The effects of Hybrid solar energy electrification on People's livelihoods on Bugala Island, Kalangala District.

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Introduction

- Over 600 million people still live without access to electricity in Africa (Adkins et al., 2012; Bhattacharyya & Palit, 2021; Gray, et al 2019).

- Less than 35% in Sub Saharan Africa have electricity access (Simpson et al., 2021)

- Only 26.7% of the population in Uganda have access to electricity (Mugagga & Chamdimba, 2019).

- Solar energy is gaining attention as the most promising and reliable source to address this challenge on islands (Chelsea et al., 2020).

Problem Statement

➢ Although studies have been on solar energy electrification and livelihoods on Islands (Kabir et al., 2018, Mukisa et al., 2020, Simpson et al., 2021)

➢ Little is done on influence of solar power plant projects on livelihoods (Huq, 2018).

➢ It creates a knowledge gap on the effects of solar energy on livelihoods

➢ The study sort to understand the effects of solar energy electrification on livelihoods

Research Objectives

General Objective

The study aimed at understanding the solar energy electrification patterns and document lessons learnt as regard to electricity access on Bugala Island, Kalangala District

Specific Objectives

1. *To determine solar energy electricity access patterns on Bugala Island, Kalangala district.*

2. *To assess the role of solar energy electricity in improving livelihoods on Bugala Island, Kalangala district.*

3. *To examine the challenges associated with solar energy electricity use on Bugala Island, Kalangala district.*

Methodology

Location of the study area
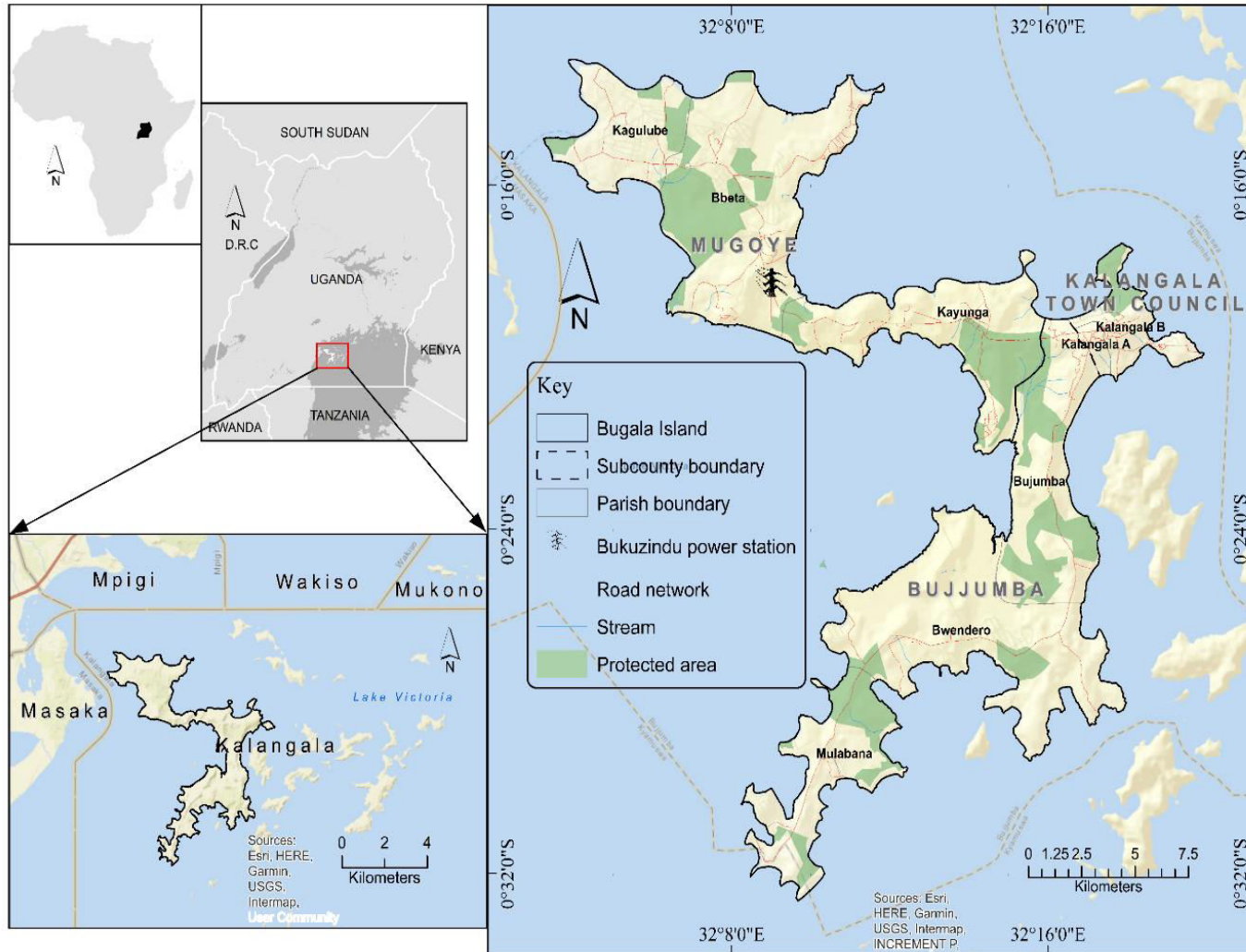
Study Area Overview

❖ Located between longitudes 32'01'East and latitudes 0'10 South and 1 00' South (Ssemmanda & Opige, *2018 and Helgason, 2019)*

❖ Bugala Island is the biggest island in the district

❖ It covers a total area of 296km^2 having 13 central forest reserves, which cover about 65km^2.

❑ Has three sub-counties; **Bujjumba, Kalangala Town Council, and Mugoye**.

❖ Population; 28,760 (UBoS *2019*)

❖ Households; 9,868 (UBoS *2019*)
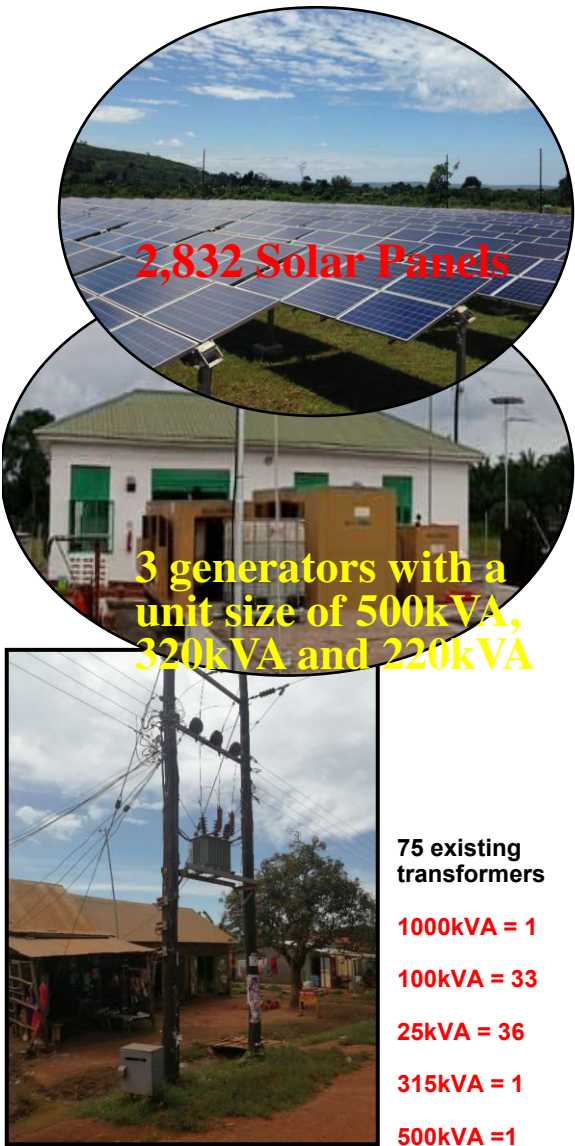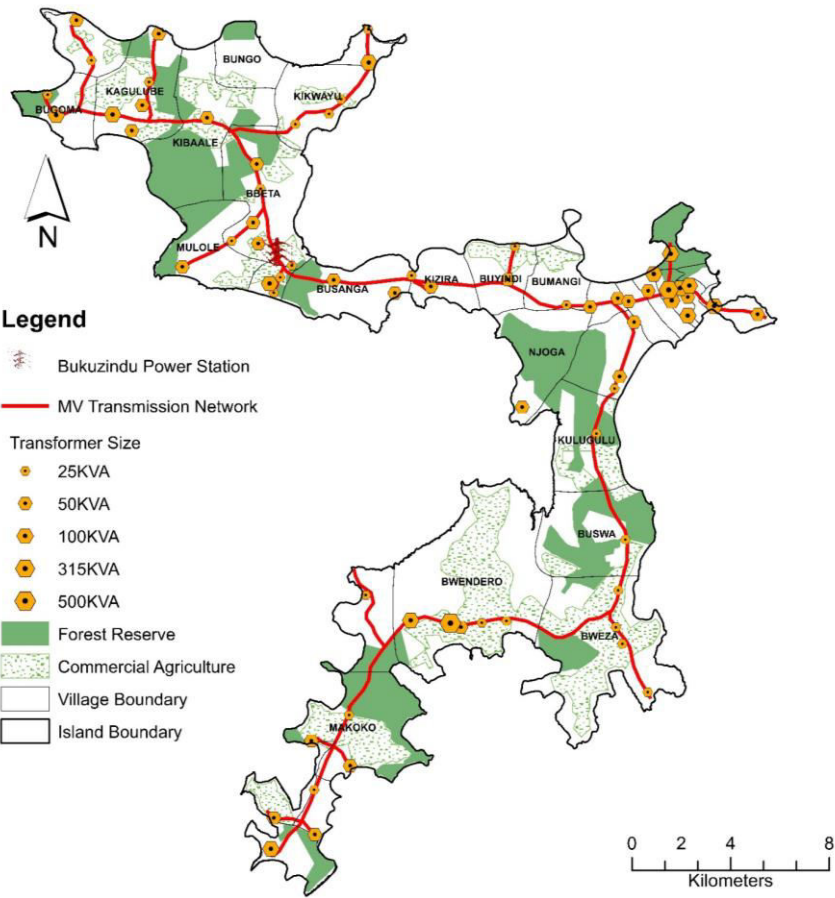
❖ Oil palm grown all the Island

Methodology cont'd

A case study survey type and a Cross-sectional survey type
❖ Random sampling and purposive sampling

Objectives	Methods	Tools	Analysis
1. To determine solar energy electricity access patterns	➢ **Mapping** ➢ **Secondary data**	❑ Global positioning system (GPS)	➢ Distribution maps ➢ Optimized hotspot analysis
2. To assess the role of solar energy electricity in improving livelihoods	➢ **Survey questionnaire**	❑ Semi-structured questionnaire *(Digitally coded and programmed using KOBO-collect and ODK)- Smartphones*	✓ Frequencies ✓ Cross tabulations ✓ Nominal Logistic Regression
3. To examine the challenges associated with solar energy electricity use	➢ **Key informant interviews**	❑ Observation checklists ❑ Recording devices ❑ Notebook and pens	➢ Frequencies ➢ Ordinal Logistic Regression ➢ Bayesian Belief Network Model (BBN)

Results: Objective 1_ Solar energy electricity access patterns

Distribution of transformers and MV line

Legend

- Bukuzindu Power Station
- MV Transmission Network
- Transformer Size
  - 25KVA
  - 50KVA
  - 100KVA
  - 315KVA
  - 500KVA
- Forest Reserve
- Commercial Agriculture
- Village Boundary
- Island Boundary

Distribution of solar energy electricity users

Legend

- Electricity user
- Forest Reserve
- Commercial Agriculture
- Island boundary

6,005 users

2,832 Solar Panels

3 generators with a unit size of 500kVA, 320kVA and 220kVA

75 existing transformers

1000kVA = 1

100kVA = 33

25kVA = 36

315kVA = 1

500kVA =1
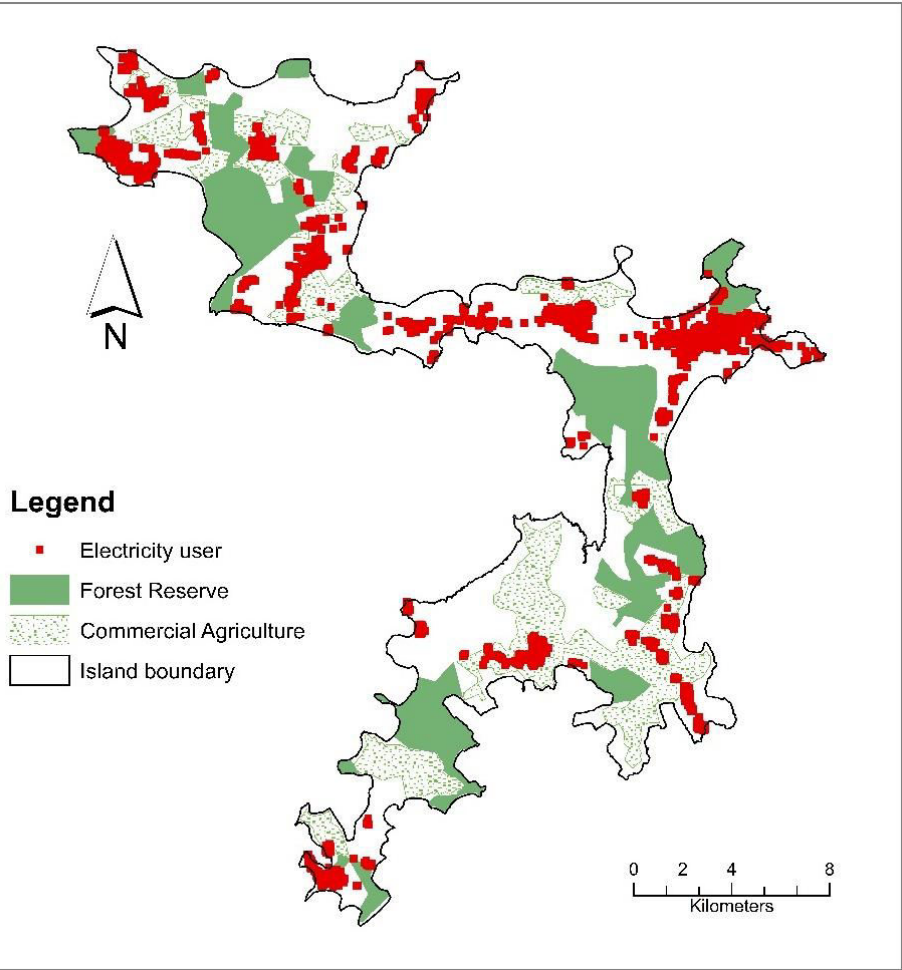
Optimized hotspot analysis on users
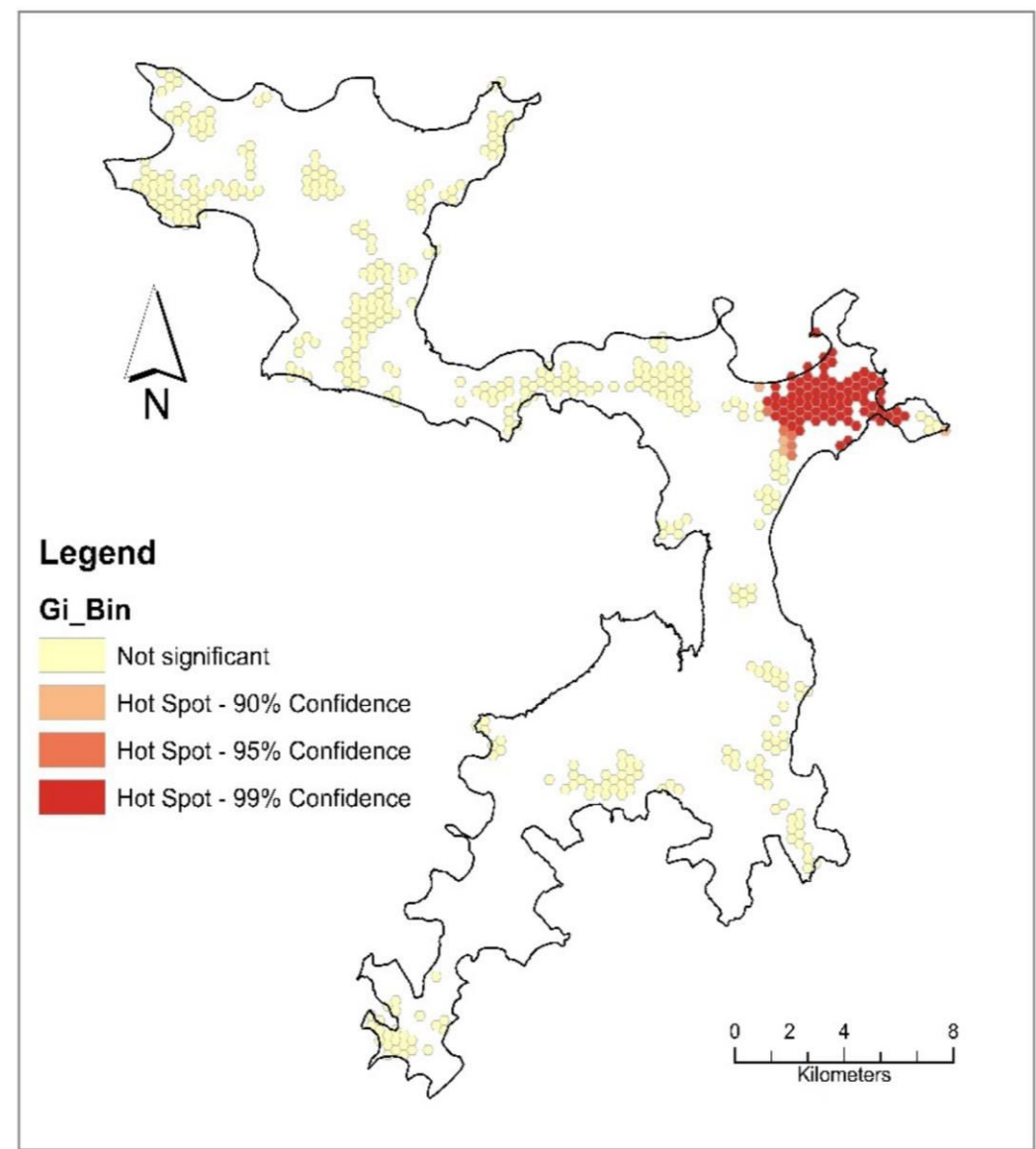
Z Score and *P*-value of spatial clustering

Confidence (%)	Z Score	P-value
Not significant	-0.270319	0.786915
90	2.350809	0.018733
95	2.745078	0.006050
99	6.89377	0.000000

The hotspot analysis produced no cold spot since there was no low negative Z score and a lower *P*-value to indicate a cold spot.

Legend

Gi_Bin

- Not significant
- Hot Spot - 90% Confidence
- Hot Spot - 95% Confidence
- Hot Spot - 99% Confidence

❑ Solar energy electricity use

12am-5am 6pm-11pm 12pm-5pm 6am-11am
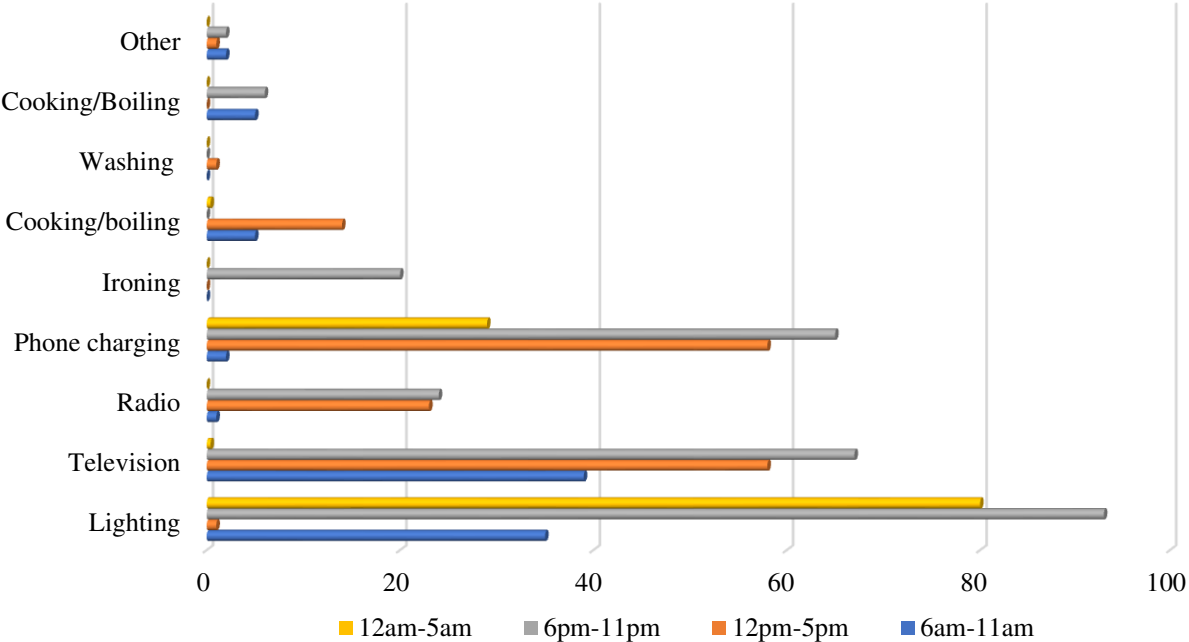
Results: Objective 1_ Role of solar energy electricity in improving livelihoods

Education

Explanatory variable	Category	Co-efficient	Std Error	Chi-square	P-values
Time spent revising/studying at home	No increase	0.0594	0.3180	0.03	0.8517
	Slight increase	0.7257	0.2482	8.55	0.0035*
	Noticeable increase	-0.0032	0.3216	0	0.9921
Teacher's presence in Schools	No increase	0.0290	0.3189	0.01	0.9274
	Slight increase	1.2494	0.2384	27.46	<.0001*
	Noticeable increase	0.5381	0.2609	4.25	0.0392*
Access to education online materials	No increase	-0.7832	0.3901	4.03	0.0447*
	Slight increase	1.1471	0.2399	22.86	<.0001*
	Noticeable increase	0.8451	0.2664	10.06	0.0015*
Attendance to evening lessons	No increase	-0.3390	0.3370	1.01	0.3144
	Slight increase	1.0343	0.2362	19.18	<.0001*
	Noticeable increase	0.0246	0.2945	0.01	0.9335
Improved performance	No increase	-0.5156	0.3371	2.34	0.1261
	Slight increase	1.2189	0.2376	26.32	<.0001*
	Noticeable increase	0.2362	0.2846	0.69	0.4065
Online learning/ teaching	No increase	-0.0142	0.3316	0	0.9659
	Slight increase	1.1301	0.2121	28.4	<.0001*
	Noticeable increase	0.2120	0.3033	0.49	0.4846

*p-Value significant at 0.05%

"Studying from home at night has been made easier by the reliable electricity provided by KIS" (CDO Kalangala Town Council)

"We longer ferry printed materials (exams) from Kampala, the PTA bought a photocopier we use now to print material" (H.M St. Simeon Bugoma Mapeera Primary)

Access to information

Explanatory variable	Category	Co-efficient	Std Error	Chi-square	P-values
Access to climate/agricultural issues	No increase	0.0847	0.6519	0.02	0.8967
	Slight increase	1.0557	0.4383	5.8	0.0160*
	Noticeable increase	0.3987	0.4081	0.95	0.3285
Access to information on health and safety issues	No increase	-2.6978	0.8576	9.9	0.0017*
	Slight increase	0.6348	0.4017	2.5	0.114
	Noticeable increase	1.0343	0.4236	5.96	0.0146*
Access to information on family planning	No increase	0.4436	0.5725	0.6	0.4384
	Slight increase	0.8981	0.4021	4.99	0.0255*
	Noticeable increase	-0.9897	0.3950	6.28	0.0122*
Access to local/national/international news	No increase	0.3316	0.7754	0.18	0.6689
	Slight increase	0.1919	0.5285	0.13	0.7166
	Noticeable increase	-0.5422	0.4663	1.35	0.2449
Access information useful for income generating activities	No increase	0.1027	0.7897	0.02	0.8965
	Slight increase	0.4940	0.4982	0.98	0.3215
	Noticeable increase	0.3339	0.4883	0.47	0.4941
Increased communications with distant relatives	No increase	-2.7519	0.9073	9.2	0.0024*
	Slight increase	1.1390	0.4518	6.36	0.0117*
	Noticeable increase	0.7858	0.4507	3.04	0.0812

*p-Value significant at 0.05%

Con: Objective 1_ Role of solar energy electricity in improving livelihoods

Health and well being

| Explanatory variable	Category	Co-efficient	Std Error	Chi-square	P-values
Easy access to health care services	No increase	1.2580	0.5663	4.93	0.0263*
	Slight increase	1.7296	0.3836	20.33	<.0001*
	Noticeable increase	1.7704	0.4088	18.75	<.0001*
Safety inside the home	No increase	-0.6145	0.6743	0.83	0.3621
	Slight increase	2.1302	0.4318	24.34	<.0001*
	Noticeable increase	1.5794	0.2934	28.98	<.0001*
Safety outside the home	No increase	0.7820	0.4922	2.52	0.1121
	Slight increase	2.2030	0.3982	30.61	<.0001*
	Noticeable increase	1.3655	0.3541	14.87	0.0001*
Household respiratory disease (cough and flue) arising from smoke	No increase	1.6871	0.3847	19.23	<.0001*
	Slight decrease	1.9006	0.3094	37.72	<.0001*
	Noticeable decrease	1.1566	0.3308	12.22	0.0005*
Workload for women	No decrease	1.5244	0.4052	14.15	0.0002*
	Slight increase	1.4252	0.4658	9.36	0.0022*
	Noticeable increase	0.4571	0.4347	1.11	0.293
Women health	No improvement	-1.6128	0.6031	7.15	0.0075*
	Slight improvement	0.7837	0.4291	3.34	0.0678
	Noticeable improvement	-0.0805	0.4001	0.04	0.8406
Have enough food for my family	No decrease	1.2864	0.3258	15.59	<.0001*
	Slight increase	1.6170	0.2825	32.76	<.0001*
	Noticeable increase	0.7353	0.3136	5.5	0.0190*

*p-Value significant at 0.05%

" *Before the introduction of electricity, pregnant women who needed operations had to be transported to Masaka via a ferry and many lost their lives in the process. But with this electricity, Kalangala Health Centre IV now operates pregnant women*" Former L.C V chairperson

"*Our health centre was able to receive the general expect machine because of the electricity, It was meant for Bukasa Health Centre IV since it is only given to Health Centre IV's and Hospitals but because the island were it located has no electricity. The machine was given to us*" Nursing Officer Mugoye

Challenges associated with solar energy electricity use on Bugala Island

Main challenge
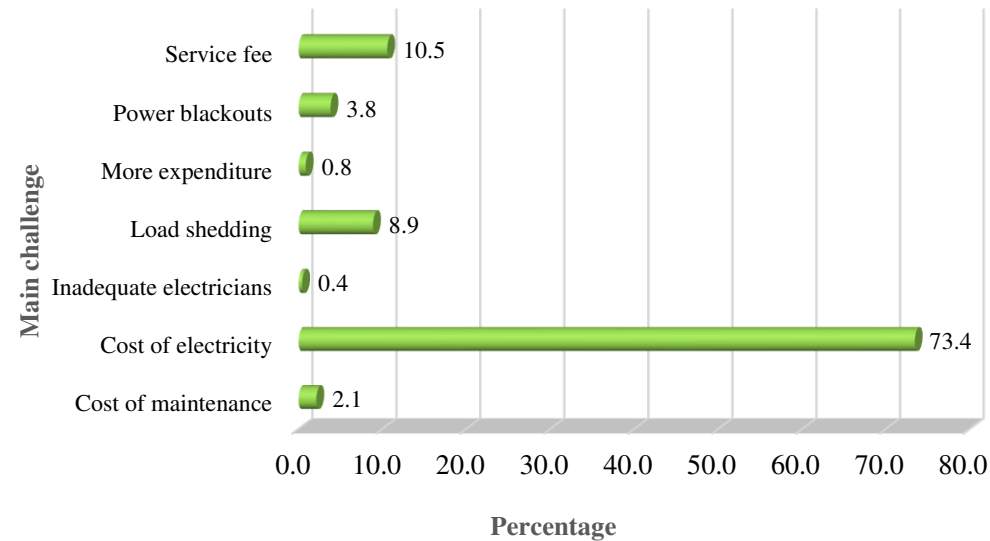
> "Electricity is too expensive, the cost of the power is not constant. This is because the price of the fuel keeps on changing and since the highest percentage of the generation is gotten from the fuel. It makes a unit very expensive" KIS Electrical Manager

> "The service fee which is paid to KIS is too high and it's we the health centre who pay our own bills" Nursing officer at Mugoye Health Centre III

> "There is partly a small number of Islander not connected; In some areas a customer might need a pole to be connected but you find that the cost for only one cost two (2) million which explain the high connection cost currently" Head IT department KIS

Nominal regression analysis on challenges

Explanatory Variables	Category	Coef.	Std. Err.	Wald	P-value
Cost of electricity	Low	1.13	1.85	0.37	0.54
	Medium	-1.14	0.98	1.35	0.25
More cost during the rainy season	Low	0.79	1.14	0.49	0.48
	Medium	0.31	0.89	0.12	0.73
Cost of maintenance	Low	0.66	0.99	0.44	0.51
	Medium	1.36	0.83	2.69	0.1
Cost of connection	Low	0.03	0.95	0	0.97
	Medium	0.14	0.82	0.03	0.86
High voltage	Low	-1.97	1.03	3.67	0.04*
	Medium	-1.69	1.07	2.49	0.11
Low voltage	Low	-1.39	1.41	0.98	0.32
	Medium	-2.94	1.46	4.05	0.03*
Illegal connections	Low	0.34	0.72	0.23	0.64
	Medium	0.37	0.56	0.33	0.55
Availability of electricians	Low	3.16	1.91	2.74	0.04*
	Medium	2.62	1.75	2.24	0.13
Vandalism	Low	-2.43	1.41	2.97	0.00*
	Medium	-1.65	1.66	0.99	0.32
Electrocution	Low	-1.34	2.52	0.28	0.59
	Medium	-1.18	2.47	0.23	0.63
More expenditure	Low	1.56	0.96	2.67	0.1
	Medium	0.76	0.73	1.06	0.29
Inadequate access to energy saving equipment	Low	-0.77	1.49	0.27	0.61
	Medium	-0.05	1.46	0	0.97
Faulty electric meters	Low	1.34	1.38	0.93	0.33
	Medium	1.93	1.49	1.66	0.19
Damage to electric appliances	Low	1.21	1.13	1.12	-0.29
	Medium	2.33	1.22	3.63	0.02*
Load shedding	Low	-0.69	0.92	0.57	0.45
	Medium	0.51	0.73	0.49	0.49
Service fee	Low	21.10	0.00	0	0.00*
	Medium	-0.21	1.13	0.03	0.85

*p-Value significant at 0.05%

Continuation: Challenges of solar energy electricity use

Bayesian Belief Network Model on challenges of solar energy electricity use
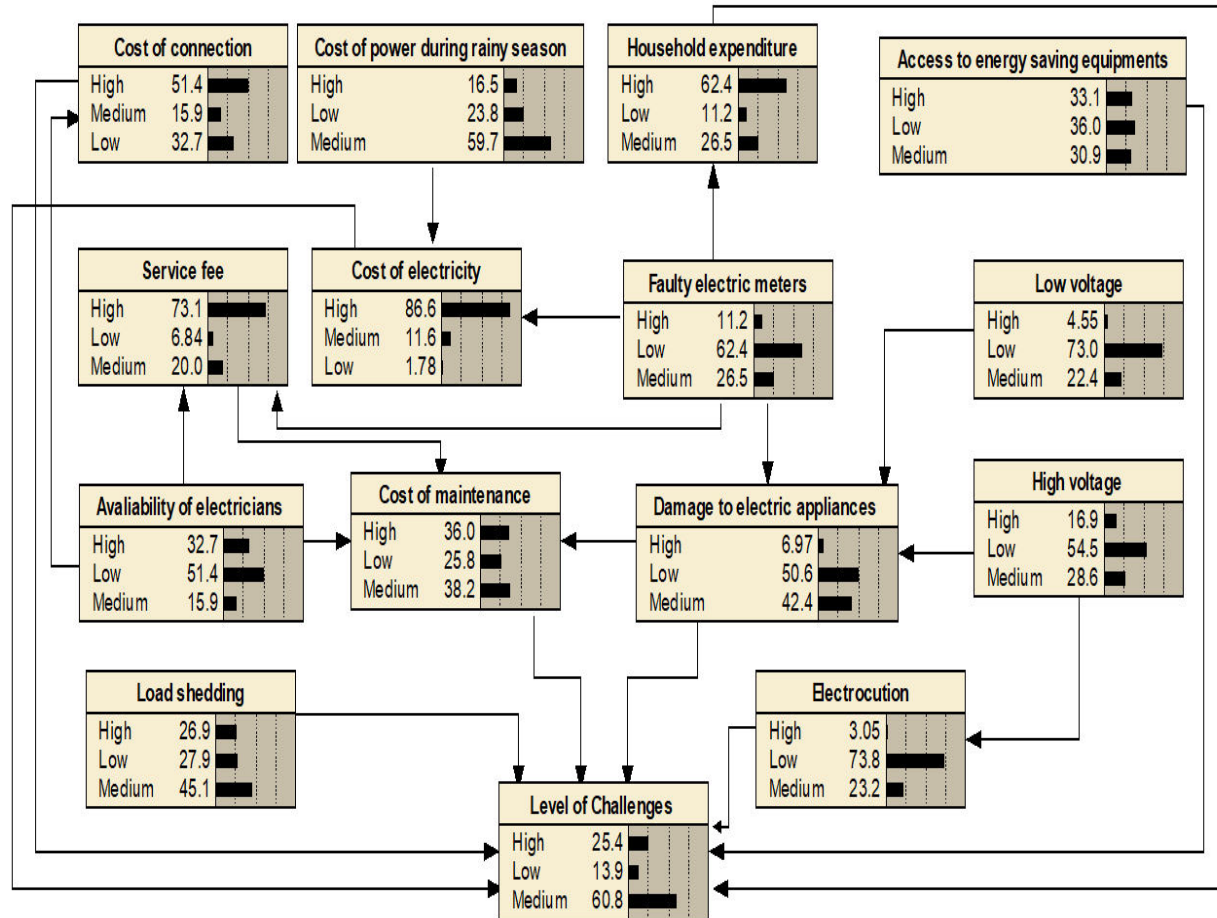
Sensitivity to findings

Nodes	Mutual Information	Entropy reduction (%)	Variance of beliefs
Load shedding	0.0243	1.82	0.0049
Cost of electricity	0.0239	1.79	0.0040
Household expenditure	0.0219	1.64	0.0033
Faulty electric meters	0.0219	1.64	0.0033
Damage to electric appliances	0.0195	1.46	0.0031
Electrocution	0.0164	1.23	0.0034
Service fee	0.0096	0.72	0.0017
Cost of connection	0.0095	0.72	0.0021
Availability of electrician	0.0095	0.72	0.0021
Cost of maintenance	0.0088	0.66	0.0018
High voltage	0.0008	0.06	0.0002
Low voltage	0.0007	0.05	0.0002
Cost of power during rainy season	0.0002	0.02	0.0000
Access to energy saving equipments	0.0000	0.00	0.0000

Thank you