

# DRE Atlas Planning Platform Technical Documentation



# Table of contents

|                                                          |           |
|----------------------------------------------------------|-----------|
| <b>Executive Summary.....</b>                            | <b>3</b>  |
| <b>Section 1: About the DRE Atlas.....</b>               | <b>4</b>  |
| Countries included in the DRE Atlas.....                 | 5         |
| <b>Section 2: Data and Methodology.....</b>              | <b>6</b>  |
| Data Sources.....                                        | 6         |
| Data Processing and Methodology.....                     | 7         |
| Settlement identification.....                           | 7         |
| Extraction of settlement characteristics.....            | 10        |
| General settlement statistics.....                       | 10        |
| Energy demand estimation.....                            | 11        |
| Access to electricity.....                               | 12        |
| Accessibility.....                                       | 13        |
| Socio-economic indicators.....                           | 13        |
| Regional agriculture indicators.....                     | 13        |
| Security.....                                            | 13        |
| <b>Section 3: Platform.....</b>                          | <b>14</b> |
| Access.....                                              | 14        |
| Platform Structure and Key Features.....                 | 14        |
| Country Platforms.....                                   | 14        |
| Detailed Settlement Information.....                     | 14        |
| Filtering.....                                           | 16        |
| Location Search.....                                     | 16        |
| Analytics.....                                           | 17        |
| Map Layers.....                                          | 18        |
| User Support.....                                        | 18        |
| <b>Annex.....</b>                                        | <b>20</b> |
| List of settlement characteristics and data sources..... | 20        |

# Executive Summary

This technical documentation has been prepared to accompany the [DRE Atlas Planning Platform](#) (in short: DRE Atlas) with two primary objectives:

1. To provide full transparency into the data sources and methodologies used to develop the DRE Atlas.
2. To offer a concise overview of the DRE Atlas, including an overview of key features and guidance on how to access the platform.

All of this information is provided in the sections below. By outlining both the underlying data processes and functionalities, this document enables users to gain an in-depth understanding of how the DRE Atlas was developed and how it can be leveraged for investment planning.

This technical documentation is part of a larger pool of resources that have been developed to accompany the DRE Atlas. For example, a detailed user guide (access [here](#)) has been developed that provides step-by-step instructions on how to leverage key features of the platform such as the filters, analytics, detailed settlement information and map layers. These features are described in this technical documentation. For full instructions on how to utilise these features, users are encouraged to consult the user guide.

The technical documentation is structured as follows:

- **Section 1** presents a brief overview of the DRE Atlas, including its purpose and key capabilities.
- **Section 2** details the datasets used and the processing workflows that transform raw geospatial inputs into the platform's outputs.
- **Section 3** offers a concise tour of the platform's access, features, and structure.

For any inquiries and potential collaboration please contact the development team:

- **The World Bank and ESMAP:** Ashish Shrestha – [ashrestha1@worldbank.org](mailto:ashrestha1@worldbank.org)
- **The IFC:** Yann Tanvez – [ytanvez@ifc.org](mailto:ytanvez@ifc.org)
- **VIDA:** Malin Fischer and Jess La Costa – [malin@vida.place](mailto:malin@vida.place), [jess@vida.place](mailto:jess@vida.place)

# Section 1: About the DRE Atlas

The DRE Atlas is a publicly accessible, map-based, and interactive online platform providing detailed information on settlements of all sizes across 58 countries. This platform enables users to easily navigate and obtain essential information about communities, facilitating informed investment decisions, especially for energy access planning. Its analytics capabilities allow decision-makers to identify key market indicators for investment planning.

Users can access highly detailed data for every settlement within these 58 countries. This includes information on the number of connections/buildings, building density, potential energy demand, electricity access, road access, economic indicators, agricultural data and security information. Over 60 key pieces of high-resolution information are available for each settlement, making it an invaluable resource for developers, investors, donors, government officials, researchers, and others involved in electricity investment decisions globally. This is the first time such comprehensive, high-resolution data for each settlement has been made publicly available.

Users can also apply filters to identify and prioritize settlements within any country. Filters available include the region, the number of buildings, the distance to existing energy infrastructure, the presence of light at night, and whether the settlement has main road access. Filters can be combined, enabling users to identify settlements across the country that meet multiple criteria.

The software also provides aggregate analytics. Users can access information about the number of communities, total connections available, total demand and other key feasibility indicators. This allows users to generate key market analytics, vital for investment decisions.

The DRE Atlas was commissioned and funded by the Energy Sector Management Assistance Program ([ESMAP](#)), the [World Bank](#), and the International Finance Corporation ([IFC](#)). [VIDA](#) generated the insights, developed the interactive, map-based online platform, and is the author of this technical documentation.



## **Countries included in the DRE Atlas**

|                                        |               |                       |
|----------------------------------------|---------------|-----------------------|
| Angola                                 | Ghana         | Pakistan              |
| Bangladesh                             | Guinea        | Papua New Guinea      |
| Benin                                  | Guinea-Bissau | Rwanda                |
| Botswana                               | Haiti         | Sao Tome and Principe |
| Burkina Faso                           | Honduras      | Senegal               |
| Burundi                                | Ivory Coast   | Sierra Leone          |
| Cambodia                               | Kenya         | Solomon Islands       |
| Cameroon                               | Lesotho       | Somalia               |
| Central African Republic               | Liberia       | South Africa          |
| Chad                                   | Madagascar    | South Sudan           |
| Comoros                                | Malawi        | Sudan                 |
| Congo                                  | Mali          | Tanzania              |
| Democratic Republic of the Congo (DRC) | Mauritania    | Timor-Leste           |
| Djibouti                               | Micronesia    | Togo                  |
| Equatorial Guinea                      | Mozambique    | Uganda                |
| Eritrea                                | Myanmar       | Vanuatu               |
| Eswatini                               | Namibia       | Zambia                |
| Ethiopia                               | Nicaragua     | Zimbabwe              |
| Gabon                                  | Niger         |                       |
| Gambia                                 | Nigeria       |                       |

## Section 2: Data and Methodology

This section outlines the underlying data and methodology used to produce the DRE Atlas. More specifically, this includes the identification of settlements of all sizes in each country, extracting settlement-level information from the collected multi-thematic geospatial data and additional sources, and modeling including energy demand estimation. Limitations of underlying or derived datasets are mentioned, where relevant.

### Data Sources

A variety of datasets were leveraged to develop the DRE Atlas. A thorough assessment of their quality was conducted before deciding on whether to include them in Atlas. This assessment considered, amongst others, extent and spatial coverage, timeliness, thematic detail, reliability and relevance to the objectives of the DRE Atlas. Most datasets have widely been used in other related DRE studies with the World Bank, especially across Sub Saharan Africa.

The Annex provides a table of all data sources and extracted settlement-level information (more details see subsequent chapter) used in the DRE Atlas.

To summarize, the following spatial datasets have been used, mentioning limitations where applicable:

- **Buildings, settlements, population:** An extensive database of building footprints was created using various sources (Microsoft and Google, detected from high-resolution satellite imagery and merged on global scale and published [here](#)). These were complemented by [OpenStreetMap](#) buildings and/or aggregated building counts from [WorldPop](#) in selected countries with low coverage (specified in platform views for Chad, Mali, Micronesia, Niger, Papua New Guinea, Solomon Islands, and Vanuatu). This was also used for settlement identification and population estimates (see next section). For the latter, country-specific population numbers from the [World Bank](#) as well as JRC's [Global Human Settlement Layer](#) for distinguishing urban and rural areas were acquired.
- **Energy access:** Existing and, where available, planned transmission network from The World Bank's [energydata.info](#) data repository or other country-specific sources (specified in each country's platform view; distinguished by voltage and implementation status where available). Mini-grid sites, substations and transformers were added where possible. Notably, grid infrastructure data from public sources can be incomplete and outdated. No data could be sourced for Micronesia, Comoros, Solomon Islands, Vanuatu, Timor-Leste, and Sao Tome and Principe.

To complement this, nightlight areas were extracted based on time-series analysis of night-light satellite imagery ([NASA](#) VIIRS Monthly Cloud-Free DNB Composites, September 2022 to August 2023) using VIDA's open-source [GridLight](#) model. Data from

the Global Solar Atlas ([Solargis / World Bank Group](#)) was collected as a proxy of photovoltaic (PV) production potential.

- **Social infrastructure and wealth:** Locations of healthcare and education facilities, including types and other metadata where available (from [OpenStreetMap](#) or other country-specific sources, specified in each country's platform view). The coverage largely varies by country and sub-regions. [Meta](#)'s relative wealth index based on national surveys, satellite imagery and connectivity data was sourced in addition (not available for all countries).
- **Multi-thematic complementary data:** Spatial datasets covering a variety of thematic areas such as Regional hubs as cities or towns with high socioeconomic importance ([OpenStreetMap](#)), agricultural productive uses ([MapSPAM](#)), water ([HydroSHEDS](#): rivers and lakes), roads of various types ([OpenStreetMap](#)), armed conflicts ([ACLED](#)), or administrative boundaries ([CGAZ](#), or other sources in selected countries, specified in each country's platform view).

Selected additional datasets, such as points of interest ([OpenStreetMap](#)), mobile towers ([OpenCellID](#)), elevation ([ESA 2022](#)) and land use/land cover maps ([ESRI 2023](#), [ESA 2021](#)), are added to the final DRE Atlas for map visualization.

## Data Processing and Methodology

### Settlement identification

A key feature of the DRE Atlas is that it provides information on every settlement within the 58 countries. As a result, the identification of these settlements was a foundational step in the development of the Atlas. This process is described below.

**Building footprints** are the core underlying dataset for settlement identification. To guarantee extensive national coverage, two public, (almost) globally available buildings datasets were merged ([Google](#) and [Microsoft](#), more information and open access to the merged dataset [here](#)). In selected countries with no or insufficient coverage, additional sources were leveraged. This includes building footprints from [OpenStreetMap](#), a crowd-sourced mapping platform, and aggregated building counts from [WorldPop](#), based on more extensive but as such not publicly available building footprint data (Maxar).

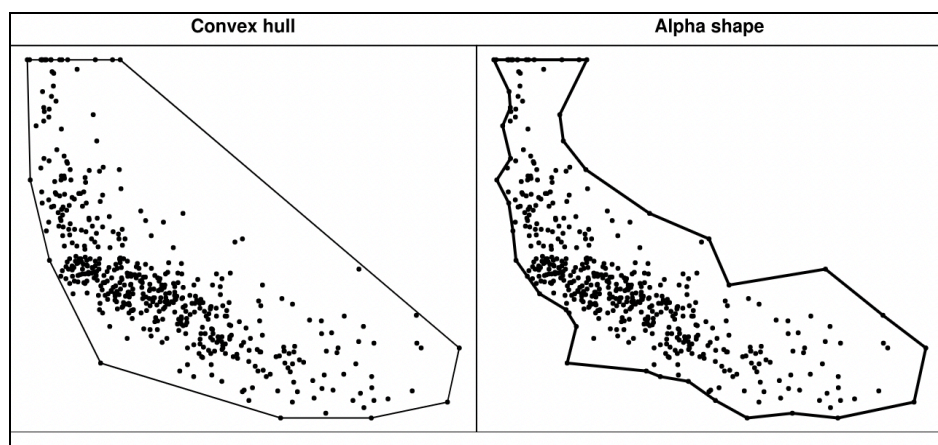
All building footprints, apart from partially otherwise crowd-sourced OpenStreetMap data, is based on identification from very-high-resolution satellite imagery (conducted by data providers). This baseline imagery can date several years back and therefore does not always capture recently built structures. Due to the high resolution, typically a 30 cm pixel size, even smaller buildings, including traditional and informal housing, are generally identified, though at lower accuracy.

A density-based **clustering algorithm** ([DBScan](#)) was applied to the building footprint data in each country to identify settlements, more specifically their boundaries. This algorithm builds a rough convex hull and then a more accurate alpha shape, smoothed with slight additional buffering, around dense built-up areas corresponding to the settlement boundaries. It uses several input parameters related to density and size of clusters to be generated. These parameters were selected based on experience from other countries as well as various experiments with subsequent result assessment using visual inspection of high-resolution imagery and generating aggregated statistics.

The following parameters were finally applied:

- **Minimum building size:** 15 (smaller buildings are likely unpopulated, e.g. store houses, sheds, kitchens, and thus less relevant for electrification planning)
- **Maximum distance between houses:** 150 meters
- **Minimum number of neighbors within this distance:** 20  
→ in selected sparsely populated countries, this was reduced to 3 to capture more dispersed settlements
- **Minimum size of a settlement:** 4 buildings (min. 15 m<sup>2</sup>)

Using these input parameters, **over 1.8 million settlements** were identified across all 58 countries. These include very small, rural villages as well as large cities and metropolitan areas. Thus, this is an extensive, country-scale collection of settlements.



*Figure 1: Schematic example of a convex hull and alpha shape of a dense cluster.*





Figure 2: A very small settlement identified in Nigeria, generated boundaries in red. Building footprint polygons are colored in bright pink (small size with 15-120 m<sup>2</sup>) and light pink (very small structures < 15 m<sup>2</sup>).

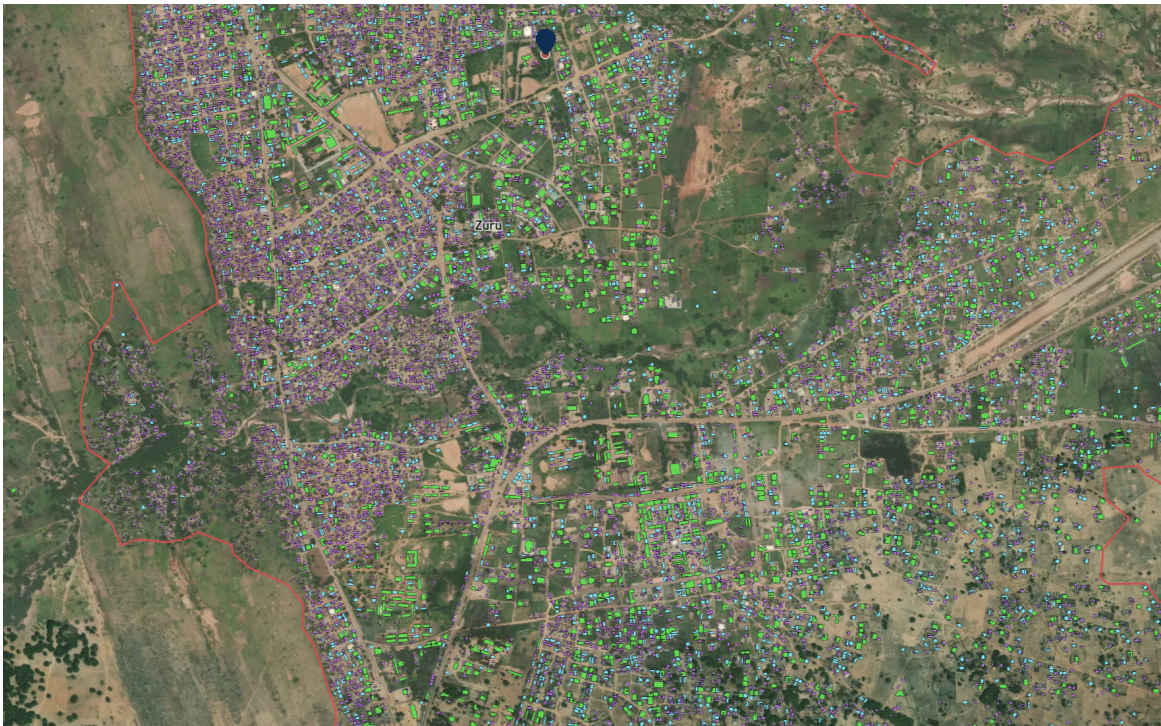


Figure 3: A large settlement mapped in Nigeria, generated boundaries in red. Building footprint polygons are colored in green (large size > 200 m<sup>2</sup>), blue (medium size 120-200 m<sup>2</sup>), bright pink (small size with 15-120 m<sup>2</sup>) and light pink (very small structures < 15 m<sup>2</sup>).

## Extraction of settlement characteristics

Next, characteristics of each identified settlement were extracted based on the previously collected datasets, using spatial analysis methods from calculating distances or counting, to more advanced, customized methods. These characteristics relate to general settlement statistics, electricity access, social infrastructure, accessibility, security, and regional agriculture. In total, over 60 quantifiable characteristics are extracted per settlement, as further outlined below. Figure 4 (next page) shows how selected characteristics are displayed on the DRE Atlas.

An extensive overview on all extracted characteristics is also provided in the Annex.

### General settlement statistics

Using a reverse geocoding algorithm, settlement centroid coordinates were used to look up the **settlement names** from public data using [OpenCage](#). Typically, for around 70 percent of settlements a name can be identified, whereas notably, official and locally used names can differ. Also, the names of the administrative subdivisions (level one and two) within which the settlement is located were identified.

Then, building-related information was extracted, including the **settlement area**, **building density** (unless aggregated building counts data from WorldPop was used as in Chad, Mali and Niger) as well as the **number of buildings** within the settlement, in total and divided into the following four different **building size categories**:

- Very small structures (< 15 m<sup>2</sup>, not relevant for electrification as they are likely uninhabited, e.g. outdoor kitchens or animal shelters)
- Small buildings (15 - 120 m<sup>2</sup>)
- Medium-sized buildings (120 - 200 m<sup>2</sup>)
- Large buildings (> 200 m<sup>2</sup>)

Based on the number of buildings, settlements were labelled as “major cities” (> 20,000 buildings), “very large” (5,000 - 20,000 buildings), “large” (1,000 - 5,000), “medium” (500 - 1,000), “small” (150 - 500), or “very small” (< 150).

**Population** estimates were derived using national [World Bank](#) population data to determine the total population and urban-rural split. Each settlement’s boundaries were overlaid with the Global Human Settlement Layer ([GHSL](#)) data to calculate the urban and rural proportions. These proportions were combined to the building counts within each settlement to determine the number of urban and rural buildings. This together with the country-level population figures allowed for calculating average occupancy rates (people per building), separately for urban and rural areas. These occupancy rates are then applied to the number of urban and rural buildings in each settlement to estimate the final population estimates at settlement level.

Additionally, **distance to water body** was extracted using [HydroSHEDS](#) river and lake data.



## Energy demand estimation

To estimate settlement-level energy demand, the DRE Atlas takes into account both the likelihood of buildings being associated with demand for electricity and the expected consumption per connected structure.

Typically, not every building will have an energy demand associated with it. The approach taken for the DRE Atlas filters out very small structures, defined as buildings with a rooftop size under 15 m<sup>2</sup>. Buildings of this nature are typically uninhabited huts, annexes, kitchens or animal shelters which are not considered relevant for electrification purposes. All remaining buildings were treated as potential **estimated number of connections**.

Once the eligible buildings were identified, each was classified into one of three size categories as explained above (also see Figure 5, next page). Then, based on building-level demand data gathered from previous electrification initiatives, average daily energy demand values were assigned to the corresponding building types:

- Large buildings: 1.1 kWh/day
- Medium buildings: 0.65 kWh/day
- Small buildings: 0.1 × 0.65 kWh/day (10% of small buildings) and 0.9 × 0.3 kWh/day (90% of small buildings)

Using this classification, the total daily **energy demand** per settlement is computed as:

$$\text{Total Daily Demand (kWh/day)} = (\text{Number of Large Buildings} \times 1.1 + \text{Number of Medium Buildings} \times 0.65 + \text{Number of Small Buildings} \times 0.1 \times 0.65 + \text{Number of Small Buildings} \times 0.9 \times 0.3)$$

In addition, the average demand per connection was calculated by dividing the total daily demand by the estimated number of connections.

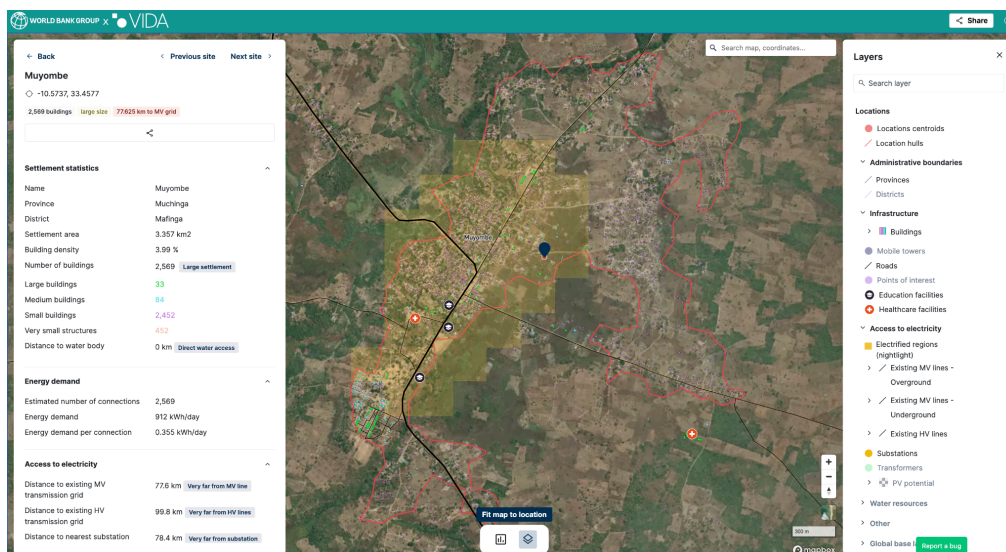


Figure 4: Presentation of selected characteristics for a Zambian settlement as presented on the DRE Atlas.



*Figure 5: Colored polygons represent rooftops categorized by building size and associated energy demand. Green polygons indicate large buildings, teal represents medium buildings, and purple denotes small buildings. Very small structures, shown in light beige, are excluded from the energy demand estimation.*

### Access to electricity

To assess a settlement's current and future access to electricity, the direct **distances to existing and planned transmission grid**, as collected from World Bank's [energydata.info](https://energydata.info) data portal or alternative country-specific sources, were calculated. The specific grid type (MV, HV, or unknown voltages) and status (existing, planned, under study, under construction) depend on the data available for each country and are specified in the DRE Atlas and shared datasets. For some countries, voltages are distinguished by color on the map. It should be noted that, in many countries, publicly available information on the existing and planned transmission grid can be incomplete and or outdated.

Additionally, depending on country-specific data availability, **distances to the nearest substation, transformer and mini-grid** are available.

Also, for all countries the **distance to the closest nightlight area** as well as **nightlight coverage** (in percent) were generated, based on nightlight areas extracted by VIDA's [GridLight](#) algorithm using [NASA's VIIRS nighttime light data](#) from September 2022 to August 2023. This serves as an additional, up-to-date indicator for electricity access. An attribute and filter whether any nightlight is detected within a settlement is available, too.

Finally, the long-term yearly average (1994-2015) of **potential PV production** under optimum conditions based on the [Global Solar Atlas](#) was extracted for each settlement.

## Accessibility

Next, information on the road accessibility of each settlement was extracted. The selected proxy is the **distance to the main road** (motorways, trunks, primary and secondary roads from [OpenStreetMap](#) which are mostly paved). Also, a characteristic and filter of general **main road access** (if the settlement is within 500 meters of a main road) was added.

Other accessibility proxies are the direct **distance to and name of the closest regional hub**, which is a larger city or town of socio-economic importance (using data of populated places from [OpenStreetMap](#)). This is also an indicator for the socio-economic importance of a settlement as for example larger markets can be accessed more or less easily.

## Socio-economic indicators

To assess social infrastructure, the **number of healthcare and education facilities** within 500 meters of each settlement, typically using [OpenStreetMap](#) data, was extracted.

Also, [Meta's](#) **Relative Wealth Index** (mean value within each settlement) was extracted as an additional socio-economic indicator. Note that it is not available in all countries and settlements.

## Regional agriculture indicators

As a proxy of socio-economic wealth as well as potential productive use cases, agricultural data was analyzed using IFRI's Spatial Production Allocation Model data ([MapSPAM](#), 2017 in Sub-Saharan Africa and 2010 elsewhere). Because of its low spatial resolution (10 kilometer pixel size), information wasn't extracted on settlement-level, but considering the wider region (administrative subdivision level two). The following characteristics were extracted: the **five most dominant crop types**, **total agricultural area** (in hectares), **crop value** (in \$ per year), **crop yield** (in kg/hectare) and **crop value per hectare** (\$/hectare).

Notably, no data was available for some countries and specific administrative subdivisions, and smallholder farming is mostly excluded in this dataset.

## Security

The [ACLED](#) armed conflict data from 2020 to 2022 was used to identify security risks for each settlement. A dedicated algorithm calculated the **number of fatalities within 25 and 50 kilometers** of the settlements by conflict type (battles, riots, violence against civilians, or explosions). If there are any fatalities within 25 kilometers, its **security risk** was then classified as "high". If there are no fatalities within 25 kilometers, but within 50 kilometers, it was classified as "medium". If there are no fatalities within 50 kilometers, the security risk was classified as "low". Additionally, the **total number of incidents within 50 km**, fatalities was extracted for each settlement. All armed conflicts are also accessible as a map layer including pop-ups with more detailed information on e.g. date and conflict type. Note that for selected small countries the radius was reduced to 10 and 20 km respectively, and for some countries outside of Sub-Saharan Africa data for only one year was available (flagged in each country's portal).

## Section 3: Platform

The DRE Atlas is a publicly available, map-based and interactive online platform with extensive information on all 58 countries. This platform allows users to easily navigate and get key information about communities to make informed investment decisions, especially for energy access. Its analytics also allows decision makers to identify potential market indicators for investment planning.

This section briefly describes the DRE Atlas, how it can be accessed and information on key features. More detailed information on how to use the platform and key features can be found in the [user manual](#).

### Access

The country platform for each country can be accessed and explored throughout a dedicated [landing page](#). This page provides a full list of each of the countries covered by the DRE Atlas. Users can click on the name of the country to access either the DRE Atlas or the underlying raw settlement data for that country.

This landing page is hosted by the World Bank, not VIDA as author of this technical documentation. Accordingly, the subsequent sections focus on the country-specific map-based platforms hosted by VIDA.

## Platform Structure and Key Features

### Country Platforms

In each country, the Atlas displays all settlements identified on an interactive overview map (see Figure 6, next page), represented by red dots as the settlements' centroids, and, when zooming in, settlement outlines in red. This serves as the starting point for all navigation and exploration of data for any given country.

A number of the key features of the DRE Atlas, such as filters, analytics, map layers and search functions, can be accessed directly from this page. Additional information on these features can be found in the sections below, and more detailed instructions in the user guide.

### Detailed Settlement Information

Users can view detailed information about individual settlements on the DRE Atlas by clicking on any location on the map, symbolised by the red dots. This will display all settlement-level data about that location, including but not limited to settlement statistics, energy access, accessibility, socio-economic data and energy demand (see Figure 7, next page). Via the top bar share button, a link to any settlement, or also country platform, can be easily copied.



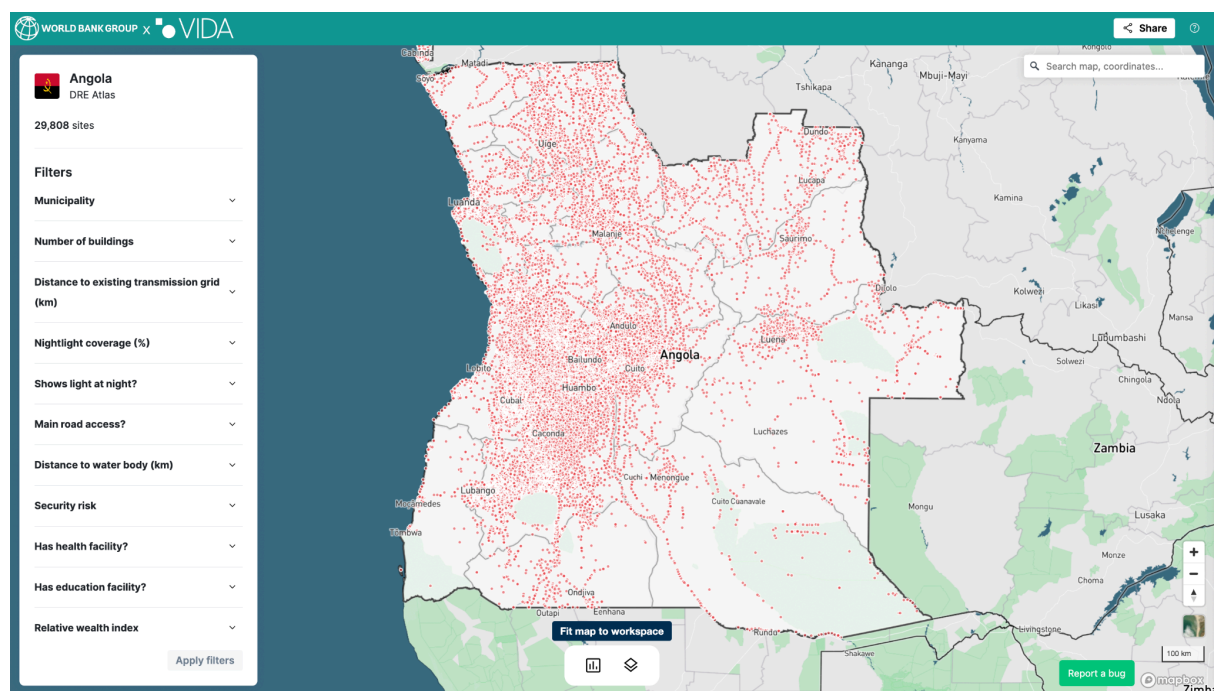


Figure 6: Angola, as seen in the DRE Atlas when first accessing the country platform. Red dots represent settlement centroids - clicking on them allows for accessing the site detail page.

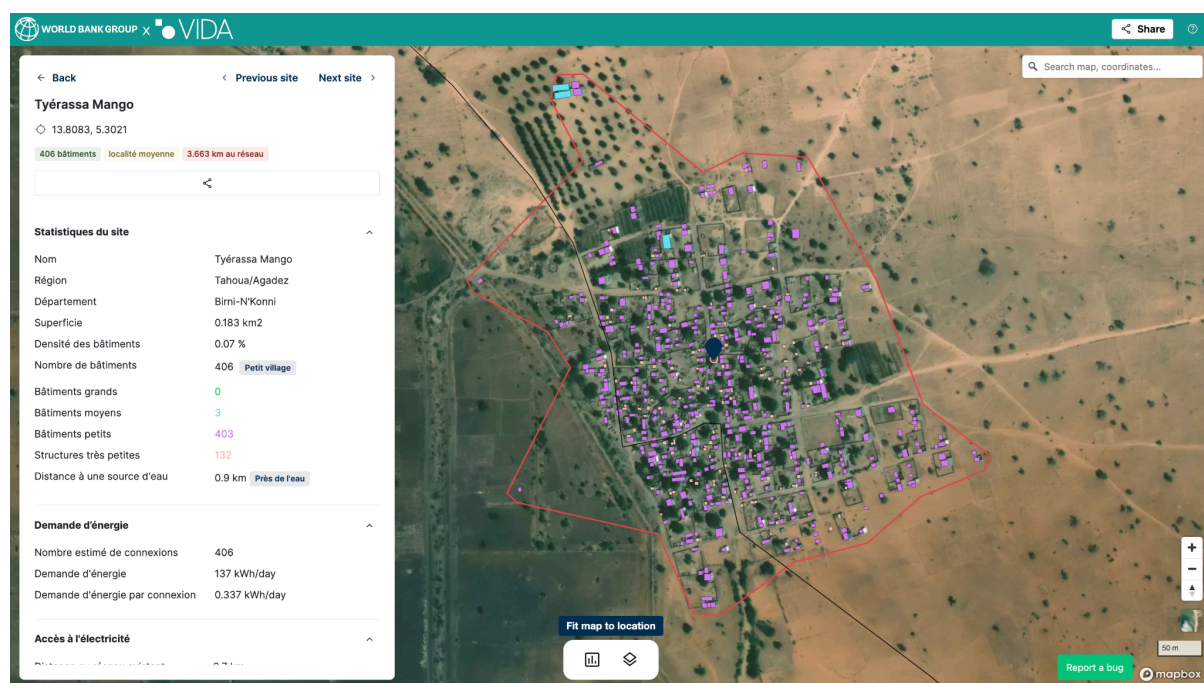


Figure 7: Selected detailed information on a settlement as seen in the DRE Atlas (all information accessible when scrolling through the left panel).



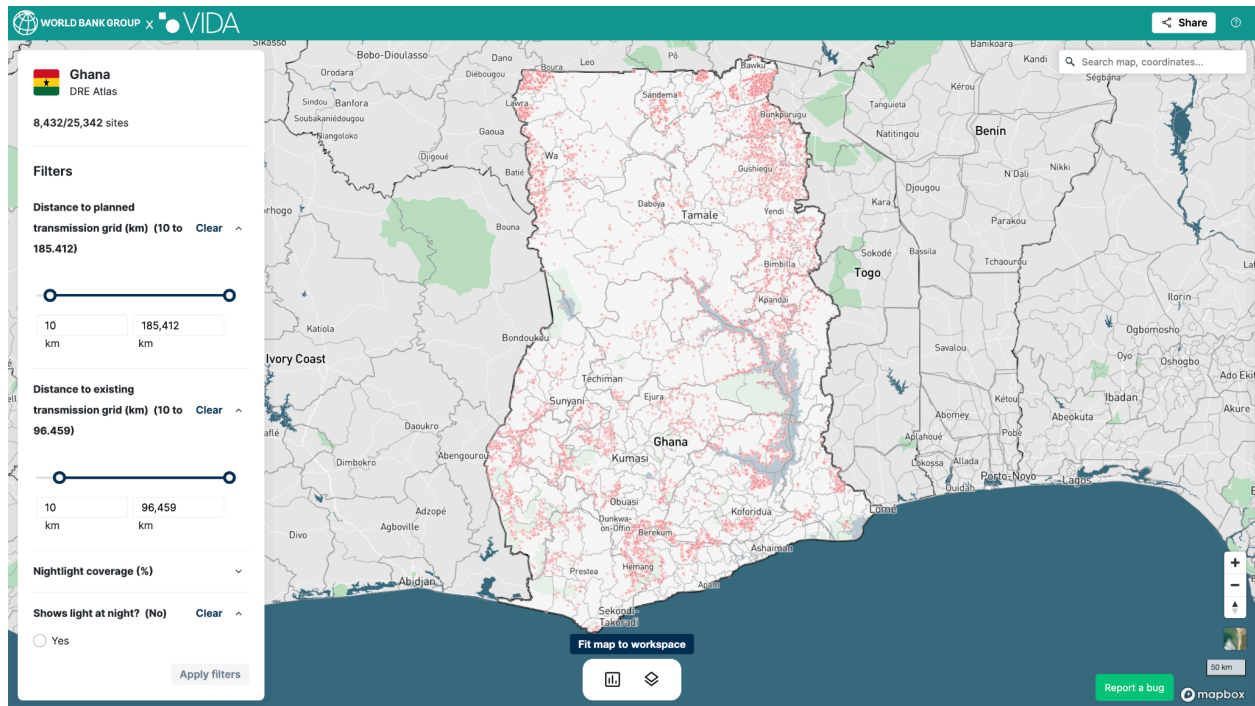


Figure 8: A filtered selection of settlements in Ghana as visualized on the DRE Atlas.

## Filtering

Customized sub-selections of settlements can be generated based on filters available on the left-hand side of the country overview page. Filters available include, amongst others, the administrative divisions, number of buildings, distance to existing or planned energy infrastructure, presence of light at night, and whether the settlement has main road access as well as education and health facilities. Filters can be combined, enabling users to identify settlements across the country that meet multiple criteria. An example of the filters in use can be found in Figure 8 above. After applying one or several filters, the map view adapt to display only settlements fulfilling the defined criteria.

## Location Search

Users can search for specific locations using the *Search* function. Searches can be made using either the name of a place or latitude and longitude coordinates, and will result in the map zooming into the place. Then, again via clicking any red settlement dot, site details can be accessed. The search function is highlighted in Figure 9 (next page).

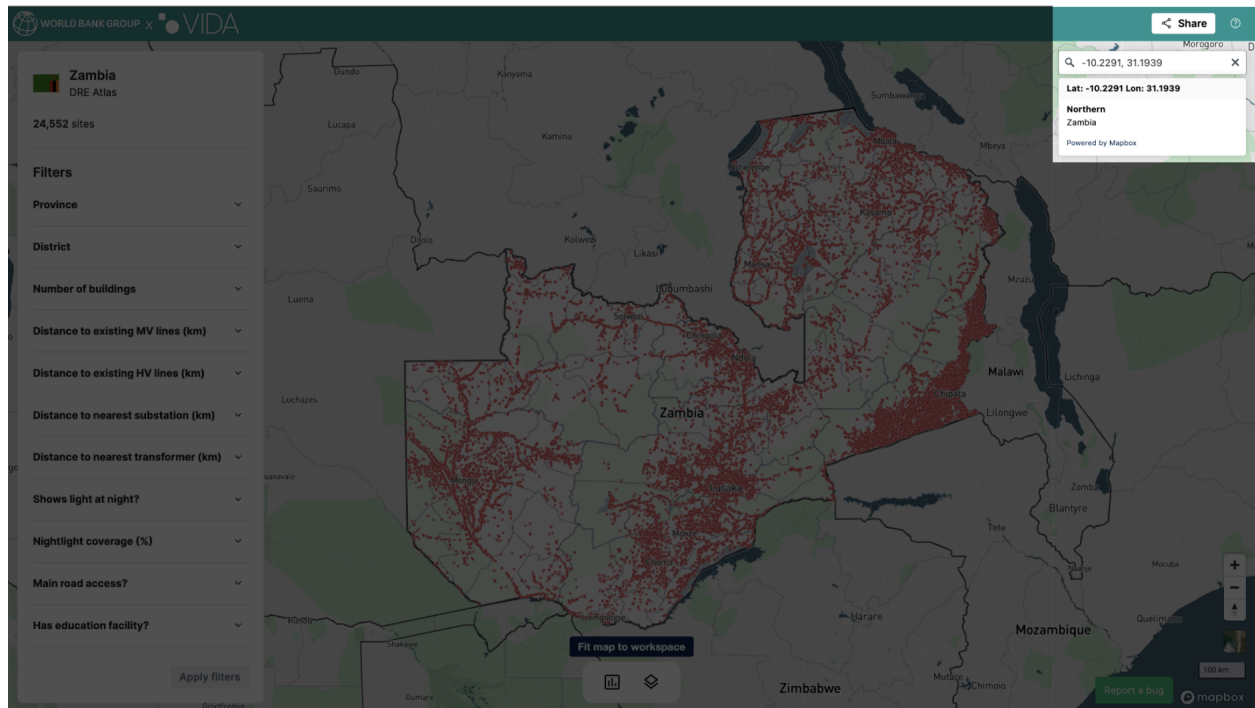


Figure 9: The search function, highlighted in the DRE Atlas.

## Analytics

Beyond accessing data of specific settlements, aggregated analytics can also be seen in the platform (see Figure 10, next page). They are viewable on the right-hand side of the overview map by default, and can also be accessed via the bottom bar switching between map layers and analytics panel. It automatically summarizes selected information about all settlements that the user has selected using the filters. In cases where no filters have been applied, Analytics will show information on every settlement identified across the country.

The Analytics tab provides several categories of information, including:

- The number of settlements considering applied filters
- The estimated number of connections across the selected settlements, including a chart to visualize the distribution by size
- The average estimated number of connections per settlement
- The total estimated energy demand across the selected settlement, expressed in kWh/day
- The estimated demand per connection across the selected settlements, expressed in kWh/day

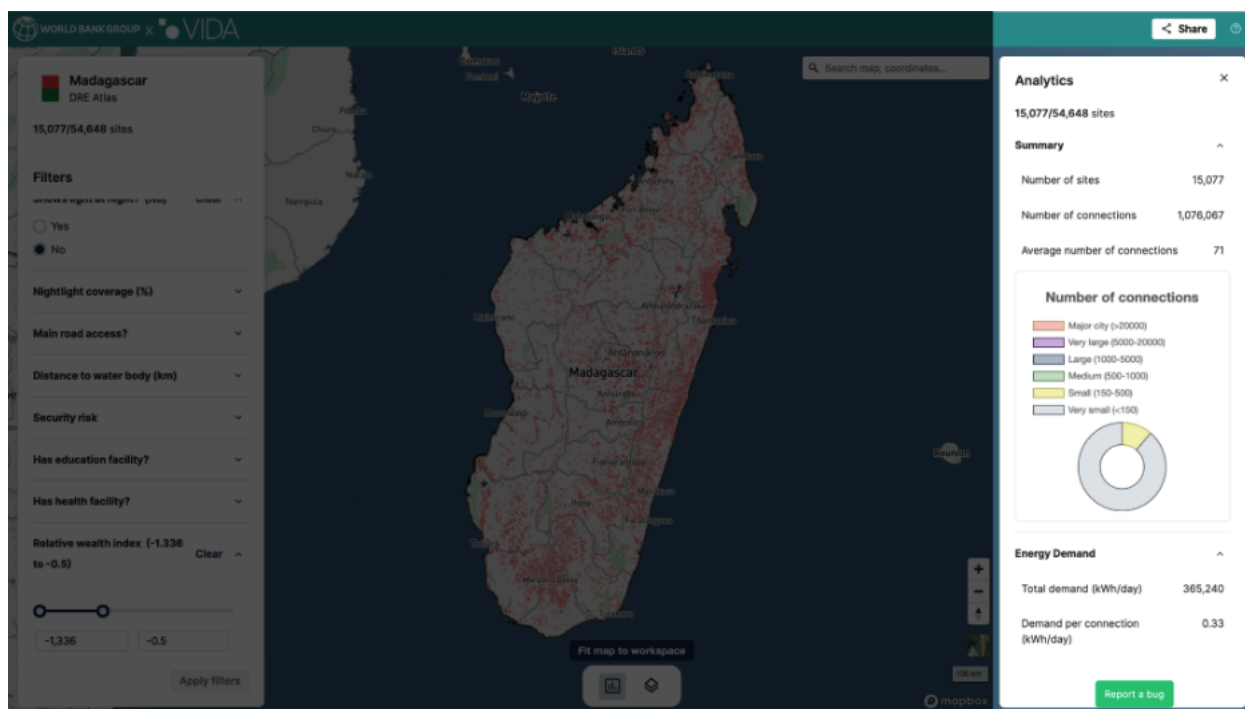


Figure 10: An example of the Analytics feature in use in the DRE Atlas.

## Map Layers

Users can also leverage layers to visualize information available for each country. Available layers include administrative boundaries; infrastructure such as healthcare facilities, education facilities, roads and mobile towers; electricity access information including the presence of light at night and available information on national-level energy infrastructure; water resources; and other information including the location of armed conflicts and the geographical spread of relative wealth.

An example of the *Layers* tab, which can be accessed by the bottom bar, can be found in Figure 11 (next page). Hovering over each layer allows for displaying or removing a layer on or from the map (eye icon) and for accessing layer information (three dots icon). For selected layers, for example most healthcare and education facilities as well as armed conflicts, pop-ups with additional information can be accessed by clicking on a symbol on the map.

## User Support

In the upper-right hand corner, users can access help in using the DRE Atlas by clicking on the question mark icon (see Figure 12, next page). “Help” directs users to the User Guide with more details, in particular video tutorials, on how to navigate the platform.

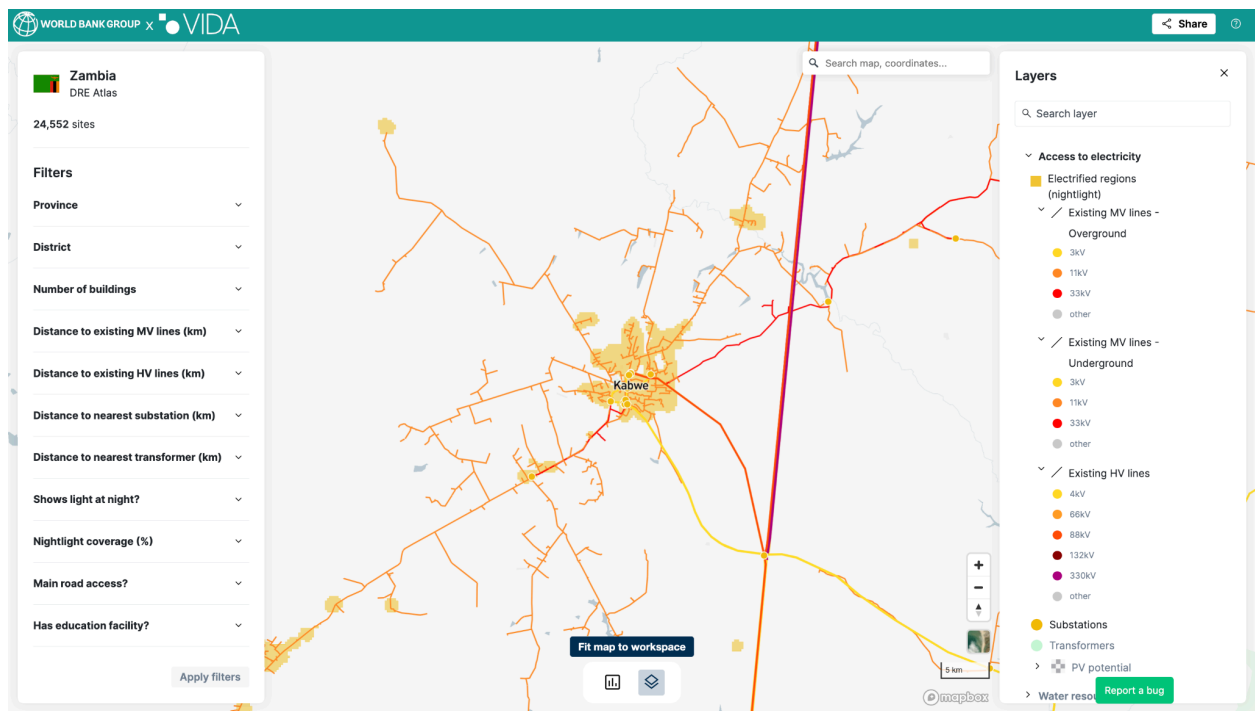


Figure 11: Using layers to view grid infrastructure and the presence of light at night, as seen on the DRE Atlas.

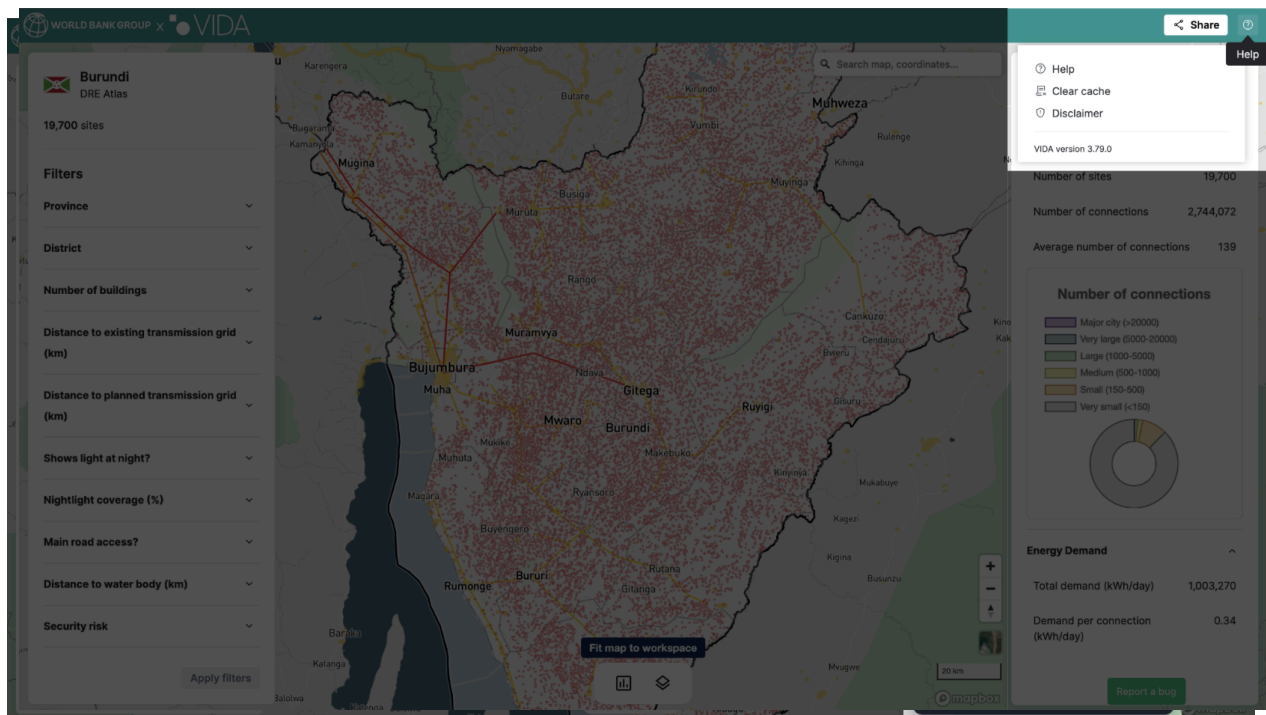


Figure 12: The help function as seen in the upper-right corner of the DRE Atlas, leading to the User Guide.



# Annex

## List of settlement characteristics and data sources

Please note that a more extensive list, including French display names and attribute keys, can be accessed together with the raw settlement data on [energydata.info](https://energydata.info) (search for “DRE” and country name).

| Settlement characteristic            | Unit            | Description                                                                                                                                                                                                                                                    | Data source                          |
|--------------------------------------|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| Name                                 |                 | Name of the settlement derived from reverse geocoding, if available - note that in some cases this might refer to the name of a larger settlement in the surrounding or an administrative sub-division, and official or local names can be different.          | <a href="#">OpenCage</a>             |
| Region or other (country-specific)   |                 | Name of the administrative sub-division level 1 in which the settlement is located (display name according to country conventions). We do not endorse or guarantee the accuracy of any country boundaries shown, which may be subject to dispute or variation. | <a href="#">CGAZ / geoBoundaries</a> |
| District or other (country-specific) |                 | Name of the administrative sub-division level 2 in which the settlement is located (display name according to country conventions). We do not endorse or guarantee the accuracy of any country boundaries shown, which may be subject to dispute or variation. | <a href="#">CGAZ / geoBoundaries</a> |
| Settlement area                      | km <sup>2</sup> | Total area of the settlement                                                                                                                                                                                                                                   | VIDA                                 |
| Building density                     | %               | Building density as settlement area covered by building footprints (in %)                                                                                                                                                                                      | see "Number of buildings"            |

|                                 |          |                                                                                                                                                                                                                                                                                        |                                                                                          |
|---------------------------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Number of buildings             |          | Total number of buildings (min. 15 m2 footprint size, excluding small structures) within the settlement. Note that in few countries buildings from <a href="#">OpenStreetMap</a> as well as <a href="#">WorldPop</a> building counts layers were used in addition for better coverage. | <a href="#">VIDA (based on data from Microsoft and Google)</a>                           |
| Large buildings                 |          | Number of buildings > 200 m2 (footprint size)                                                                                                                                                                                                                                          | see "Number of buildings"                                                                |
| Medium buildings                |          | Number of buildings 120-200 m2 (footprint size)                                                                                                                                                                                                                                        | see "Number of buildings"                                                                |
| Small buildings                 |          | Number of buildings 15-120 m2 (footprint size)                                                                                                                                                                                                                                         | see "Number of buildings"                                                                |
| Very small structures           |          | Number of buildings < 15 m2 (footprint size) - these are typically non-inhabited built-up structures which are not relevant for electrification (e.g. animal sheds, outdoor kitchens, storage space), and are therefore not included in the total building count                       | see "Number of buildings"                                                                |
| Population                      |          | Population estimates by VIDA derived from building counts and urban/rural classifications based on the Global Human Settlement Layer (GHSL), calibrated against World Bank sub-national population statistics.                                                                         | VIDA (based on <a href="#">GHSL</a> , <a href="#">World Bank statistics</a> , buildings) |
| Distance to water body          | km       | Distance to the closest river or lake                                                                                                                                                                                                                                                  | <a href="#">HydroSHEDS</a>                                                               |
| Estimated number of connections |          | Number of estimated potential connections corresponding to the total number of buildings (min. 15 m2 footprint size)                                                                                                                                                                   | Calculations based on buildings (VIDA/WB); see "Number of buildings"                     |
| Energy demand                   | kWh /day | Estimated energy demand of all potential connections / buildings (min. 15 m2 footprint size), with the following assumptions: large buildings: 1,100 Wh/day, medium buildings: 650 Wh/day, small buildings: 10 % with 650 Wh/day & 90 % with 300 Wh/day                                | Calculations based on buildings (VIDA/WB); see "Number of buildings"                     |

|                                           |          |                                                                                                                                                                                       |                                                                                 |
|-------------------------------------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| Energy demand per connection              | kWh /day | Mean energy demand per connection                                                                                                                                                     | <i>Calculations based on buildings (VIDA/WB); see "Number of buildings"</i>     |
| Distance to existing lines                | km       | Distance to the closest existing transmission grid line (unknown or mixed voltages) - note that public grid data can be outdated / inaccurate.                                        | Country-specific (mostly <a href="http://energydata.info">energydata.info</a> ) |
| Distance to planned lines                 | km       | Distance to the closest planned transmission grid line (unknown or mixed voltages) - note that public grid data can be outdated / inaccurate.                                         | Country-specific (mostly <a href="http://energydata.info">energydata.info</a> ) |
| Distance to transmission grid             | km       | Distance to the closest existing or planned transmission grid line (unknown or mixed voltages) - note that public grid data can be outdated / inaccurate.                             | Country-specific (mostly <a href="http://energydata.info">energydata.info</a> ) |
| Distance to existing MV transmission grid | km       | Distance to the closest existing medium-voltage (MV) transmission grid line (MV classification according to original data) - note that public grid data can be outdated / inaccurate. | Country-specific (mostly <a href="http://energydata.info">energydata.info</a> ) |
| Distance to existing HV transmission grid | km       | Distance to the closest existing high-voltage (HV) transmission grid line (MV classification according to original data) - note that public grid data can be outdated / inaccurate.   | Country-specific (mostly <a href="http://energydata.info">energydata.info</a> ) |
| Distance to planned MV transmission grid  | km       | Distance to the closest planned medium-voltage (MV) transmission grid line (MV classification according to original data) - note that public grid data can be outdated / inaccurate.  | Country-specific (mostly <a href="http://energydata.info">energydata.info</a> ) |
| Distance to planned HV transmission grid  | km       | Distance to the closest planned high-voltage (HV) transmission grid line (MV classification according to original data) - note that public grid data can be outdated / inaccurate.    | Country-specific (mostly <a href="http://energydata.info">energydata.info</a> ) |

|                                                             |           |                                                                                                                                                                                                                                            |                                                                                                          |
|-------------------------------------------------------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Distance to existing transmission grid - Under construction | km        | Distance to the closest existing transmission grid line under construction - note that public grid data can be outdated / inaccurate.                                                                                                      | Country-specific (mostly <a href="https://energydata.info">energydata.info</a> )                         |
| Distance to planned transmission grid - Under study         | km        | Distance to the closest planned transmission grid line under study - note that public grid data can be outdated / inaccurate.                                                                                                              | Country-specific (mostly <a href="https://energydata.info">energydata.info</a> )                         |
| Distance to existing UV transmission grid                   | km        | Distance to the closest existing transmission grid line (unknown voltage) - note that public grid data can be outdated / inaccurate.                                                                                                       | Country-specific (mostly <a href="https://energydata.info">energydata.info</a> )                         |
| Distance to nearest substation                              | km        | Distance to the closest substation - note that public substation data can be outdated / inaccurate.                                                                                                                                        | Country-specific (mostly <a href="https://energydata.info">energydata.info</a> )                         |
| Distance to nearest transformer                             | km        | Distance to the closest transformer - note that public transformer data can be outdated / inaccurate.                                                                                                                                      | Country-specific (mostly <a href="https://energydata.info">energydata.info</a> )                         |
| Distance to nearest mini grid                               | km        | Distance to the closest mini-grid - note that public mini-grid data can be outdated / inaccurate.                                                                                                                                          | Country-specific (mostly <a href="https://energydata.info">energydata.info</a> )                         |
| Shows light at night?                                       |           | Yes/true, if settlement overlap with nightlight areas is > 0 % (areas where light was detected by night from <a href="https://viirsnighttime.org/">NASA's VIIRS nighttime light data</a> over a period of one year - Sep 2022 to Aug 2023) | VIDA (based on VIIRS nighttime data from NASA)                                                           |
| Nightlight coverage                                         | %         | Share of settlement area overlapping with nightlight area (areas where light was detected by night from <a href="https://viirsnighttime.org/">NASA's VIIRS nighttime light data</a> over a period of one year - Sep 2022 to Aug 2023)      | VIDA (based on VIIRS nighttime data from NASA)                                                           |
| Distance to nightlight                                      | km        | Distance to closest nightlight area (where light was detected by night from <a href="https://viirsnighttime.org/">NASA's VIIRS nighttime light data</a> over a period of one year - Sep 2022 to Aug 2023)                                  | VIDA (based on VIIRS nighttime data from NASA)                                                           |
| Potential PV production                                     | kWh /kW p | Long-term yearly average (1994-2015) of potential PV electricity production under optimum conditions                                                                                                                                       | <a href="https://solargis.com/">Solargis</a> / <a href="https://www.worldbank.org/">World Bank Group</a> |

|                                             |    |                                                                                                                                                                                                                |                                                                      |
|---------------------------------------------|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|
| Main road access?                           |    | Yes/true, if the settlement is within 500 meter of a main road (see below)                                                                                                                                     | <a href="#">OpenStreetMap</a>                                        |
| Distance to the main road                   | km | Distance to the closest main road (types: motorway, trunk, primary, secondary - these are mostly paved and/or well-maintained main transportation routes)                                                      | <a href="#">OpenStreetMap</a>                                        |
| Nearest regional hub                        |    | Name of the closest regional hub, if available (see below)                                                                                                                                                     | <a href="#">OpenStreetMap</a>                                        |
| Distance to nearest hub                     | km | Distance to the closest regional hub (populated places of types: city, town)                                                                                                                                   | <a href="#">OpenStreetMap</a>                                        |
| Education facilities                        |    | Number of education facilities within 500m of the settlement (OSM: schools, colleges, universities, kindergartens, language schools, and general educational institutions)                                     | <a href="#">OpenStreetMap</a><br>(or custom country-specific source) |
| Has education facility?<br>(only as filter) |    | Yes/true, if at least one education facility (see above) is within 500m of the settlement. Not displayed in site details, but available as a filter and in raw data..                                          | <a href="#">OpenStreetMap</a><br>(or custom country-specific source) |
| Healthcare facilities                       |    | Number of healthcare facilities within 500m of the settlement (OSM: doctors, dentists, clinics, hospitals, pharmacies and other general healthcare facilities)                                                 | <a href="#">OpenStreetMap</a><br>(or custom country-specific source) |
| Has health facility?<br>(only as filter)    |    | Yes/true, if at least one healthcare facility (see above) is within 500m of the settlement. Not displayed in site details, but available as a filter and in raw data.                                          | <a href="#">OpenStreetMap</a><br>(or custom country-specific source) |
| Relative wealth index                       |    | Mean relative wealth index within the settlement (index derived from survey data, satellite imagery, connectivity, and other geodata) - note that not all settlements and countries are covered by this index. | <a href="#">Meta</a>                                                 |
| Top five dominant crops                     |    | The five dominant crops grown in the administrative subdivision level 2. SPAM data is not available in selected countries / subdivisions.                                                                      | <a href="#">MapSPAM</a>                                              |



|                                                                               |         |                                                                                                                                                                                                                                                   |                         |
|-------------------------------------------------------------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| Total agricultural area                                                       | ha      | Agricultural (harvested) area within administrative subdivision level 2. SPAM data is not available in selected countries / subdivisions.                                                                                                         | <a href="#">MapSPAM</a> |
| Total crop value                                                              | \$/year | Total crop value within administrative subdivision level 2. SPAM data is not available in selected countries / subdivisions.                                                                                                                      | <a href="#">MapSPAM</a> |
| Total crop yield                                                              | kg/ha   | Total crop yield within administrative subdivision level 2. SPAM data is not available in selected countries / subdivisions.                                                                                                                      | <a href="#">MapSPAM</a> |
| Total crop value per hectare                                                  | \$/ha   | Total crop value per area within administrative subdivision level 2. SPAM data is not available in selected countries / subdivisions.                                                                                                             | <a href="#">MapSPAM</a> |
| Fatalities within 10 km (battles:riots:violence against civilians:explosions) |         | Number of fatalities from armed conflicts from 2020-2022 within 10 km of the settlement by conflict type (battles, riots, violence against civilians, explosions) - in selected countries, less years are available as displayed on the platform. | <a href="#">ACLED</a>   |
| Fatalities within 20 km (battles:riots:violence against civilians:explosions) |         | Number of fatalities from armed conflicts from 2020-2022 within 20 km of the settlement by conflict type (battles, riots, violence against civilians, explosions) - in selected countries, less years are available as displayed on the platform. | <a href="#">ACLED</a>   |
| Fatalities within 25 km (battles:riots:violence against civilians:explosions) |         | Number of fatalities from armed conflicts from 2020-2022 within 25 km of the settlement by conflict type (battles, riots, violence against civilians, explosions) - in selected countries, less years are available as displayed on the platform. | <a href="#">ACLED</a>   |
| Fatalities within 50 km (battles:riots:violence against civilians:explosions) |         | Number of fatalities from armed conflicts from 2020-2022 within 50 km of the settlement by conflict type (battles, riots, violence against civilians, explosions) - in selected countries, less years are available as displayed on the platform. | <a href="#">ACLED</a>   |

|                                                                  |  |                                                                                                                                                                                                                                    |                       |
|------------------------------------------------------------------|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Total number of incidents within 20 km                           |  | Number of incidents (armed conflicts of types battles, riots, violence against civilians, explosions) from 2020-2022 within 20 km of the settlement- in selected countries, less years are available as displayed on the platform. | <a href="#">ACLED</a> |
| Total number of incidents within 50 km                           |  | Number of incidents (armed conflicts of types battles, riots, violence against civilians, explosions) from 2020-2022 within 20 km of the settlement- in selected countries, less years are available as displayed on the platform. | <a href="#">ACLED</a> |
| Security risk                                                    |  | Security indicator based on number of fatalities as described above: high: 1+ fatalities within 25 (or 10) km, medium: 1+ fatalities within 50 (or 25) km, low: all other                                                          | <a href="#">ACLED</a> |
| <i>displayed below settlement name on top of the detail view</i> |  | Latitude of settlement centroid (EPSG:4326)                                                                                                                                                                                        |                       |
| <i>displayed below settlement name on top of the detail view</i> |  | Longitude of settlement centroid (EPSG:4326)                                                                                                                                                                                       |                       |
| <i>not displayed</i>                                             |  | Unique identifier (based on coordinates)                                                                                                                                                                                           |                       |