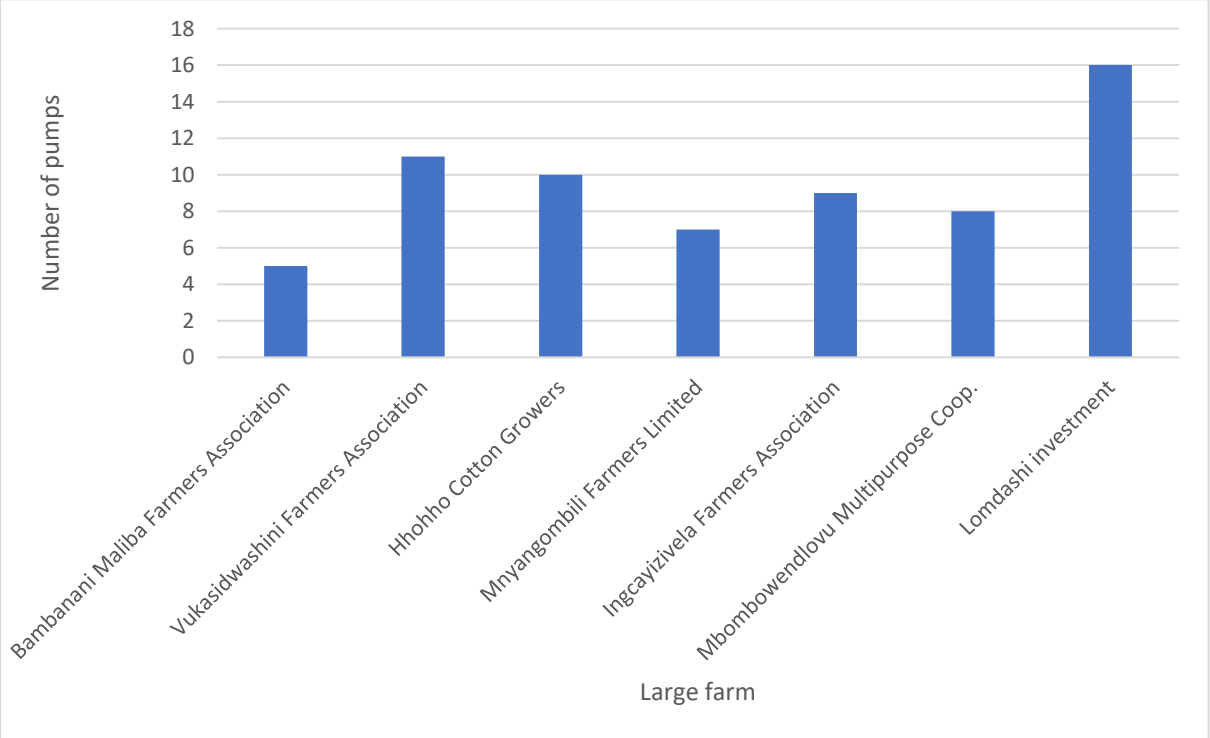

Figure 13. Number of pumps used by large farms.

The quantity and power consumption of the pumps used in a solar-powered irrigation system have specific requirements. The kind of pumps used, how efficient they are, the type of irrigation employed, and the size of the farm all significantly affect how much power is needed. Additionally, factors such as the water source and its distance from the farm, as well as the desired flow rate and

pressure, also play a role in determining the power requirements of a solar-powered irrigation system. Therefore, careful consideration and analysis of these variables are essential for designing an efficient and sustainable system.

1.2 Farmers with a solar system already installed

24 farms with solar irrigation systems installed in the period 2017-2023 were assessed, for this assessment, the farms were divided per region, in KDDP, LUSIP and the Malkerns areas. Most of the sugarcane growers using solar systems are located in the southern region (LUSIP), with 14 growers irrigating 4,400 ha with an installed solar capacity of 3,900 kWp. Within this region the largest grower has an overall area of 885 hectares with an overall PV capacity of 1500 kWp, the United Plantations, installed in 2017.

The smallest solar power plant in the southern region, the Johannes Manguluza Tsabedze, has a capacity of 14.7 kWp and irrigates 7.5 ha. It was founded in 2022. The southern region offers enormous solar potential, as noted in the Power Potential section, and growers familiar with the system have been highlighting its benefits since 2017.

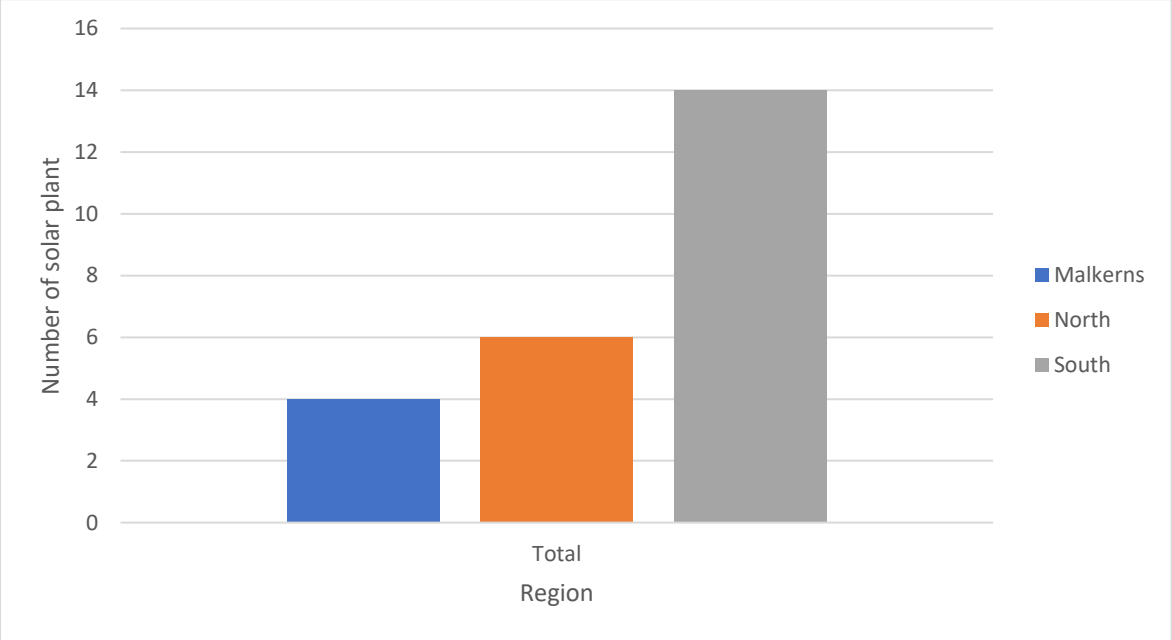

Figure 14. Cane growers with solar irrigation systems

The second largest group of farms using solar irrigation is located in the northern region (KDDP). With a total of seven solar power plants and 1,969 kWp of solar capacity for irrigating 4,370 ha. The solar irrigation practice began in 2019. In this region, solar irrigation covers an average area of 728 ha. The largest solar plant in this area, with a capacity of 1,600 kWp, is needed at Tambankulu Sugar Estate due to its 3,439 ha of irrigation area, the plant became operational in 2021, also being the largest farm among the assessed farms with solar irrigation installed. The Volindi Estates is the smallest solar-powered irrigation system in the north, with a 35 kWp solar power for the irrigation of 161 ha of land.

The Malkerns region has the lowers number of installed solar systems, even though it is the largest GHI, this might be due to the lower number of farms in this region. Farms with solar systems in the Malkerns have an average area of average of 113 hectares, a total of eight solar power plants that generate 681 kWp of electricity.

The largest system in this area was installed in Dalcure Farm in 2021, with a size of 452 kWp over an area of 290 ha. Despite having the second-largest land or irrigation area (85 hectares), the Makhomba has the lowest power generation, a 60 kWp system installed in the year 2020.

2. Conclusions and next steps

- This report analyzed data from 66, among the farmers without solar irrigation systems sugarcane growers in Eswatini who are interested in solar irrigation practices. The total area used for sugarcane cultivation by these farms is 5,540.01ha and their power requirements amount to 13.8 MW of power required for pumping.

- The average farm size among the growers without solar energy growers is 179 ha, while the average number of pumps per farm is four, and the average power requirements 329 kW.

- Most of the assessed sugarcane growers (22) without solar energy are medium-sized farms (100 ha to 300 ha).

- The Mbombowendlovu Multipurpose co-operation has the highest power consumption (1,365kW) of all the assessed growers without solar irrigation systems. This grower is located in the northern region having an area size of 450 ha using a sprinkler and pivot irrigation system with eight pumps to distribute the water.

- The smallest power requirements within the assessed farms without solar irrigation systems corresponds to Mngomaneni Investments, using one 45 kW pump for irrigating an area of 54.94 ha.

- The data analyzed in this report will be used as a base to shortlist six farms from this list for the conduction of the technical and economical feasibility study for the implementation of solar irrigation systems, the shortlisting will be conducted based on an analysis of the region of the farms, the area and the number and power consumption of the farms.

3. Limitations of the study

- The main limitation when conducting this study is the available data. While the data obtained provides relevant insights on energy consumption and infrastructure, a more detailed assessment will require historical electricity consumption data, which was requested to the EEC, but has not yet been provided.

- The results of this assessment are limited to 42 cases which were selected along with the ECGA and ESA according to their relevance as possible case studies for the introduction of solar irrigation systems, along with the data from 24 cases where solar irrigation has alread been implemented. A larger sample would provide more accurate insights regarding the overall sugarcane farming sector in the country.

4. References

[1] “Solar resource maps of Eswatini.” https://solargis.com/maps-and-gis-data/download/eswatini (accessed Sep. 05, 2023).

Annex – Assessed farmers data

No.	Growers	Area (ha)	Region	Irrigation system	Number of pumping stations	Number of pumps	Total power requirements (kW)	Mill	Location
1	Vukasidwashini Farmers Association	349.57	North	semi-solid sprinkler	4	11	630	Mhlume	Komati river
2	Hhohho Cotton Growers	351.20	North	drip and pivots	4	10	560	Mhlume	Komati river
3	Mangweni/Tingonono Farmers Association	194.40	North	semi-solid sprinkler	4	9	344	Mhlume	River Majama
4	Mbombowendlovu Multipurpose Coop.	450.00	North	sprinklers & pivots	2	8	1,365	Mhlume	Komati river
5	Ingcayizivela Farmers Association	423.48	North	sprinklers & pivots	2	9	785	Mhlume	Komati river
6	Phuzamoya	228.00	South	sprinklers & pivots	1	4	315	Big Bend	River Phuzumoya
7	Mnyangombili Farmers Limited	398.30	North	semi-solid sprinkler	2	7	1,145	Mhlume	Mafucula
8	Mthombowempilo Farmers Association	160.84	North	floppy system	2	5	375	Mhlume	Komati
9	Mpofu Multi purpose	160.00	North	semi-solid sprinkler	2	5	261	Mhlume	River
10	Mashobashoba	123.00	South	semi-solid sprinkler	2	5	300	Big Bend	River
11	Maplotini	235.00	South	drip	1	4	219	Big Bend	
12	Lomdashi investment	630.75	South	sprinklers & pivots	2	16	1,137	Big Bend	Dam
13	Ndinda farmers	59.71	North	sprinklers & pivots	2	2	165	Mhlume	River

14	Buhle Besive	178.10	North	semi-solid sprinkler	2	8	450	Mhlume	River
15	Intamakuphila Malibeni	234.20	North	semi-solid sprinkler	2	6	390	Mhlume	River
16	Sivukile farmers	108.80	North	semi-solid sprinkler	2	3	145	Mhlume	River
17	Nhlanguyavuka	144.30	North	semi-solid sprinkler	2	4	240	Mhlume	River
18	Bambanani Maliba Farmers Association	302.68	North	sprinklers & pivots	2	5	450	Mhlume	River
19	Mthomanzi Investments	106.00	South	semi-solid sprinkler	1	3	165	Big Bend	LUSIP dam
20	Matimavu	85.00	South	semi-solid sprinkler	1	3	270	Big Bend	LUSIP dam
21	Ayandza Emadvodza Farmers Association	205.43	North	semi-solid sprinkler	2	6	450	Mhlume	River
22	Bambanani Balimi Farmers Assoc.	231.40	North	drip	1	2	520	Simunye	Dam
23	Madlangampisi Farmers Company	152.60	North	semi-solid sprinkler	1	3	265	Mhlume	River
24	Mavalela	133.19	South	semi-solid sprinkler	1	2	264	Big Bend	Sivunga dam
25	Singeni`	48.80	North	sprinklers & pivots	1	1	90	Mhlume	River
26	Bomakhelwane Investment	89.20	South	semi-solid sprinkler	1	3	135	Big Bend	LUSIP dam
27	Libhumane Investments	76.00	South	semi-solid sprinkler	1	2	90	Big Bend	LUSIP dam
28	Maphobeni Cane Growers	62.60	South	sprinklers & pivots	1	2	180	Big Bend	LUSIP dam
29	Phendukani	113.00	South	sprinklers & pivots	1	2	82	Big Bend	LUSIP dam
30	Kwenta Akufani Investments	192.47	South	semi-solid sprinkler	1	2	180	Big	Mpofu

								Bend	dam
31	Mtfweni Investment	104.50	South	semi-solid sprinkler	1	3	225	Big Bend	LUSIP dam
32	Asibebahle Mbabala Investments	41.15	South	semi-solid sprinkler	1	1	55	Big Bend	Mpofu dam
33	Mbabala Mngomaneni investments	54.94	South	semi-solid sprinkler	1	1	45	Big Bend	Mpofu dam
34	Sekuyakhona Ngoni Investments	126.20	South	sprinklers & pivots	1	2	150	Big Bend	Mpofu dam
35	Umchwele	118.90	South	semi-solid sprinkler	1	3	202	Big Bend	LUSIP Feeder canal
36	Mganyaneni FA	45.40	South	sprinklers & pivots	1	1	75	Big Bend	LUSIP dam
37	Lobovu Farmers Coop	86.20	South	semi-solid sprinkler	1	2	150	Big Bend	LUSIP dam
38	Emadvodza ayayengana Farmers	113.35	North	semi-solid sprinkler	1	1	110	Mhlume	River
39	Sinqobanjalo Investment (Pty) Limited	214.70	North	semi-solid sprinkler	2	6	344	Mhlume	River
40	Etibusisweni Farm	49.00	Malkerns	dragline sprinkler	1	2	74	Simunye	
41	Mbetseni Farm	90.00	Malkerns	dragline sprinkler	1	2	110	Simunye	
42	Umbane	264.30	Malkerns	semi sprinkler	1	3	330	Simunye	

Farmers with solar systems

No.	Growers	Area (ha)	Location	Grower Category	Mill	Solar Plant		Status	Installed Date
						Size (kWp)	No. Plant		
1	United Plantations	885	South	MSG	Ubombo	1,500	1	Operational	2017
2	Batch Farms(Pty) Limited	178	South	MSG	Ubombo	99	1	Operational	2019
3	Volindi Estates	161	North	MSG	Mhlume	35	1	Operational	2019
4	Murton Nigel	26	South	SSG	Ubombo	30	1	Operational	2019
5	Packard & Wright	31	Malkerns	SSG	Simunye	69	1	Operational	2019
6	L.A. Hulley (Pty) Ltd	46	Malkerns	MSG	Simunye	100	1	Operational	2020
7	Makhomba	85	Malkerns	MSG	Simunye	60	2	Operational	2020
8	Dalcrue Farm	290	Malkerns	MSG	Simunye	452	4	Operational	2021
9	River View Farm	88	South	MSG	Ubombo	70	1	Operational	2021
10	Tambankulu Sugar Estate	3,439	North	LSG	Mhlume	1,600	1	Operational	2021
11	John Bezuidenhout	0	South	SSG	Ubombo	69	1	Operational	2021
12	Crooks Brothers Limited	2,157	South	LSG	Ubombo	1,371	5	Operational	2021
13	Canterbury	196	South	MSG	Ubombo	355	1	Operational	2021
14	Nhlanhla Nhleko	9.5	South	SSG	Ubombo	22	1	Operational	2022
15	Cel'colo Sukati	34	South	SSG	Ubombo	62	1	Operational	2022
16	Manguluza Johannes Tsabedze	7.5	South	SSG	Ubombo	14.7	1	Operational	2022
17	Nisela - site 1	760	South	MSG	Ubombo	198	1	Operational	2022
18	Ben Ngcamphalala	15.7	South	SSG	Ubombo	24	1	Operational	2022
19	Phakama Mafucula	325	North	SSG	Mhlume	65.4	1	Operational	2022
20	Calamuva - phase 1 (99kW)	173.8	North	SSG	Mhlume	99	1	Operational	2022
21	Mavela Farmers	62.6	North	SSG	Simunye	38	1	Operational	2023
22	Ekuvinjelweni	207.2	North	SSG	Mhlume	132	2	Operational	2023
23	Mgulugulu	-	South	SSG	Ubombo	36.8	1	Operational	2023
24	Vuka Sive Samaja	50	South	SSG	Ubombo	93	1	Operational	2023