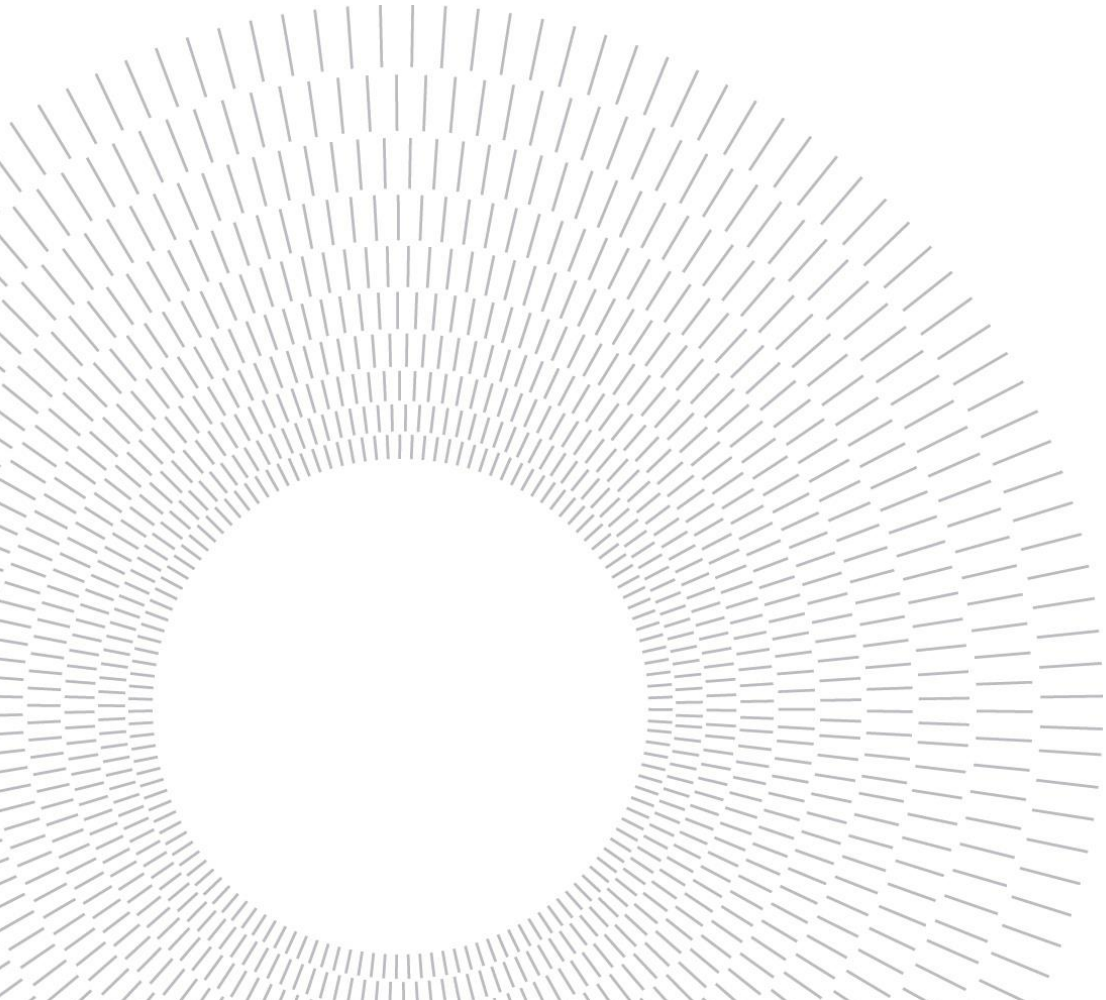
POLITECNICO
MILANO 1863

SCUOLA DI INGEGNERIA INDUSTRIALE
E DELL'INFORMAZIONE

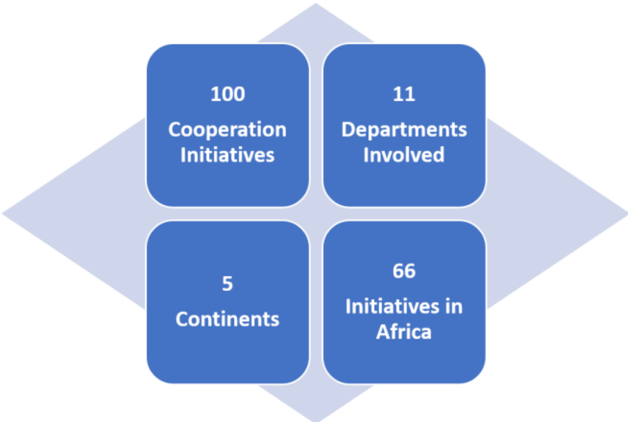
TERESA Project:

An Overview on the Electrification in Sub-Saharan Africa



Politecnico di Milano 1863

Established in 1863, Politecnico di Milano is one the most outstanding technical universities in Europe, and the largest Italian university in Engineering, Architecture and Design, with over 47,500 students. The university has seven campuses located in Milan and in other nearby Italian cities: Lecco, Cremona, Mantova and Piacenza. It is organized in 12 Departments and in 4 Schools, respectively devoted to research and education. **Since 2005**, POLIMI has embraced its vocation for **Academic Cooperation**, starting from a characterization linked to the interest and commitment of individual professors who have been able to lay solid foundations to build a more inclusive institutional interest and participation. The number of projects, involved researchers and partners has been growing in the last two decades and Polimi's strategy now alignes with the international frameworks. In the most recent years academic institution can play a stronger role on the international arena with specific reference to developing regions for scaling up education and scientific research asset to support local development.



Specifically, **Energy for Growing (E4G)** is an initiative of a research group of the Energy Department of ***Politecnico di Milano*.** The group studies innovative energy approaches, devoted to improve sustainability and efficiency in the **electric energy management**. One of the main focus is on on-grid and off-grid solutions for the electrification of rural areas in developing countries. Energy Storage solutions, Energy Communities and energy markets structure are also investigated.

ICEI

ICEI is an Italian NGO founded in 1977 that carries out cooperation interventions in Italy and around the world, working with people and local communities to improve social and economic conditions and promote inclusive, fair and sustainable societies in a participatory way. ICEI is active in 12 different countries with more than twenty active projects and 15.700 beneficiaries. ICEI works with people and local communities to improve social and economic conditions and promote inclusive, fair and sustainable societies in a participatory manner. The priority targets, across all areas, are the most vulnerable, with a special focus on young people and women. Since 2011 ICEI operates in Mozambique with a sustainable rural development program that includes agricultural and environmental projects carried out in the provinces of Nampula and Zambezia.

Intercultural Citizenship: the ability of citizens to strengthen their interactions by building bridges between cultures and blending diversity to build trust and cohesive communities, facilitate access to and protection of rights and provide new opportunities.

Work Inclusion: Promote employability, prevent exclusion and ensure equal access of people to the labor market, including entrepreneurship as a form of self-employment, in particular by supporting the integration into employment of the most disadvantaged people and groups (migrants, young women).

Responsible Tourism: design projects aimed at local development; valorization of natural resources and artistic and cultural goods, fighting poverty and creating employment by community-based tourism; creating employment by community-based tourism; Contributing to reconverting the tourism industry to practices based on sustainability and social responsibility.

Sustainable Agriculture: Ensuring food security and promoting sustainable agriculture; Promoting fast, inclusive and sustainable economic growth; Ensuring sustainable production and consumption patterns; Promoting ecological trends in agriculture; Supporting agricultural research.

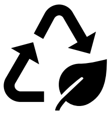
Contents

Acronym

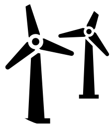
ICEI	Istituto Cooperazione Economica Internazionale
SDG	Sustainable Development Goals
IEA	International Energy Agency
LCOE	Levelized Cost of Electricity
SE4All	Sustainable Energy for All
GISELe	GIS for rural electrification
VANIA	Village ANalytics In Africa
E4G	Energy For Growing
UNEP	United Nation Environment Programme
MTF	Multi-Tier Framework
WHO	World Health Organization
O&M	Operation and Maintenance
TERESA	TEchnology for Rural Electrification in Sub-Saharan Africa
EACREEEE	East African Centre of Excellence for Renewable Energy and Efficiency
IRENA	International Renewable Energy Agency
LV	Low Voltage
MV	Medium Voltage
HV	High Voltage
AAGR	Average Annual Growth Rate
JICA	Japanese international cooperation agency

1 Introduction

One of the foundational elements of human development is access to energy. The United Nations has adopted the objective of having affordable, reliable, and sustainable energy as the 7th goal of the 2030 Agenda for Sustainable Development across the world, which has increased attention to this topic substantially in recent years. Goal 7 comprises five targets: two of them are "means of accomplishing target," while the other three are "outcome targets".



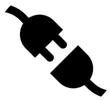
7.1 Universal access to modern energy



7.2 Increase percentage of renewable energy

7.3 Double the improvement in energy efficiency

Promote access to research and investments

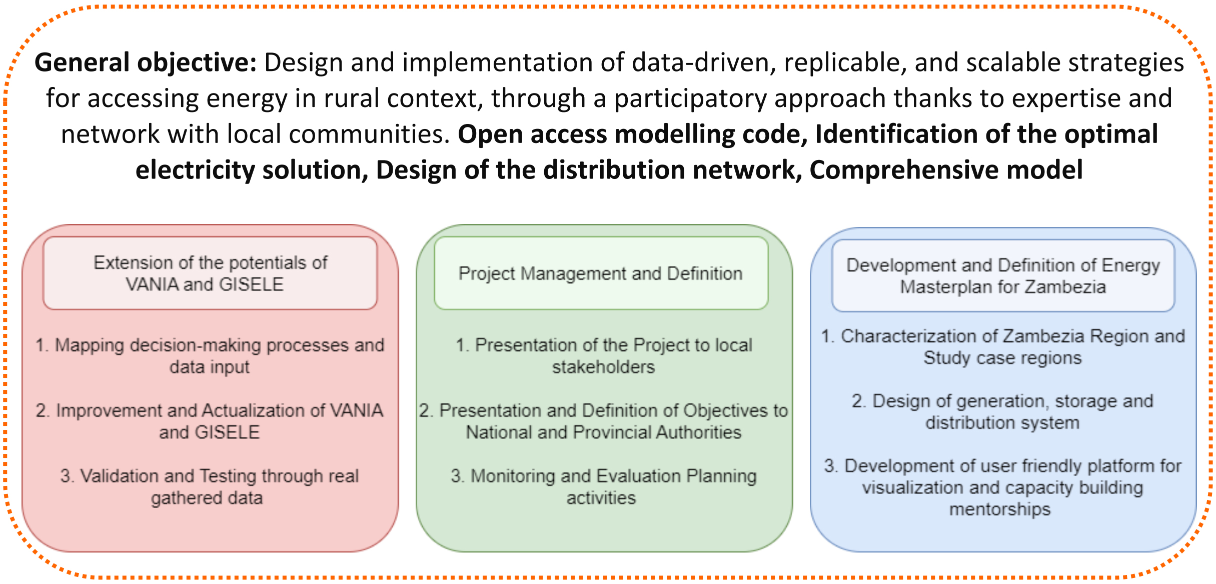


Expand energy services for developing countries

The "Energy Progress Report" shows that access to power has dramatically risen over the past decade. However, the Covid-19 pandemic reversed the positive trend in energy access, causing the first regression since 2013 and up-today 660 million people is without reliable electricity (most of whom are in Sub-Saharan Africa). In this context, it is widely recognized that energy does not represent only a goal but a pillar in guaranteeing the quality of livelihoods and a key element in development: an enabler of socio-economic development, capable of leading to direct improvements in multiple social dimensions and improving the quality of life. In 2020, Sub-Saharan Africa's portion of the global population without access to electricity was 77% with a significant disparity in electrification rates between urban and rural communities in this region, with the former at 78.3% and the latter at 28.7%. In order to face this challenge a comprehensive approach must be undertaken, in which several significant issues must be addressed: 1. Lack of accurate data; 2 Physical Constraints, e.g., those correlated to inaccessible villages; 3. Social constraints such as people's awareness and acceptance of the new situation.

1.1. The Project: TERESA

The TERESA project is funded by Technologies for Sustainable Development 2021 – Program of Fondazione Cariplo and Fondazione Compagnia di San Paolo. It aims at contributing in ensuring universal access to affordable, reliable, and modern energy services in Mozambique, in line with SDG 7 "Accessible and clean energy", through promoting innovation in the field of international development cooperation (open innovation/challenges, training, events/networking). TERESA project has been carried out between January 2022 and June 2023. In particular, it contributes to "guarantee universal access to affordable, reliable, and modern energy services "and to" strengthen international cooperation to facilitate access to research and clean energy technology ". Indeed, the objective is to strengthen existing tools that will be applied to develop an electrification master plan for the Zambezia province of Mozambique, which will remain "at the service of local and international stakeholders".



A multidimensional master plan will be carried out in Zambezia Region, the province that among the ten that make up Mozambique, is the one with the highest number of people without access to electricity. Moreover, some specific case studies with deeper analysis will be presented, such as the region that includes the surveyed communities.

Zambezia Region, Mozambique

March 2022 – May 2023

ICEI; Politecnico di Milano – Energy Department; FUNAE
Collaborations and interactions: ENGreen – USAID – Power Africa; ESRI; EDM; GIZ

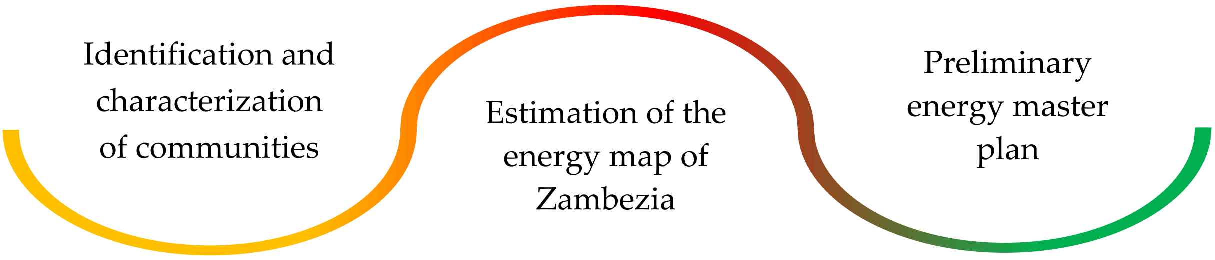
Cariplo Foundation and Compagnia di San Paolo Foundation

Zambezia Community; Policy makers; Stakeholders

The project focuses on the province of Zambezia, located in the central coastal region with a population of 5.11 million, the second most populated province and the least electrified. The lack of affordable energy access in Zambezia has significant social and economic impacts. Without access to electricity, households are forced to rely on expensive and often unreliable sources of energy such as kerosene lamps or candles. This can result in increased health risks due to indoor air pollution, limited educational opportunities, and reduced economic opportunities and small businesses that cannot operate beyond daylight hours. Despite different efforts, significant challenges remain in expanding energy access in Zambezia and other parts of Mozambique.

2 Methodology

The goal of this paragraph is to better characterize the steps of the used procedure for the definition of the preliminary energy plan. In particular, the whole proposed procedure consists of three main steps:



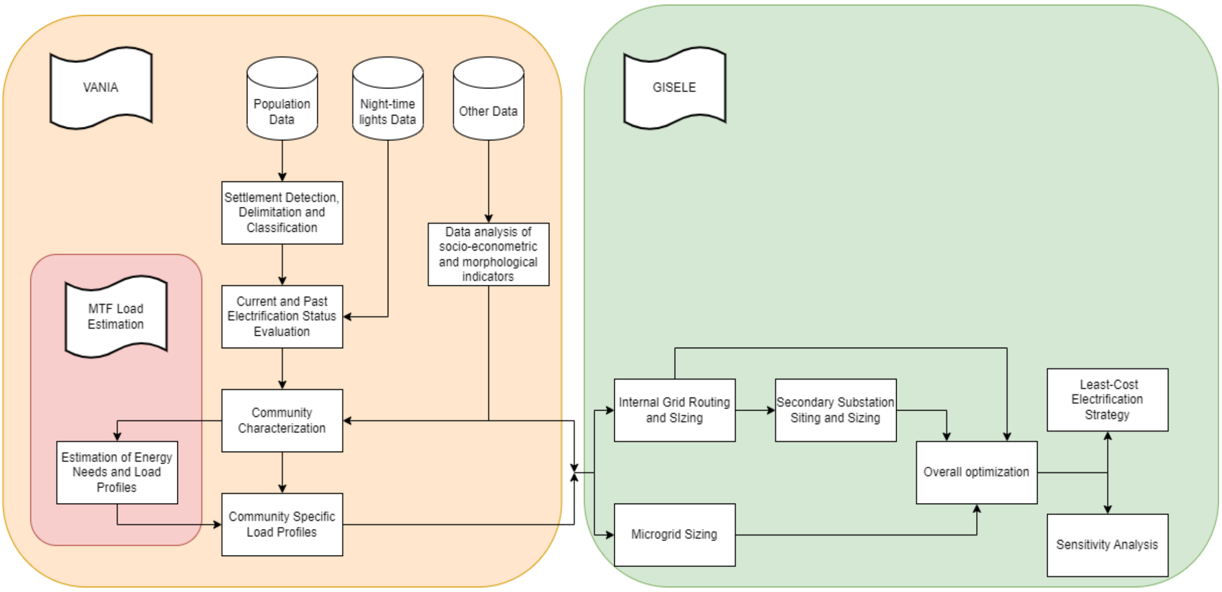


Figure 1. Overall used procedure

2.1. Identification and characterization of communities

With the help of VANIA, it's possible to gather socio-econometric information that can be correlate to specific cluster. In particular it is able to:

1) Locates unelectrified communities in an area of interest;
2) Processes currently available open-source dataset to perform socio-economic parametrization of the communities.

The clustering procedure utilizes an iterative implementation of DBScan, a density-based algorithm commonly adopted for population clustering. The current version of the tool defines the borders based on the building footprint and the population density. Once the boundaries of each community are defined, the procedure attributes multiple parameters for characterizing each cluster through economic, social, environmental, and infrastructural information. The result, according to the availability of the different datasets, is a complete database that refers to the different defined communities.

Name	Source	Name	Source
Administrative	UN Agencies	Networks	World Bank
Cell towers	OpenCell	Night Lights	NASA
Clustering (Sub)	KTH	Population	Facebook
Crops	Harvard	Population Growth	Columbia
Development Potential	Columbia	Poverty	WorldPop
Distance to city	-	Protected areas	Protected Planet
Elevation	RCMRD	Relative Wealth	Facebook
Food Insecurity	Columbia	Rivers	Hydroshed
GHI	Global Solar Atlas	Roads	OSM
HDI	UN	Schools	OSM
Hospitals	OCHA	Substations	Multiple
Landcover	ESA	Urban percentage	WorldPop
Literacy	WorldPop	Wind	Global Wind Atlas
Locations	OpenStreetMap	MTF	World Bank

Table 1. Name and source of considered data-set

Finally, the electrification status of the communities is defined thanks to electric grid datasets and nighttime lighting, based on a global database[1], with a spatial resolution of 1 km and temporal resolution of one year, from 1992 to 2018.

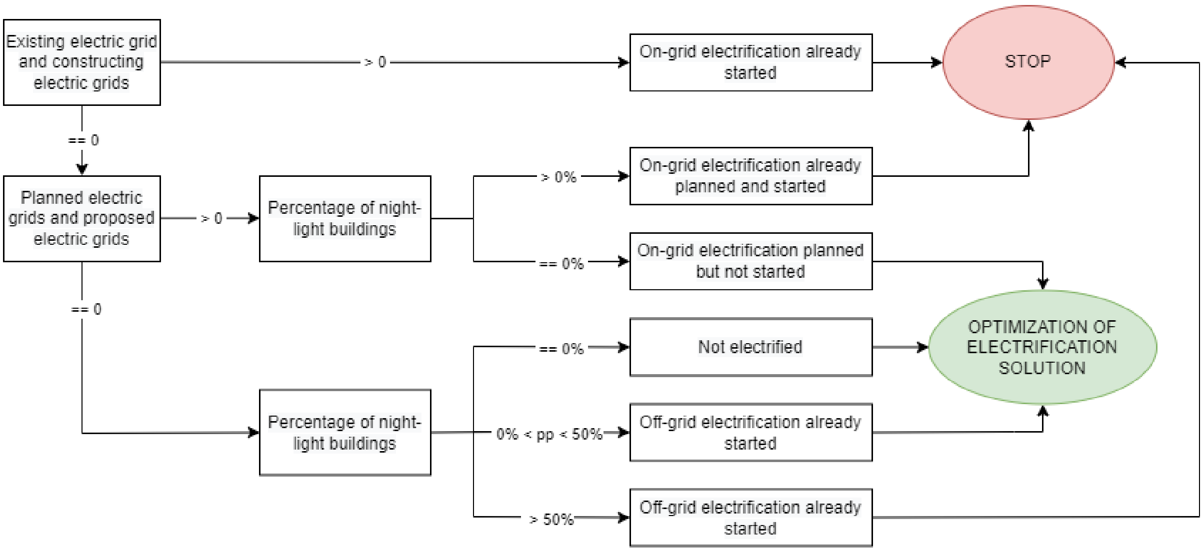
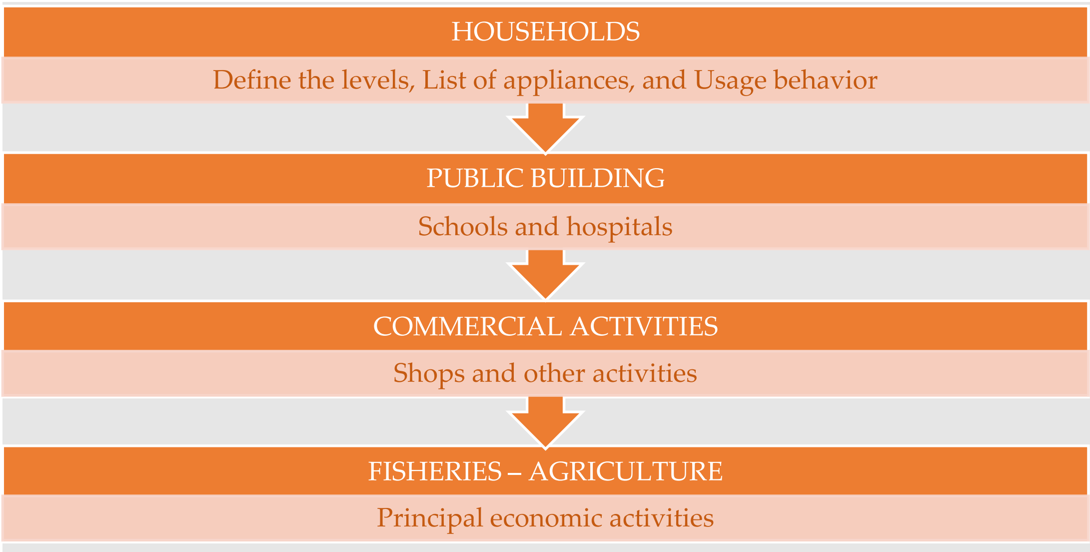


Figure 2. Definition of electrification status and type procedure

[1] Li, X., Zhou, Y., Zhao, M., Zhao, X., 2020. A harmonized global nighttime light dataset 1992–2018. Scientific Data 7, 168. https://doi.org/10.1038/s41597-020-0510-y

2.2. Estimation of the energy map of Zambezia

Load profile estimation is critical for planning rural electrification and it could be essential for determining the energy system's capacity and selecting the best technology for electrification. The proposed procedure relies on a detailed engineering representation of the energy systems which makes it more realistic. Thus, the consumers must be classified into different user classes, that refers to different appliances and time-usage. By knowing the appliance's power and functioning time, the daily electric energy consumption could be calculated. The calculation of the energy load profile of households is the added to other layers, such as commercial activities and public buildings. In order to overcome the complexity of investing a big area, a layer analysis approach was selected for this study. In this way, all the activities and their energy needs will be grouped into different classes based on their activity and usage behavior. Through this approach it is possible to create an energy density map for each cluster. The overall procedure and the different layers of the energy density map are summarized in the following.



- Households: ESMAP launched MTF program to collect comprehensive data about energy access at the country level. The Framework provides a methodology for measuring access in a tiered spectrum – from Tier 0 (no access) to Tier 5 (the highest level of access). Thus, the captured data could allow a better understanding of energy access gaps and develop a potential solution for improvement. This study uses a criterion of 5% of a household's income and expenditure to classify households into tiers. In this layer, there are five tiers of households based on their appliance's ownership with respect to MTF analysis. As it's presented in Table 2, **Error! Reference source not found.**for each tier there is a detailed information about the appliances and usage window.

Table 2. Tiers, usage windows and appliances

Appliance	Tier 1			Tier 2			Tier 3			Tier 4			Tier 5		
	Watts	hours /day	Min. annual consumption (kWh)	Watts	hours /day	Min. annual consumption (kWh)	Watts	hours /day	Min. annual consumption (kWh)	Watts	hours /day	Min. annual consumption (kWh)	Watts	hours /day	Min. annual consumption (kWh)
Task Lighting	1	4	1.5	2	4	2.9	2	4	2.9	2	8	5.8	2	8	20
Phone Charging	2	2	1.5	2	4	2.9	2	4	2.9	2	4	2.9	2	4	2.9
Radio	2	2	1.5	4	4	5.8	4	4	5.8	4	4	5.8	4	4	5.8
General Lighting				12	4	17.5	12	4	17.5	12	8	35	12	12	52.5
Air Circulation				20	4	29.2	40	6	87.6	40	12	175.2	40	18	262.8
Television				20	2	14.6	40	2	29.2	40	2	29.2	40	2	29.2
Food Processing							200	0.5	36.5	200	0.5	36.5	200	0.5	36.5
Washing Machine							500	1	182.5	500	1	182.5	500	1	182.5
Refrigerator										300	6	657	300	6	657
Iron										1100	0.3	120.5	1100	0.3	120.5
Air Conditioner													1500	3	1642.5

- Education Centers: all the education centers, such as schools, universities, institutions, etc. are included in this layer. Due to the lack of reliable sources to define the minimum requirement for the education centers, it's harder to categorize the centers and define electric appliances ownership. In order to understand the overall situation better, the result of a questionnaire conducted in Zambezia region was used to define their characteristics.
- Health Centers: the system consists of three level of health services and different hospitals, that relates to the type of health centre and the population covered by that. According to the UNMHCP, it was possible to define a tiered base guideline for the different levels of health services and a list of electric appliances was estimated for each health center and hospitals to reach the final goal of energy needs estimation.
- Other: For what concern the shops, the authors refer to JICA energy masterplan that defines the loads for ten different communities. A correlation with the households' energy load curve has been depicted and normalized. Trhough this it has been possible to calculate a hourly key-factors that were used to compute the final shops load demand of each community.

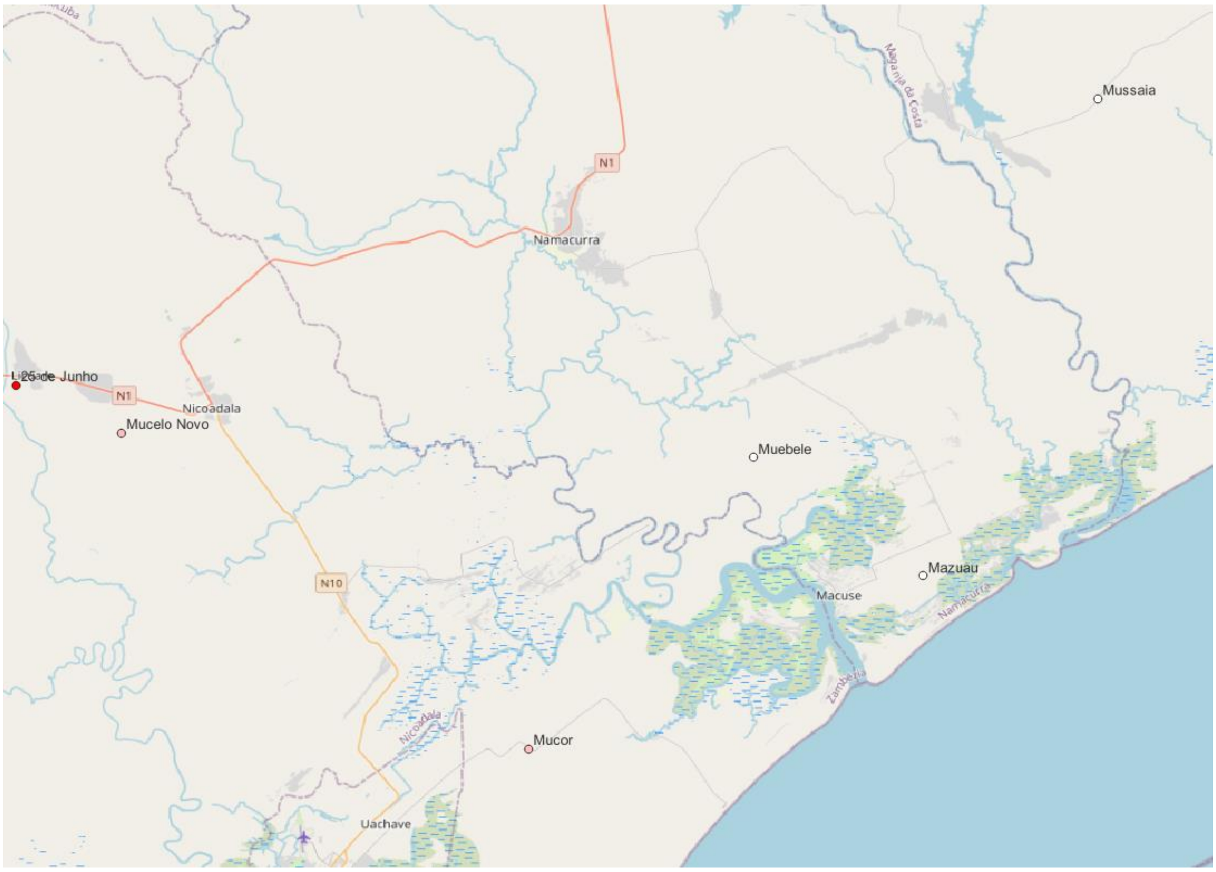
Finally, the authors s

LOGIC

1. USING THE SURVEYS WE WERE ABLE TO CALCULATE THE SHARE OF TIERS
2. WITH THE TIERS WE USE OPEN SOURCE TOOL RAMPO THAT CONSIDERS THE STOCASTICITY OF THE EVENT
3. WE HAVE CALCULATED THE MAXIMUM POWER AND ENERGY LOAD PROFILE
4. IN ORDER TO COMPARE WITH ALL THE COMMUNITES, WE CONSIDER AT FIRST THE URBAN – RURAL – SEMIURBAN DIVISION AND CHECK IT THROUGH THE AVERAGE INCOME

5. IN ORDER TO VALIDATE IT WE USE THE ENERGY ESTIMATION AND CREATE SOME CLASSES (Wh/DAY) THAT WAS ALSO CHECKED WITH MTF DATA
6. FINALLY DIVIDING THE ENTIRE ZAMBEZIA AND NORMALIZING TH ENERGY DEMAND ON THE POPULATION AND TYPE OF COMMUNITIES WE CREATE THE ENERGY DENSITY MAP

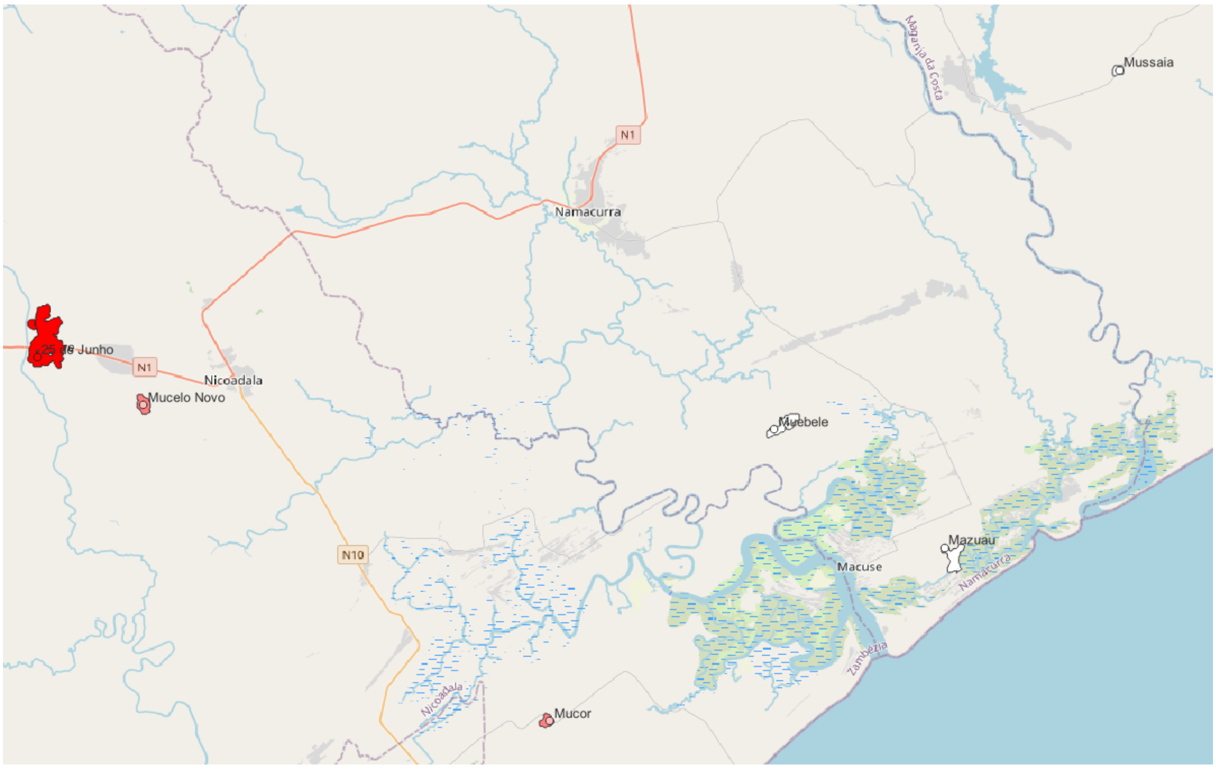
THE FIRST FILTERING WAS BASED ON AVERAGE INCOME

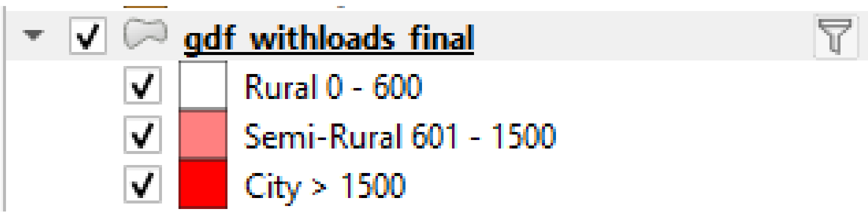


OUR STUDY IS BASED ON WHAT THEY COULD AFFORD (5% OF INCOME)

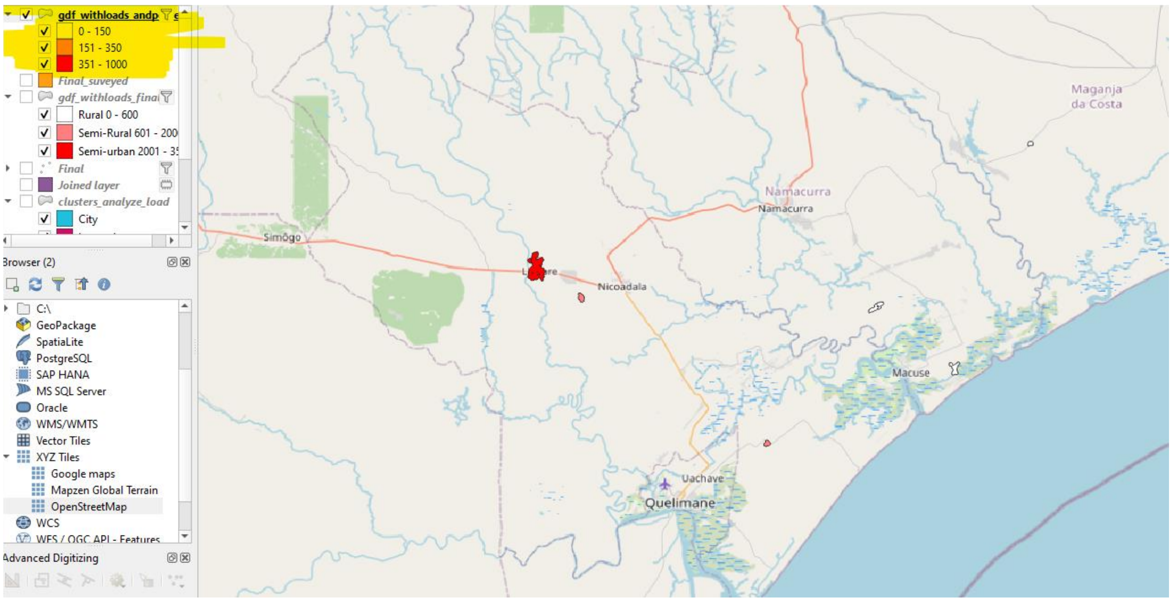
GURAI AND MASQUEIRA UNCERTAINTIES WITH THE LOCATION

NAVILEMBO NUMBER OF TIERS 5 HENCE OUTLIERS





THE CHECK WAS DONE ALSO ON POWER SIDE



ATTRIBUTES		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
1. Peak Capacity	Power capacity ratings[28] (in W or daily Wh)		Min 3 W	Min 50 W	Min 200 W	Min 800 W	Min 2 kW
			Min 12 Wh	Min 200 Wh	Min 1.0 kWh	Min 3.4 kWh	Min 8.2 kWh
	OR Services		Lighting of 1,000 lmhr/day	Electrical lighting, air circulation, television, and phone charging are possible			
2. Availability (Duration)	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
	Hours per evening		Min 1 hr	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs
3. Reliability						Max 14 disruptions per week	Max 3 disruptions per week of total duration <2 hrs
4. Quality						Voltage problems do not affect the use of desired appliances	
5. Afford-ability					Cost of a standard consumption package of 365 kWh/year < 5% of household income		
6. Legality						Bill is paid to the utility, pre-paid card seller, or authorized representative	
7. Health & Safety						Absence of past accidents and perception of high risk in the future	

2.3. Electrification procedure

As the final step, the optimization procedure for the least cost electrification plan is defined through GISELe. This tool calculates the optimal routing of the local distribution grid and compares two options for each cluster: extension of the existing national grid or stand-alone micro grid. A comprehensive analysis can help identify the lowest LCOE.

3 Field Survey and Interviews

In order to measure the access in a tiered spectrum, it's important to capture data to have a better understanding of the overall situation. In recent years, most of the surveys are done in a simplistic way which just report binary information without considering the quality and quantity of services. As an example, the irregular supply, outgases, and voltage fluctuations will not be reported. Besides, the existing data on the energy needs rely on the minimum consumption and services, which could mislead the providers for the electrification planning. Such parameters mostly rely on different indicators, like household's income, size, sources, and others. Lack of data often hinders the reliability of results, especially while dealing with rural areas. In order to tackle this criticality, the authors, together with the local partner ICEI, have started a data gathering campaign based on surveys. In particular, the objective was to define, with statistical relevance over the total population of the considered community. In order to estimate the number of surveys for each community, the following references have been takes: confidence level = 90%; margin error = 10%. The population was computed through the mean of VANIA tool. Moreover, through this approach the model has been used for the validation of VANIA itself. To facilitate the gathering of data, a comprehensive list of communities in which there are active or closed project with the local partner has been analyzed and among them different communities have been chosen. This approach helped throughout the process thanks to the knowledge and expertise of ICEI. The surveys have been carried out through local enumerators that already have experience in data gathering and participatory approach. In the following table a full list of the communities that have been surveyed with the key factors is presented:

Distrito	Administrative post	Community	Latitude	Longitude	Estimated pop	Number of survey
Quelimane	Maquival	Navilembo	-17,65°	36,69°	405	**63**
Quelimane	Maquival	Mucor	-17,63°	36,63°	404	**67**
Nicoadala	Nicoadala sede	Mucelo novo	-17,62°	36,76°	710	**68**
Nicoadala	Nicoadala sede	25 de junho	-17,58°	36,70°	577	**64**
Namacurra	Namacurra sede	Muebele	-17,86°	36,90°	11960	**133**
Mocubela	-	Gurai	-17.31°	37.97°	N/a	**72**
Maganja da costa	Baixo licungo	Mussaia	-17,41°	37,35°	363	**65**
Namacurra	Macuse	Mazuau	-17,69°	37,24°	1583	**113**
Maganja da costa	Baixo licungo	Masqueira	-17,55°	37,46°	564	**79**

Figure 3. Surveyed community in Zambezia

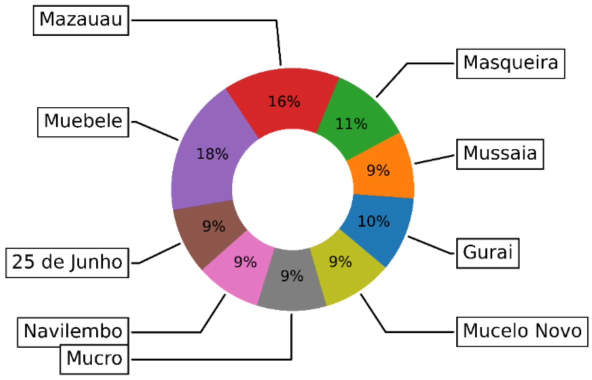


Figure 4. Share of survey in the different communities

3.1. Discussion of results

The surveys have been carried out through local enumerators that already have experience in data gathering and capacity building, fastening the data acquisition and improving the reliability of the acquired data, thanks to relationships with local communities they built in previous projects. 724 surveys have been done, divided between the communities as shown in

Figure 4 and in Figure 8. Finally, the author carried out a post processing of acquired data with the objective to well defined the criticalities, the main features and the key-indicators for validating the approach explained in the previous chapters. Though the survey was possible to analyze the income, the expenditure and the willingness to pay of the households, as well as information about the appliances, the outages and others. At a first analysis, a correlation between the income and the expenditure can be noticed, while it is not possible for the income and the willingness to pay. Indeed, in the community of 25 de Junho, higher incomes are related to very low willingness to pay. In order to deepen into, the electrification ratio is to be plotted and investigated.

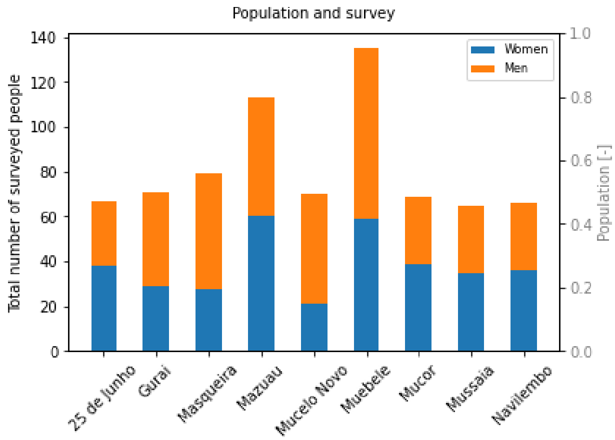


Figure 5. Population and gender of different surveyed communities

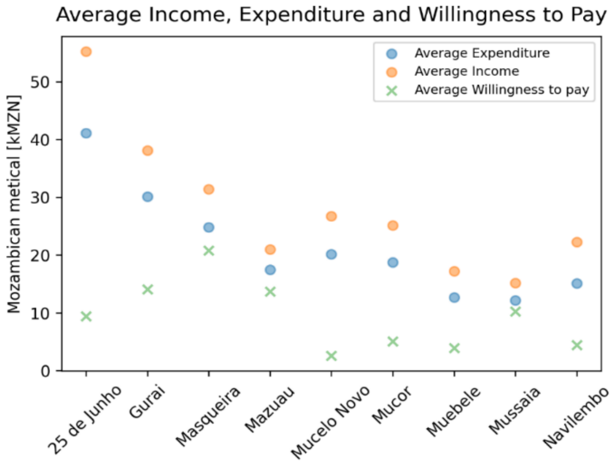


Figure 6. Comparison between income, expenditure and willingness to pay

The authors were then interested on the usage of electricity in economic activities. Focusing on the partially electrified communities, only the 5.5% of surveyed working people use electricity in their generating income activity (Figure 7).

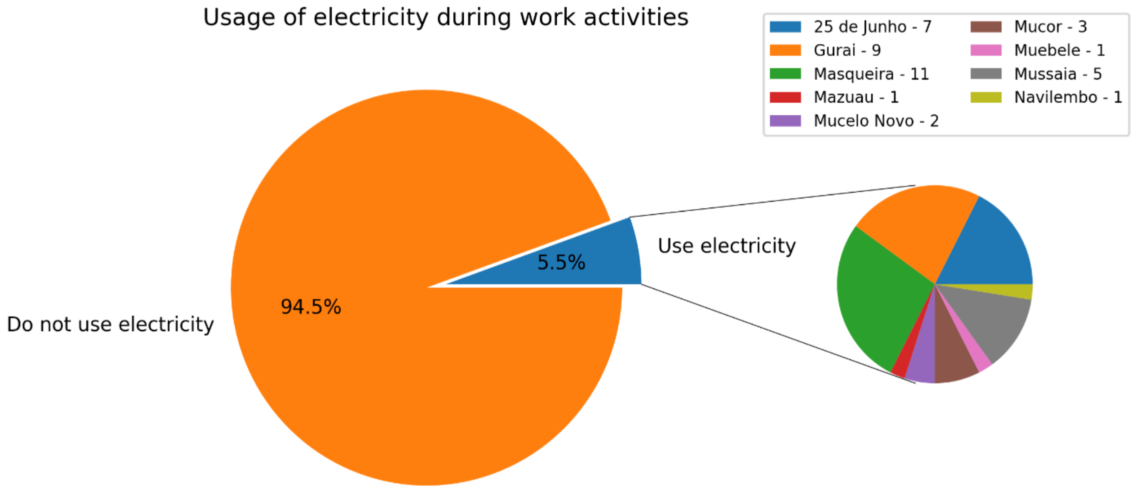


Figure 7. Electricity in generating income activity

It is interesting to highlight how the electrification ration are always lower than the 50% but the division in tiers show a prevalence in Tier 1 and 2 with a small percentage in Tier 3, meaning they could afford basic appliances such as phone and lights. Hence, the author tried to deepen into the perception of lack of access to reliable electricity, showing that most of the people territorial limitation issues or lack of money. However more than 20% of people state they do not know the cause for lack of such infrastructure.

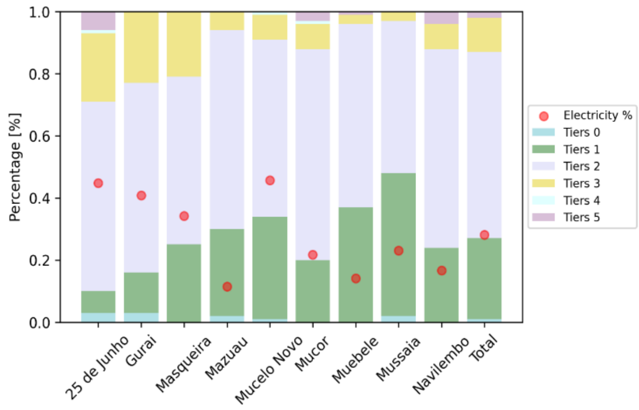


Figure 8. Comparison between share of tiers and electrification ratio

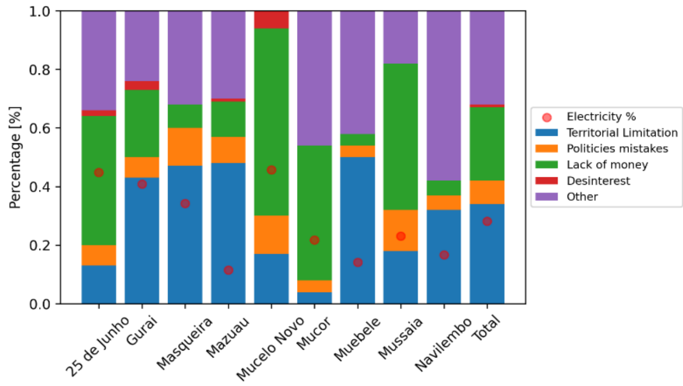


Figure 9. Perception of the causes for lack of electricity

While only the 30% of people declared to have access to reliable electricity, it is fundamental to understand the way they are electrified. In such a rural area costs of national grid routing can be a barrier to electrification; however, we can state that the share of source of electricity is equally divided between national grid and solar home system, underlining a lack in micro-grids in the surveyed region.

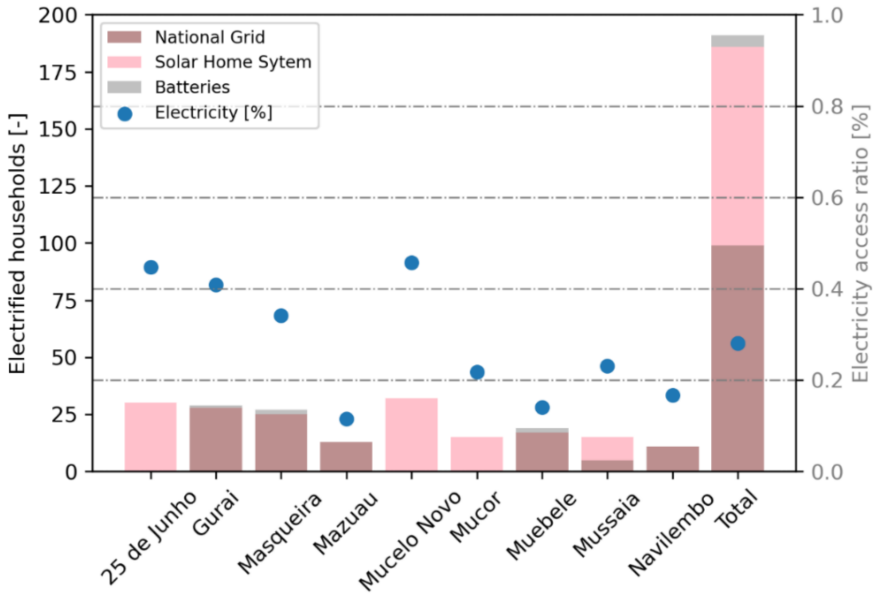


Figure 10. Type of electricity supply for communities

Finally, using the MTF approach explained previously, the author created the load profile of households for each tiers (Figure 11) and the load estimation of each surveyed communities (Figure 12). The load profile is a combination of tier characterization and population, hence Muebele, the one with the highest load profile counts for almost 12 thousand of people. The inputs required by GISELe are the peak load and the total daily energy, in order to characterize the distribution and the generation infrastructure. Up-to-date the design and size of the infrastructure is not completed.

3.1.1. Post processing of acquired data

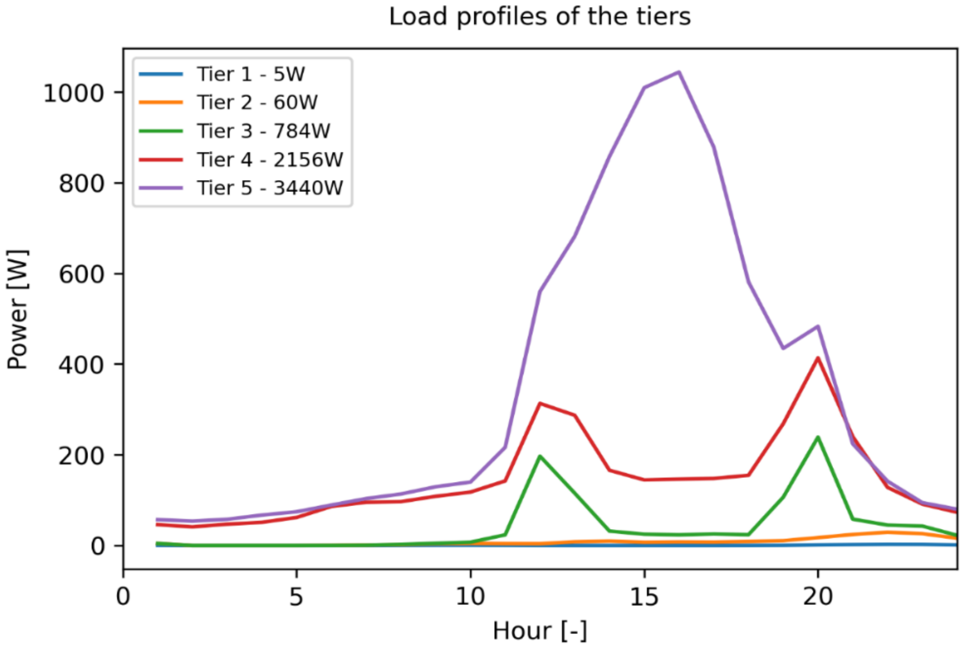


Figure 11. Load estimation of one household in each analysed tier

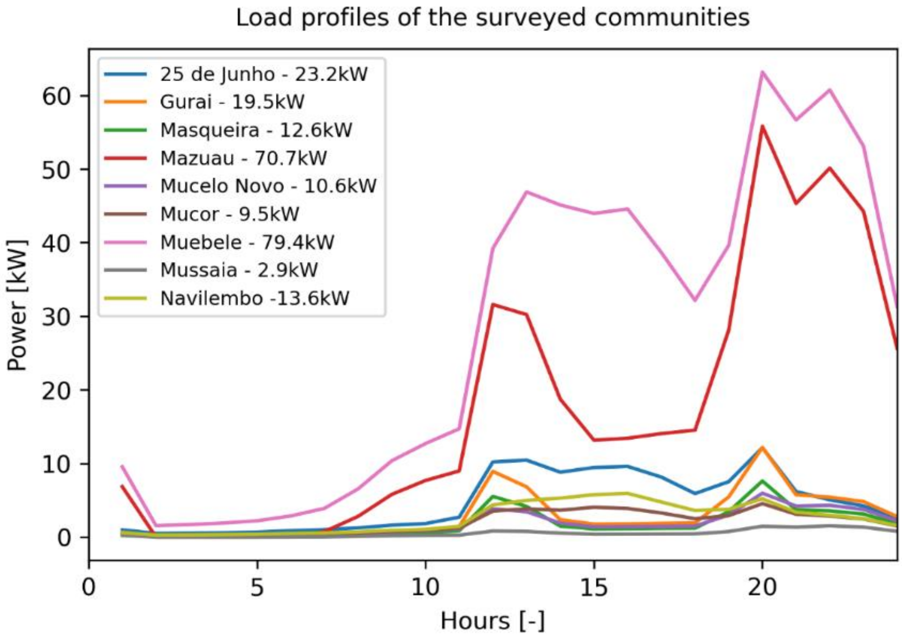


Figure 12. Load estimation of surveyed communities using MTF approach

4 Final Analysis

The scope of this chapter is to present the proposed electrification

5 User friendly Final Analysis

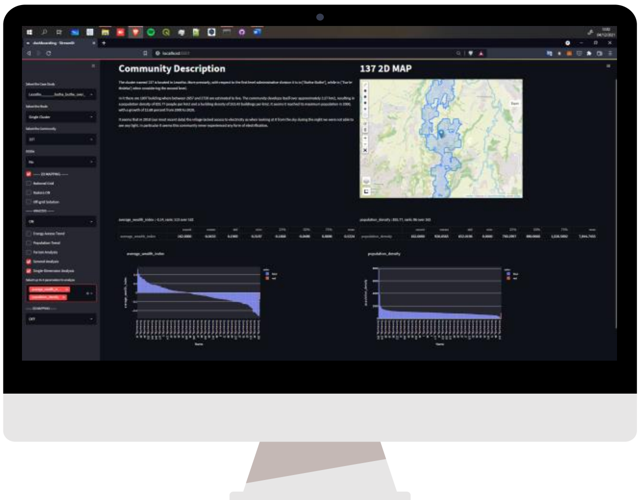
As the final objective of the project, the authors implemented an open-source user-friendly tool based on a app framework in Python language. This chapter will try to briefly present the main features and structure of the tool. Particularly, from the main page it is possible to read about the partners of the project and being able to be redirected to their websites if interested.

5.1. VANIA

This section is related to the definition and characterization of the tool. Particularly

5.2. Case study

5.3. Main result



6 Future improvement and Follow-ups

- Fisheries and Agriculture: The objective of this paragraph is the calculation of the loads for the main economic activities within the region. The lack of data and difficulties to gather information leave this chapter open for next follow-ups.

- Shops to be better analysed

- The application of this procedure to Zambezia is quite difficult due to the high sparsity of population across the region. Hence, definition of new procedure for clustering or improvement of the proposed one will be carried out

- Opensource data and difference with surveys

Annex 1. Databases for VANIA

Name	Format	Source
Administrative	MultiPolygon Vector	UN Agencies
Cell towers	Points	OpenCell
Clustering (Sub)	MultiPolygon Vector	KTH
Crops	Raster	Harvard
Development Potential	Raster	Columbia
Distance to the closest city	Raster	-
Elevation	Raster	RCMRD
Food Insecurity	Raster	Columbia
GHI	Raster	Global Solar Atlas
HDI	Shapefile	UN
Hospitals	Points	OCHA
Landcover	Raster	ESA
Literacy	Raster	WorldPop
Locations	Vectors	OpenStreetMap
Multi-Tier Framework	Stata Dataset	World Bank
Networks	Vectors	World Bank
Night Lights	Raster	NASA
Population	Raster	Facebook
Population Growth	Raster	Columbia
Poverty	Raster	WorldPop
Protected areas	Vector	Protected Planet
Relative Wealth	Points	Facebook
Rivers	Vector	Hydroshed
Roads	Vector	OSM
Schools	Points	OSM
Singularities	Vectors	Multiple
Substations	Vectors	Multiple
Urban	Raster	WorldPop
Wind	Raster	Global Wind Atlas

Through the combination of the geospatial data and the datasets needed to obtain the different attributes, different indicators are calculated:

Name	Description
Administrative Areas	Number of administrative areas for each level present in the cluster

OSM Locations	Categorized (villages, towns, etc.) OSM locations inside the cluster
Geometry	Area and extension of the cluster
Population	Estimated (distributed) population through Facebook's dataset
Buildings	Estimated Buildings distribution through Worldpop's dataset
Densities	Population and building densities
Urban/Rural	% of urban and rural areas inside the cluster
Area with nightlights	% of the area with nighlights
Buildings with nightlights	% of buildings in areas with nighlights
Gisele or not Gisele	Decision whether or not to include cluster in the Gisele modelling
Load barycenter location	Estimation of the load barycenter of the cluster
Elevation statistics	Max, min, average elevation
Wind speed	Highest and average wind speed value in the cluster
PV plant approximate location	Potential location for PV plant (assuming PV-only off-grid system)
Wind plant approximate location	Potential location for wind plant (assuming wind-only off-grid system)
Electric grids extension	Km of electric grids (categorized by type: existing, planned, etc.)
Close to grid buildings	% of buildings close (500m) to the electric grids (categorized by type)
Roads	Km of roads within the cluster
Close to roads buildings	% of buildings close (500m) to the roads
Health centers	Number of health centers
Electrified Health centers	Close to (500m) grid health centers
Schools	Number of Schools and Number of Schools per 1000 inhab
Electrified Schools	Close to (500m) grid Schools
Landcovers	% of area inside the cluster for each landcover category
Rivers	Rivers in a (15km) buffer zone with respect to the cluster
Relevant rivers points	Closest rivers' point and highest flow rate river point
GHI	Average GHI value in the cluster
Areas for PV and Wind	Max areas [km^2] required for PV and Wind Power based on peak load
Electrification status	Categorization of the electrification status