Village Data Analytics

TFE Energy

CASE STUDY

VIDA for mini-grid site selection in Togo

1 - Background

Around 600 million people in Sub-Saharan Africa do not have adequate access to electricity. In Togo, this is a problem for half of the total population of 8 million. As part of its electrification strategy, the government of Togo now wants to encourage mini-grid companies to electrify remote villages via a tendering process.

To prepare mini-grid companies for this process, 317 off-grid villages that had been identified for electrification have been surveyed. The process has taken several months and the results provided only a limited depth and quality of information. This delayed the tendering process and reduced mini-grid developer interest in participation.

Our Village Data Analytics (VIDA) team first reviewed and assessed the survey data and then used earth observation and data analytics to provide quality checks and additional information layers. This document shows the results of the analysis for three example villages and gives recommendations for future tender processes.

The three villages were selected based on data coverage, size and location to ensure an exemplary diversity. The goal of this case study is to show how the VIDA analysis can cross check on-site surveys and evaluate sites reliably, at scale and at speed.

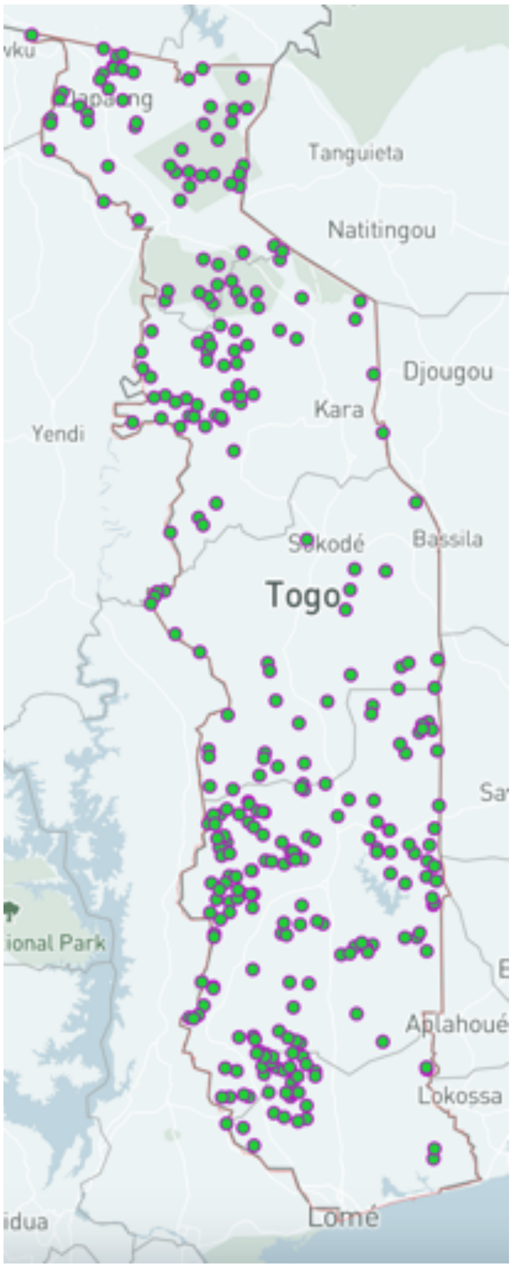

Figure 1
317 villages across Togo selected for mini-grid electrification

2 - The VIDA approach

"Creating reliable decision-making information at scale remains a key challenge in the electrification sector and holds back our progress towards universal electrification. In simple terms: what is not known, understood and measured, does not get done."

TFE Energy's Village Data Analytics (VIDA) is an artificial intelligence (AI) powered, data-enabled service that utilises satellite imagery, publicly available data, on-ground data, and energy modelling to identify and extract information about remote villages to assess their suitability for off-grid electrification.

VIDA is designed as a decision-making tool to accelerate site identification and evaluation. It was developed with the support of appliedAI and the European Space Agency (ESA).

3 - Survey data analysis

To begin with, VIDA looked at the survey data itself, to assess its coherence and reliability. We analyzed different survey questions by looking for correlations that one might expect (e.g. between television ownership and monthly income). Values vary between [-1,1], where -1 is a perfect negative correlation and 1 a perfect positive correlation. Values beyond ±0.5 indicate a relevant correlation.

Our analysis showed that most parameters were either uncorrelated or only weakly correlated, suggesting that either that they are indeed highly unrelated (unlikely), or that information was not correctly or precisely gathered and that the data-set is internally inconsistent.

This is not unusual. In our work, we often see that survey data is unreliable. If the survey data is good enough, however, it can be very usefully combined with the VIDA analysis. (And VIDA can help to conduct better surveys by providing a second, independent, objective data-set.)

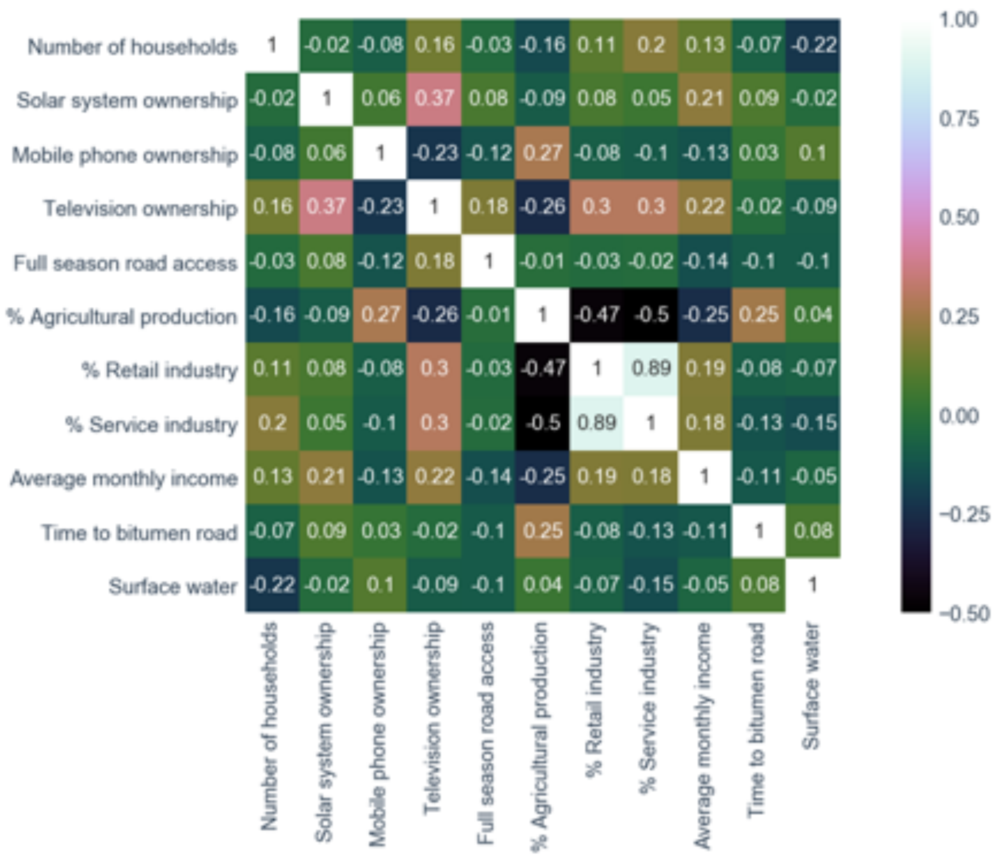

Figure 2
Correlation matrix

4 - VIDA extraction of village characteristics

We then conducted a detailed analysis on three villages, using satellite imagery and VIDA's proprietary algorithms. In two instances, we merged two villages due to their proximity.

Village 1
Azigo and Assanoubui

Village 2
Kikpang

Village 3
Abossehoe and Sikpe-Afidegnon

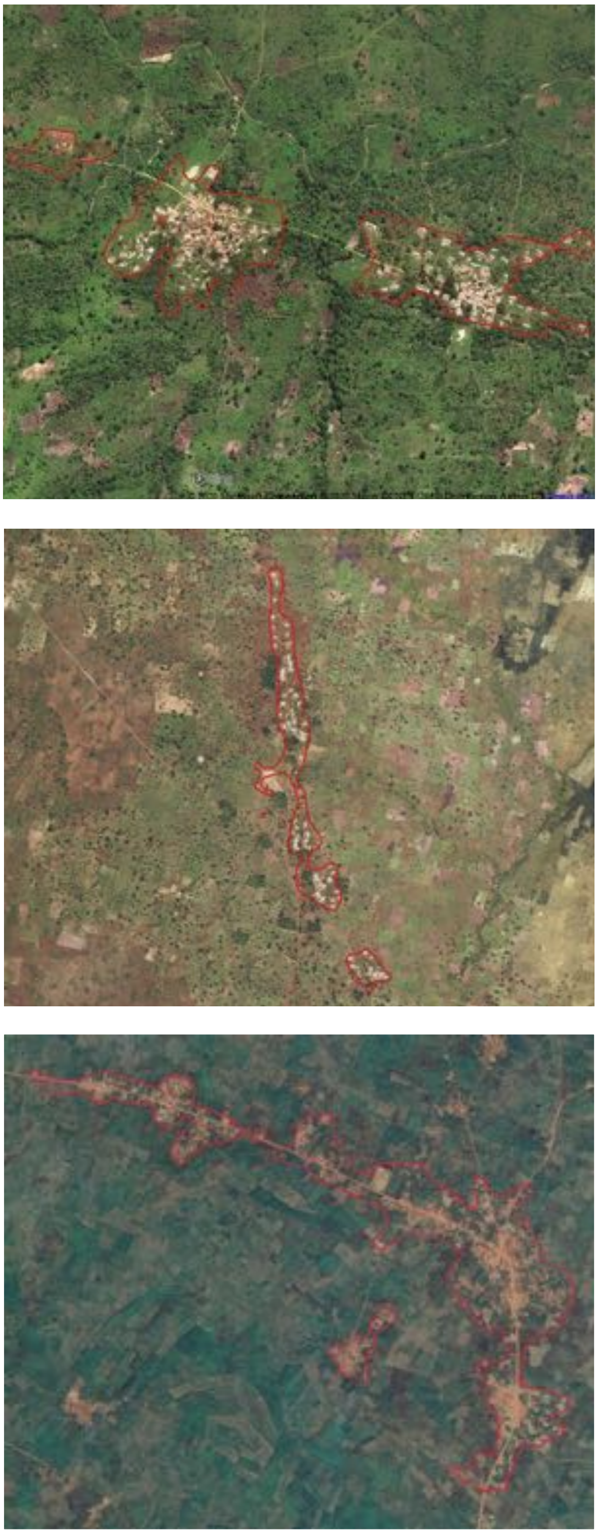

Figure 3
Settlement extent of villages identified by VIDA

The three villages show a wide variation in quantity and size of settlements, buildings, population, and road length. These are factors that have an impact on the cost of a mini-grid (density, grid layout) and demand estimation. None of the three villages had education or health facilities, which could have served as anchor loads.

Village characteristics	Village 1	Village 2	Village 3
Area of settlement (km2)	0.29	0.18	1.28
Population (HRSL)	1.273	732	4.940
Population density (per km2)	4467	4000	3853
Identified buildings	330	254	839
Access to roads	2 (unclassified)	6 (unclassified)	9 (tertiary, unclassified)
Total roads length (km)	1.08	1.22	7.28
Education/health facilities	None	None	None
Water coverage (within 2.5 km)	0%	0%	4%
Cropland coverage (within 2.5 km)	7%	83%	78%
Forest coverage (within 2.5 km)	80%	3%	10%
Village buildings profiles	Small: 58 Medium: 238 Large: 31 Very large: 3	Small: 161 Medium: 87 Large: 4 Very large: 2	Small: 146 Medium: 607 Large: 52 Very large: 34
Village type	Some larger buildings	Mostly small huts	Some larger buildings
Density type	High density	Medium density	High density

Table 1
Initial VIDA insights of all three villages

Water, cropland and forest coverage was estimated around each village center. Village 1 stands out with much more forest cover and less cropland. Results are shown in Figure 4 below.

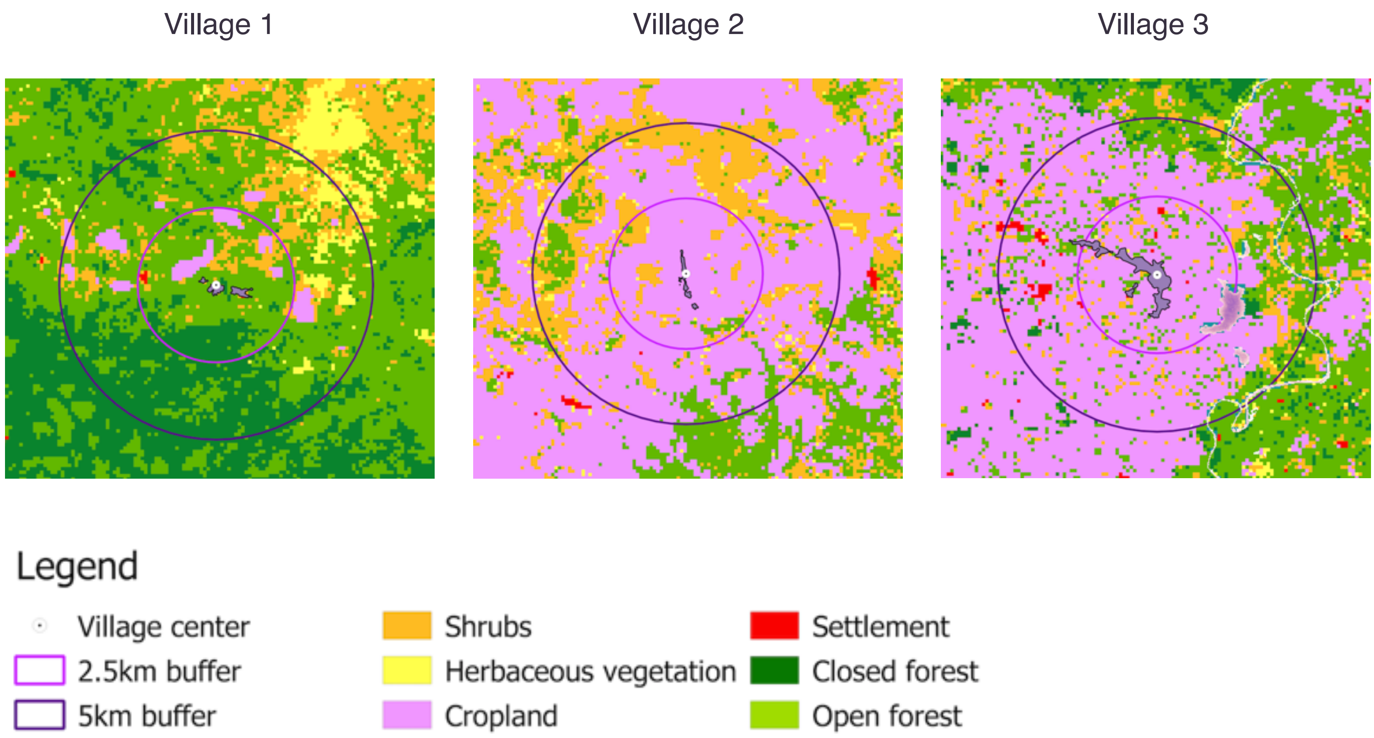

Figure 4
Overview of land cover around villages based on satellite data products

Building footprints were then segregated by size and classified as shown in Figure 5. Accordingly, villages were characterised as either "mostly small huts" or "some larger buildings" (village 3). Figure 6 shows that Village 3 has significantly more medium-sized buildings than the others. These are all inputs into a deeper analysis of viable mini-grid sites.

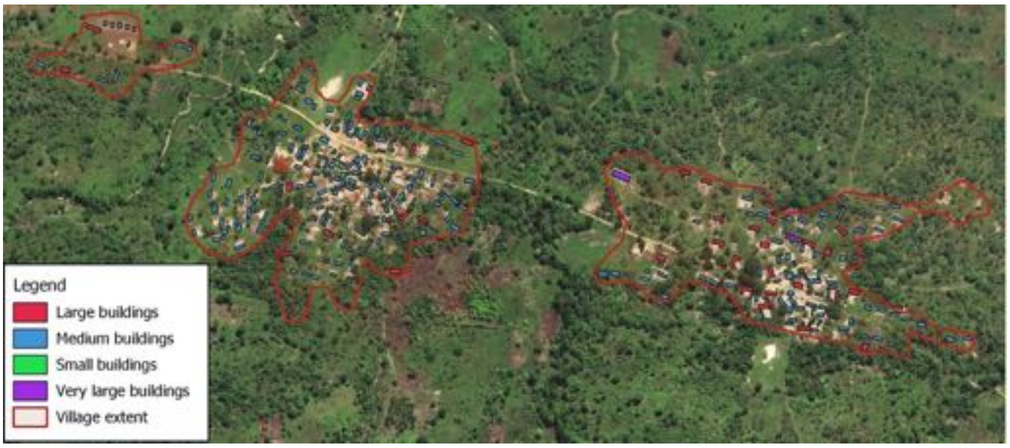

Figure 5
Example of building types classification (village 1)

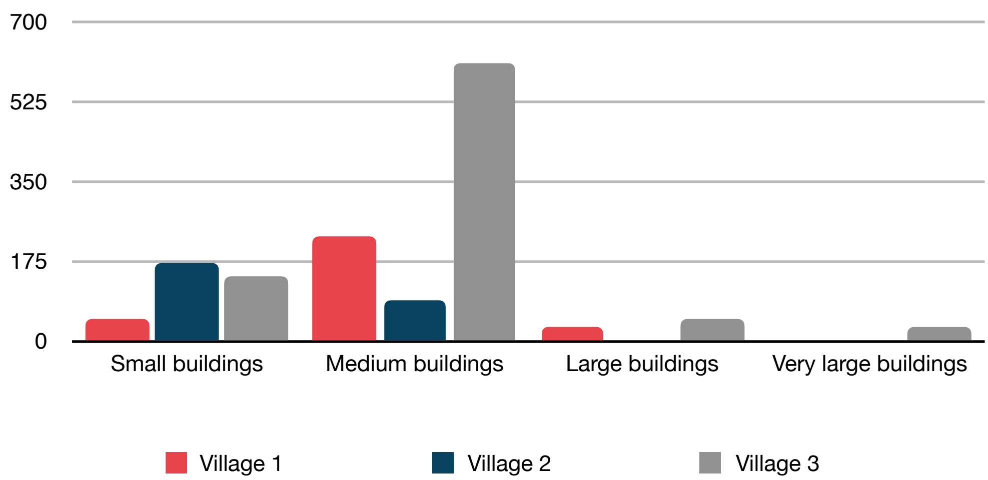

Figure 6
VIDA buildings classification for villages 1-3

x= Building type

y= Number of buildings

5 - VIDA mini-grid site assessment

In a second stage, VIDA provides a site evaluation, based on factors such as high value customers, energy demand and grid design. That helps decision-makers assess a site's potential and right-size a mini-grid.

Identification of high value customers

Potential high value customers are identified through a number of analyses, including hyper-local building density and accessibility, as seen in Figure 7.

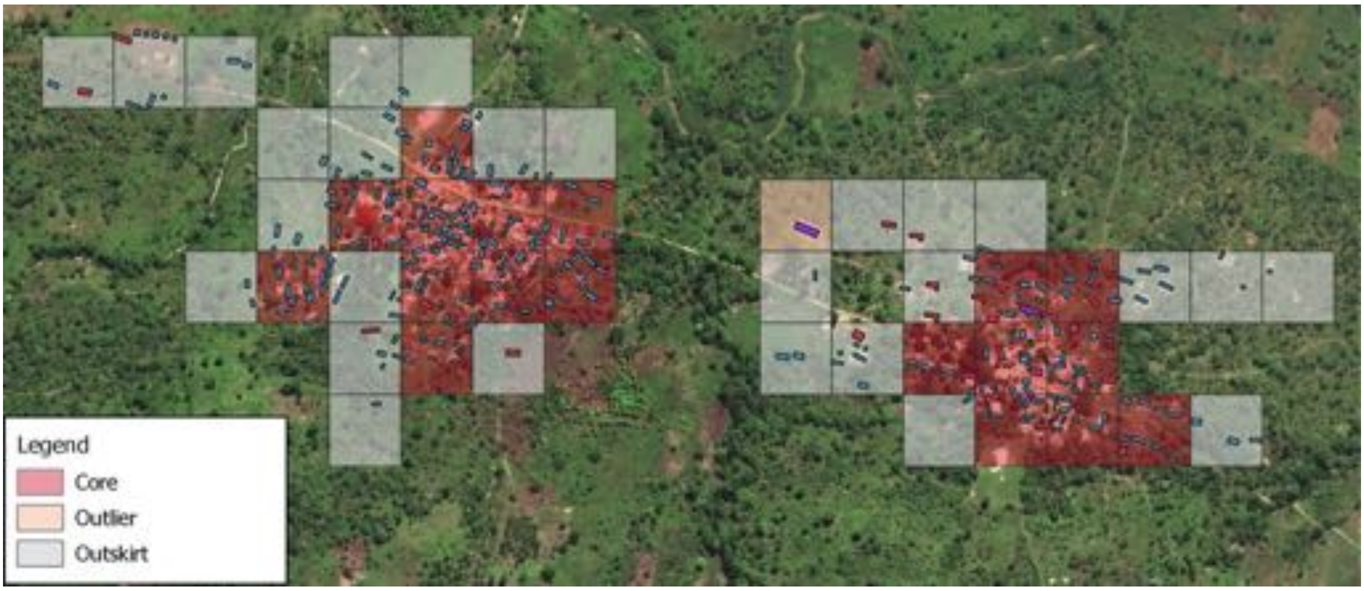

Figure 7
Example: Core, outliers and outskirts of village 1

Identification of demand and density of high value customers

Based on past experience and data, VIDA estimates power demand per building. The energy demand of high value customers, derived for all three villages is compared in the plot below. Village 3 has the highest potential demand. Buildings for which VIDA projects low demand can still be electrified by a Solar Home System (SHS).

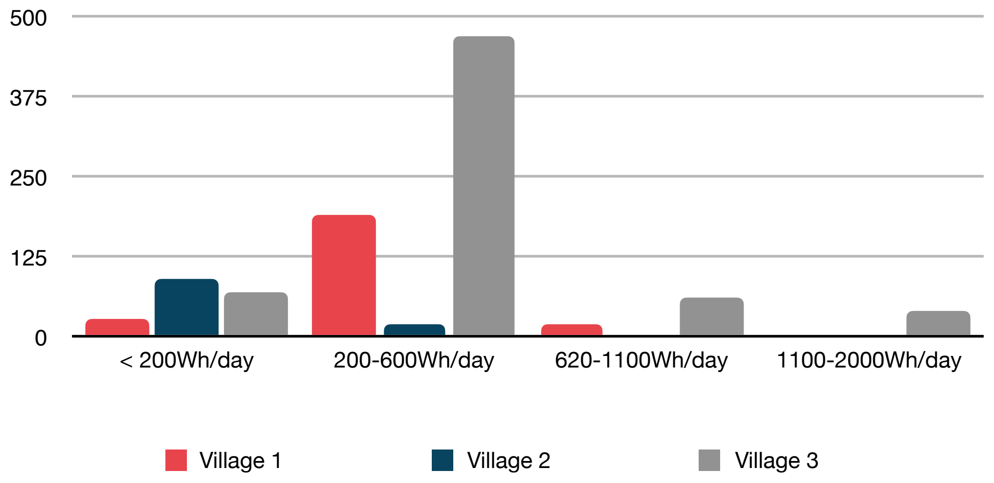

Figure 8
Estimated energy demand of high value customers across all three villages

x= Demand distribution

y= Number of buildings

VIDA's minimum spanning tree (MST) based algorithm, shown in Figure 10, estimates distances between high value customers.

Figure 9
Example: Minimum spanning tree of village 1

Preliminary distribution layout

Based on the location of high value customers and taking into account accessibility, VIDA's algorithms suggest a preliminary mini-grid layout. It consists of main trunk line(s), poles and drop down lines. In Table 2, we suggested two different drop-down lines lengths allowing mini-grid developers to estimate the difference for electrifying customers within and beyond 50m from the road. (In general, parameters can be easily customised as per user preferences and around scenarios.)

	Village 1	Village 2	Village 3
Average distance between buildings (m)	23	21	29
Length of distribution line (km)	19.18	3.95	33.96
Length of trunk line (km)	1.22	0.77	4.27
Length of drop-down wire (km)	18.24	3.18	29.69
Length of drop-down wire within 50m from the main road (km)	3.7	3.1	7.2
Number of poles	42	26	144

Table 2
Preliminary distribution layout parameters

Figure 10 showcases the full distribution layout for village 1 as well as detailed screenshots for selected locations in all three villages.

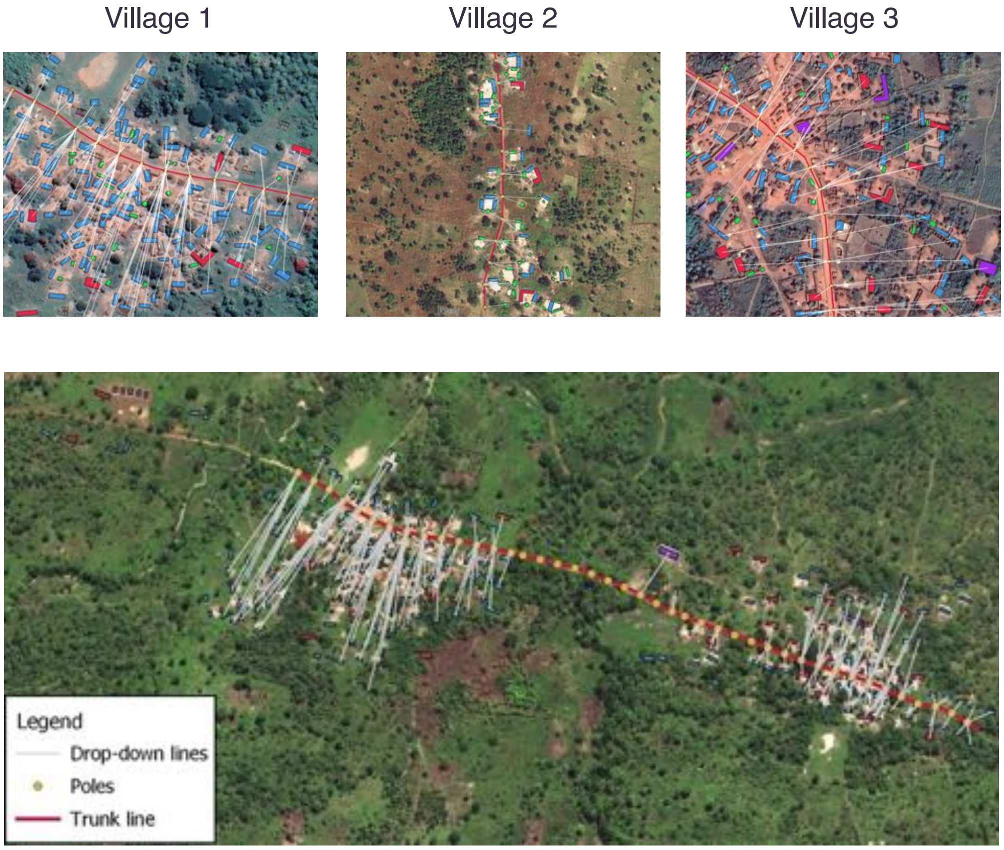

Figure 10
Preliminary distribution layouts of all three villages

6 - Decision-making information

VIDA provides different types of decision-making information to different electrification stakeholders and can be adapted to their different criteria. For instance, a developer might want to optimise for the total number of connections or demand. Or, the average village connection value might be considered more important. In reality, it is often a mixture of parameters. The marginal connection value helps right-size a mini-grid by comparing the marginal cost for an additional connection with the marginal expected demand. These can be modelled by VIDA in a user specific manner and through comparing scenarios. The table below gives an example of a number of extracted criteria.

Table 3
Decision-making factors for mini-grids

	Village 1	Village 2	Village 3
Total number of customers	330	254	839
High value customers	249	121	459
Distribution of high value customers (small:medium:large:very large buildings)	31:192:24:2	93:23:3:2	60:467:53:37
Availability of institutional loads (health & educational facilities	None	None	None
Mini-grid demand (kWh/day)	156	40	337
Total length of distribution (km)	19.2	4	34
Number of poles	42	26	144
Overall village connection value (kWh/km/day)	8.1	10.3	10
Mini-grid viability	**Average**	**Poor**	**Good**

7 - What VIDA can do

1. Survey support: VIDA can be combined with on-ground surveys to check results and increase quality, to add information layers and to plan survey routing.

2. Mini-grid developer support: VIDA can be used by developers to identify and evaluate viable mini-grid sites at scale and with minimal survey effort. It can help evaluate risks, right-size projects, optimise system layouts and assess latent power demand. It can support investor documentation, fundraising and monitor impact.

3. Tender support: VIDA can improve tender processes by identifying large numbers of sites rapidly and reliably, by increasing the credibility and richness of site information, by displaying site level information in an interactive format and by assessing viability gaps and subsidy requirements.

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