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Electrification planning with focus on hybrid mini-grids

A comprehensive modelling approach for the Global South

10th IRES Conference

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The Reiner Lemoine Institut (RLI)

Overview

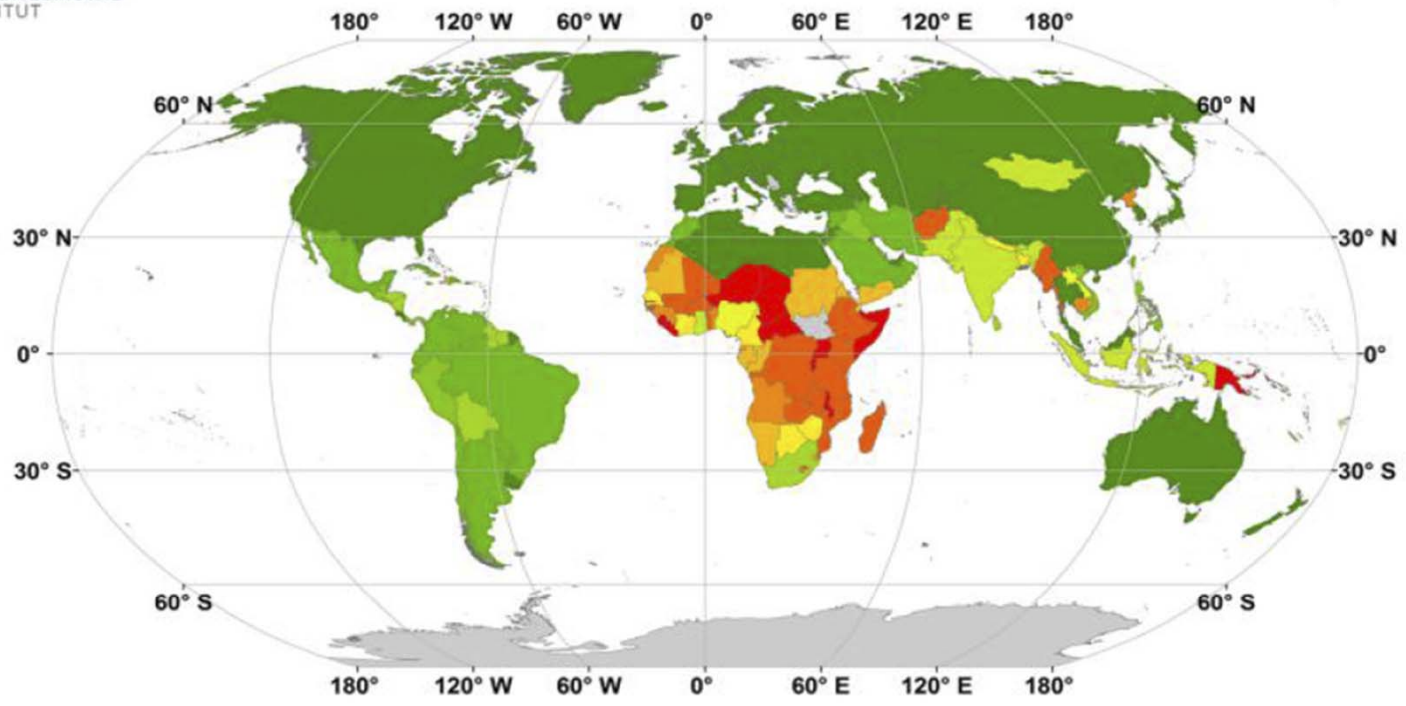
- Not-for-profit research institute
- 100 % subsidiary of Reiner Lemoine-Foundation (RLS)
- Established 2010 in Berlin
- Managing Director: Dr. Kathrin Goldammer
- Member of: ARE, eurosolar, BNE, dena, EEA

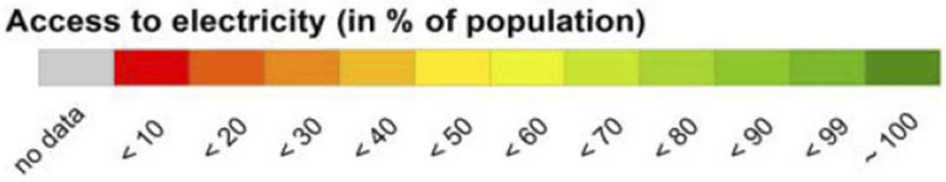
Reiner Lemoine
Founder of Reiner Lemoine-Foundation

Agenda

- Motivation for electrifcation modelling
- Tool comparison
- Presentation RLI approach
- Conclusion

Rural electrification - Map



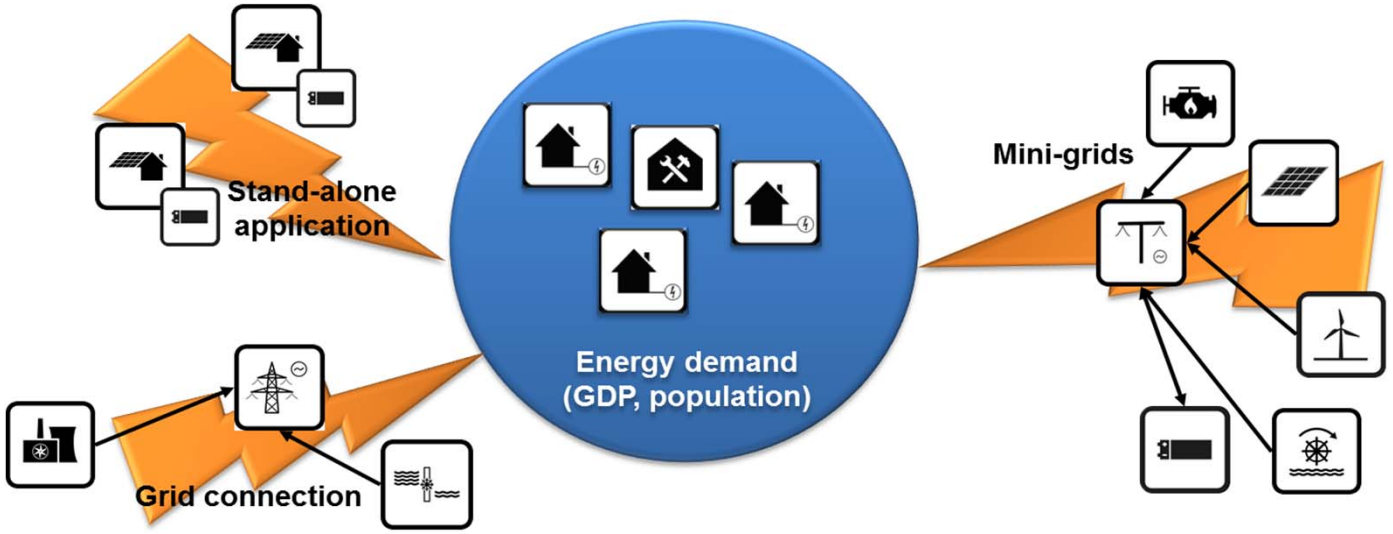


Sources:
www.gadm.org
UNDP 2009
IEA 2011

Cader, C. et al. (2015) **Global cost advantages of autonomous solar-battery-diesel systems compared to diesel-only systems.** Energy for Sustainable Development, 2015.

Rural electrification - challenges

- Currently, 1.4 billion people have no access to sustainable energy
- Different electrification options exist
- Challenge of assessing the least-cost electrification option for non-electrified areas
  - Dynamic modelling and simulation tools are needed



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Tool comparison

Tools	HOMER Energy	Network Planner	GEOSIM
General criteria			
Geospatial planning	no	yes	yes
Energy system modelling	yes	no – only static analysis	yes - cost-benefits optimisation
Technology criteria			
Load projections	yes – loads are created based on input, also deferrable loads are possible	no - load needs to be provided	yes – detailed projection builds on different user classes and surveys
Hybrid mini-grid	yes	no, only diesel based mini-grids	yes – but no solar mini-grid
Stand-alone system	no	yes – solar home system	yes - solar home system
Grid extension modelling	no – only calculation of breakeven grid extension distance	yes - but no topographic details are considered	yes – but no topographic details are considered

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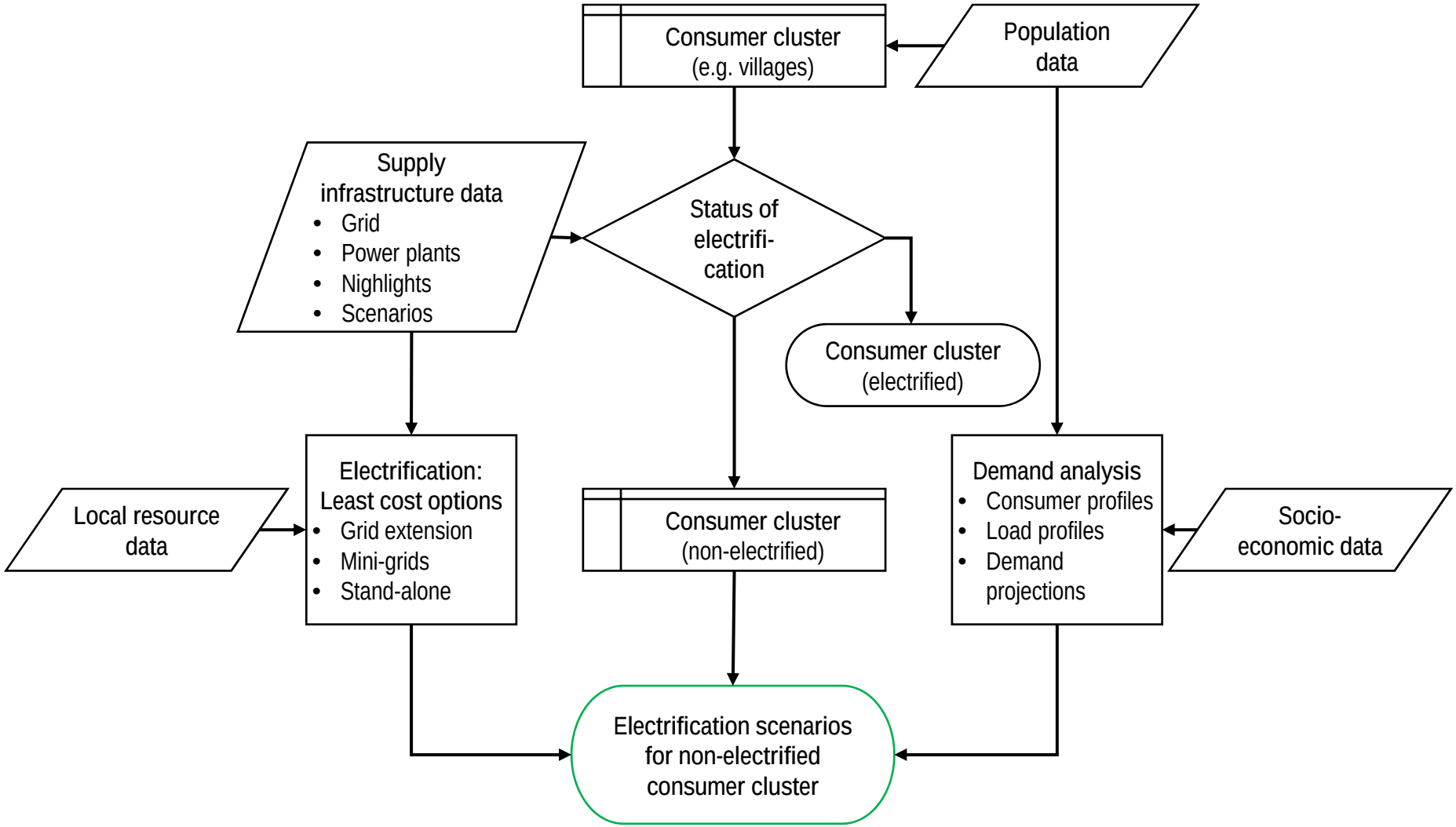
RLI electrification modelling approach



Dynamic electrification modelling - Showcase

- Electrification modelling along the example of Plateau State

Nigerian Energy Support Programme (NESP) – Component III: Rural Electrification

Rural electrification planning

- GIS analyses
- Evaluation of on- and off-grid supply options
- Local capacity development

INTEGRATION

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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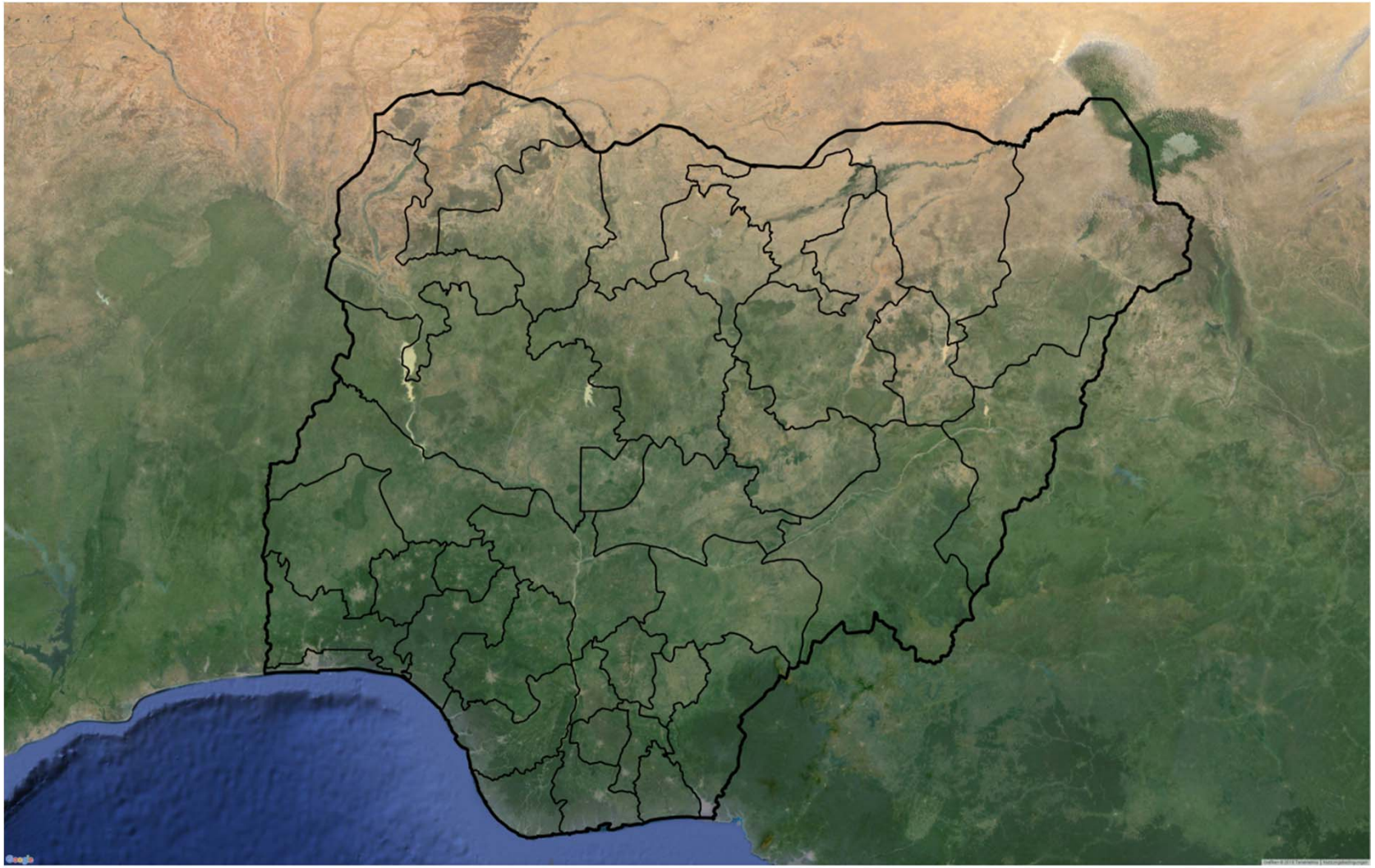
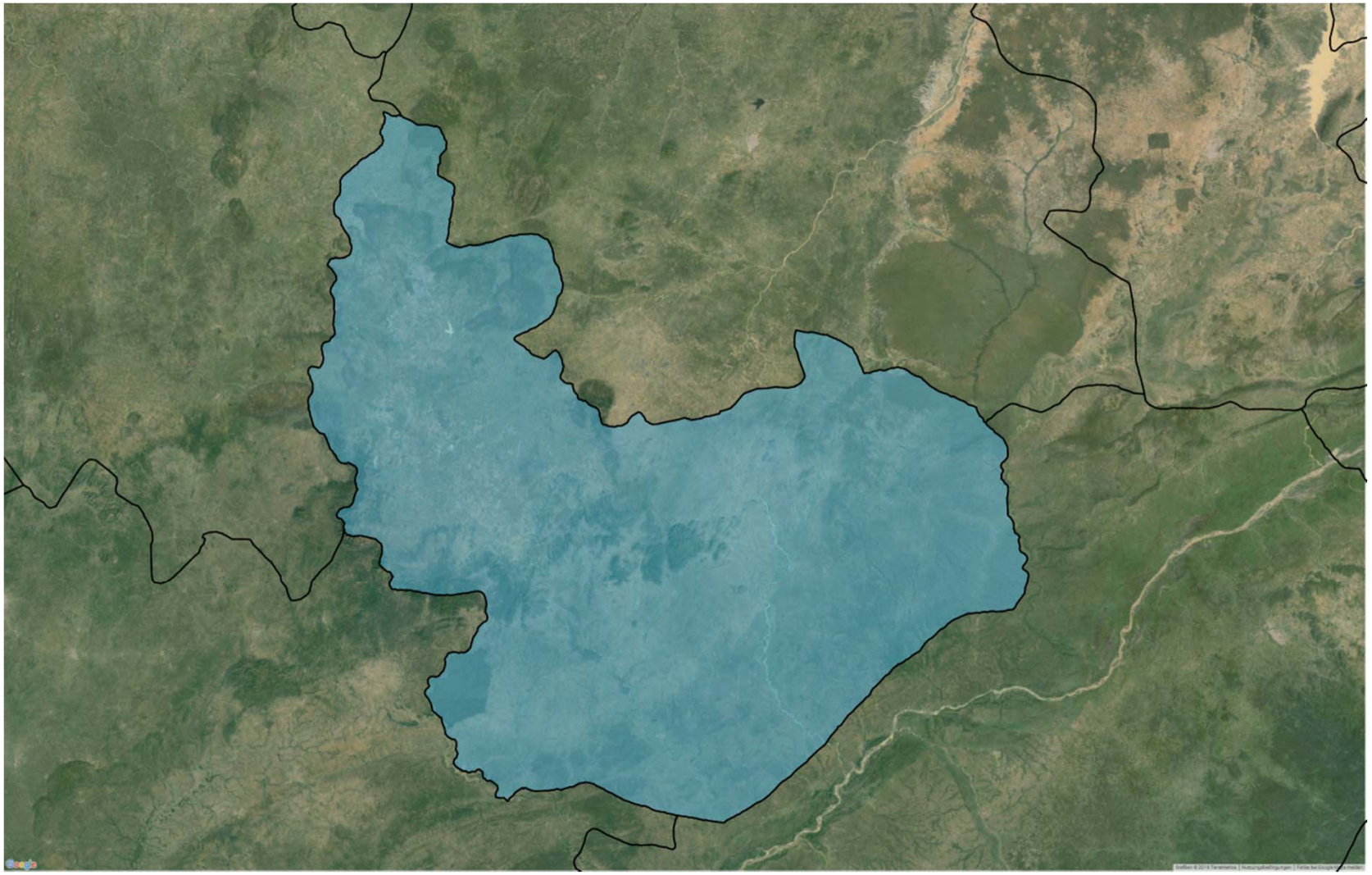
Map of Nigeria

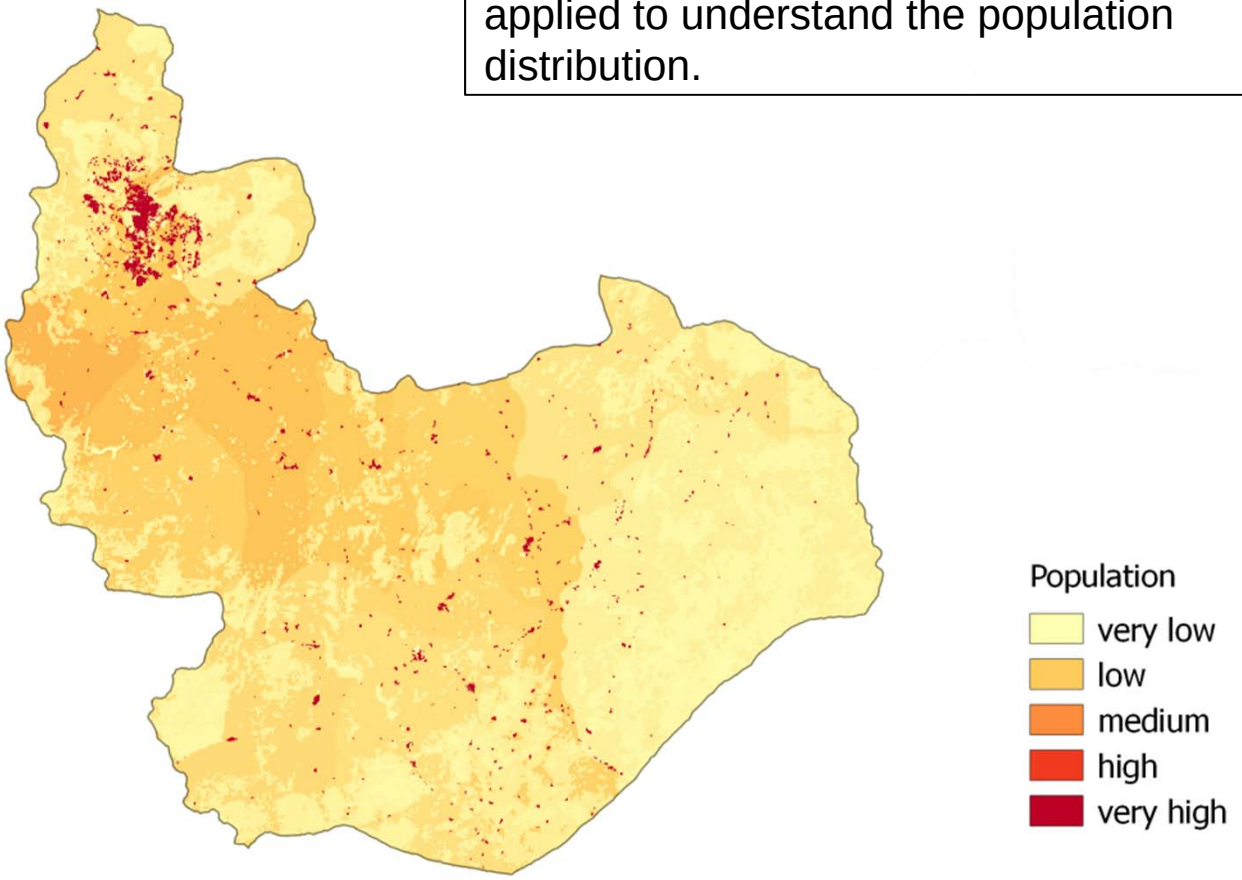


Map of Nigeria - Plateau zoom



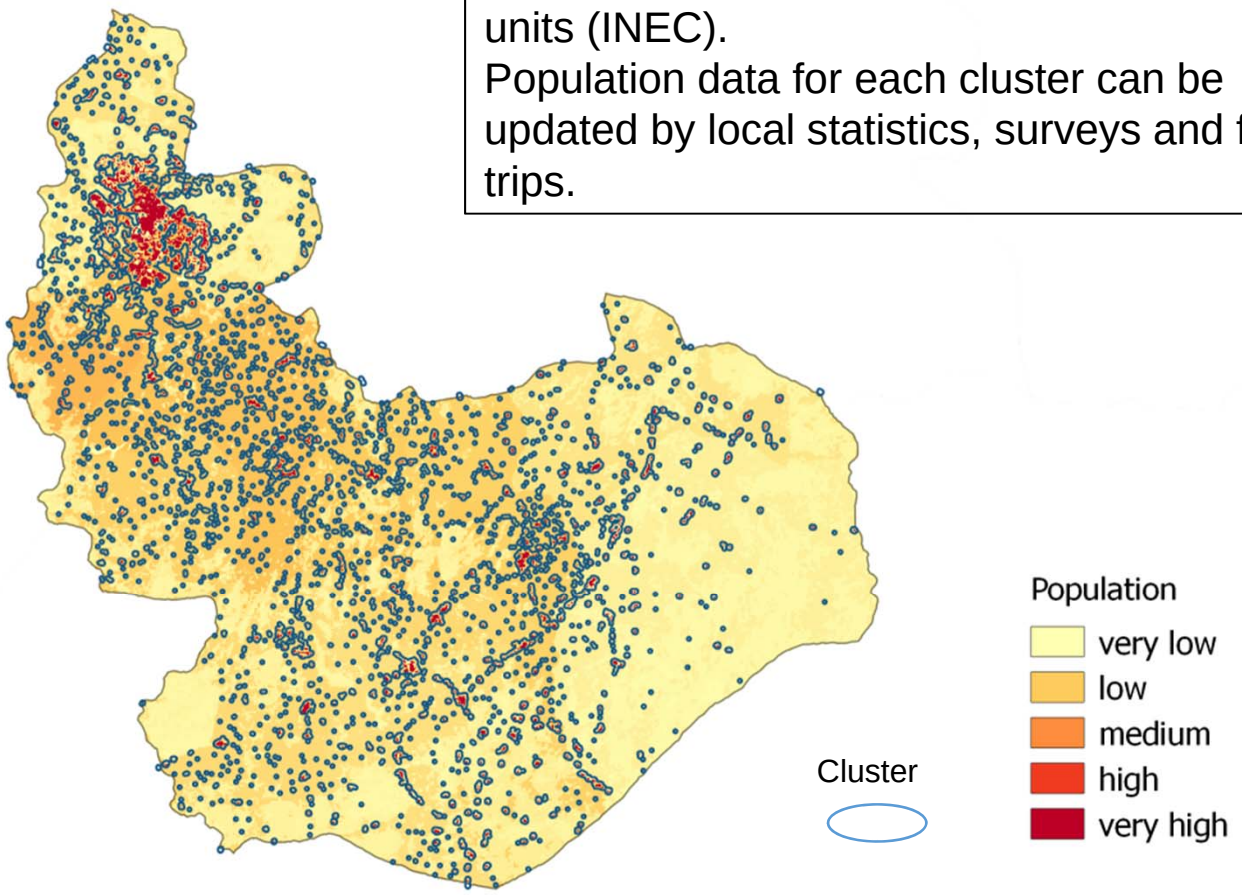
Step 1a: Identification of consumer cluster - population

Consumer cluster build the baseline of electrification modelling. Global data sets are applied to understand the population distribution.



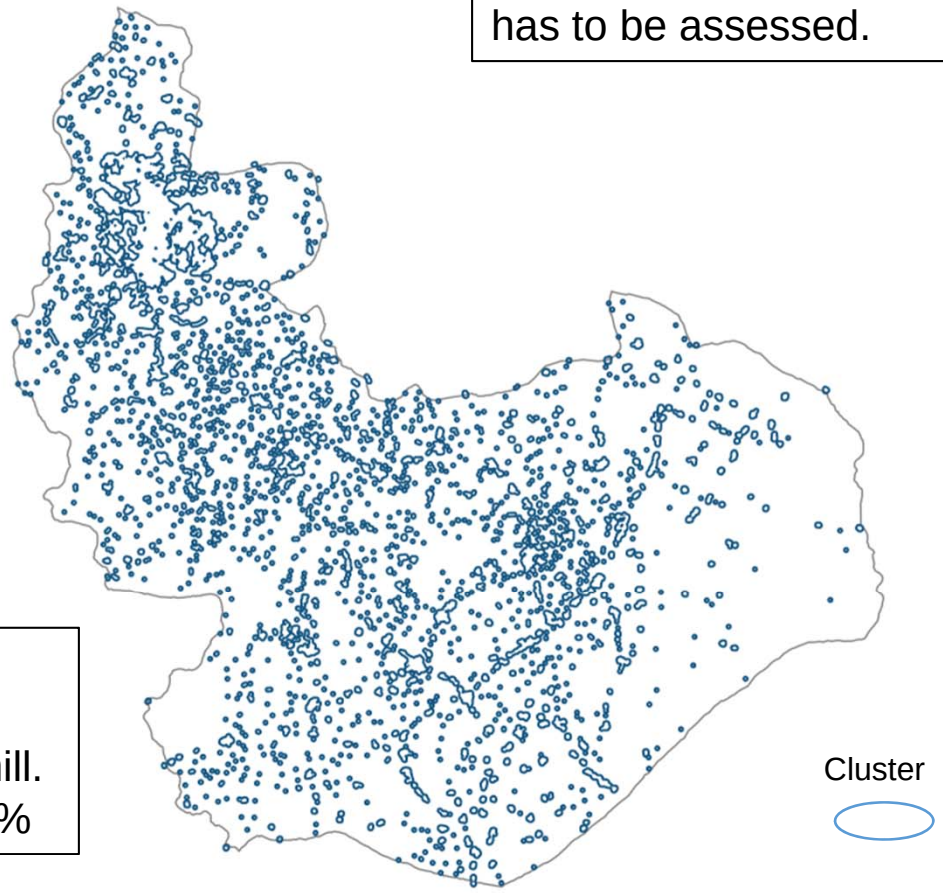
Step 1a: Identification of consumer cluster - location

Consumer cluster are derived based on population density, school data and polling units (INEC).
Population data for each cluster can be updated by local statistics, surveys and field-trips.



Step 1b: Assessment of status of electrification

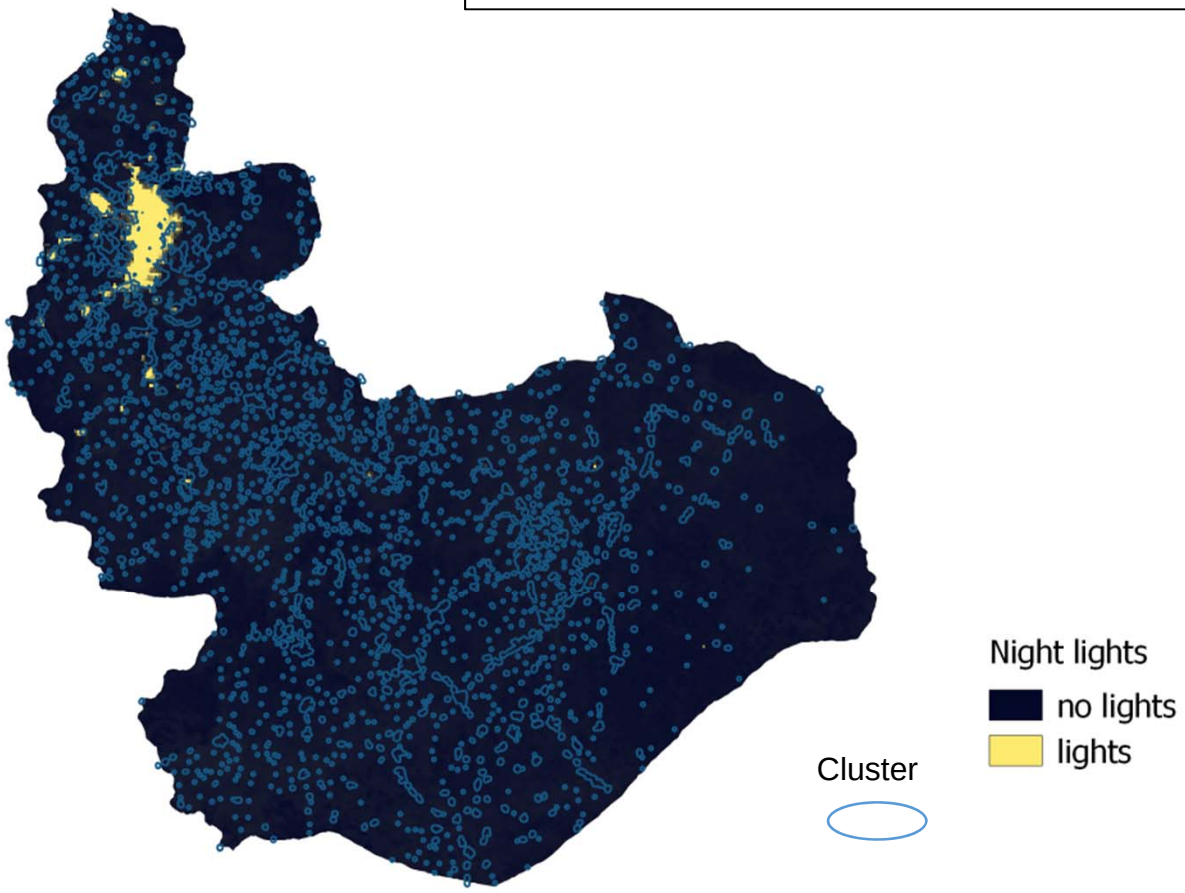
Consumer clusters and their population data are identified. Now the status of electrification has to be assessed.



Results
Clusters: 1,834
Pop. in clusters: 3.785 mill.
Covered by clusters: 94 %

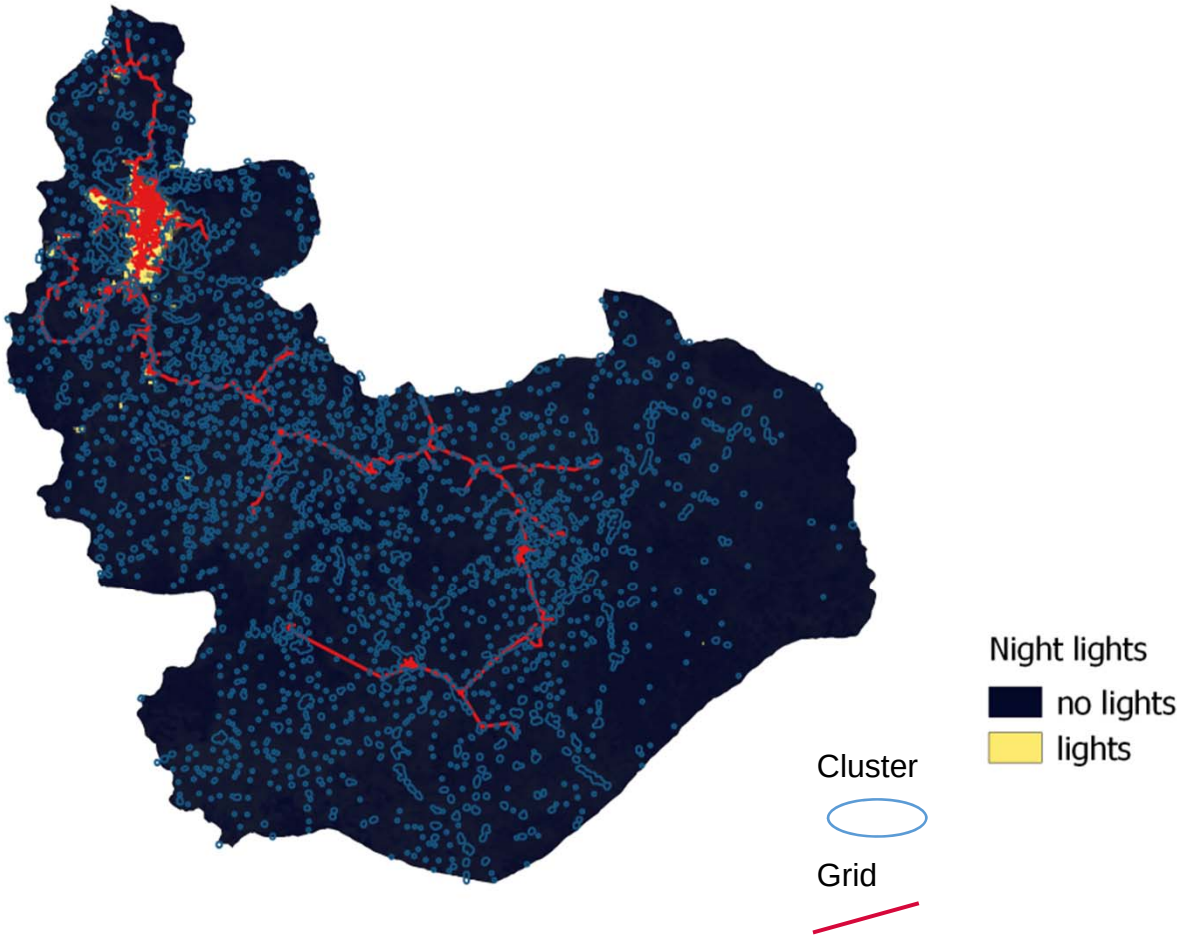
Step 2: Night light imageries

Light emissions during night indicate availabilty of electricity



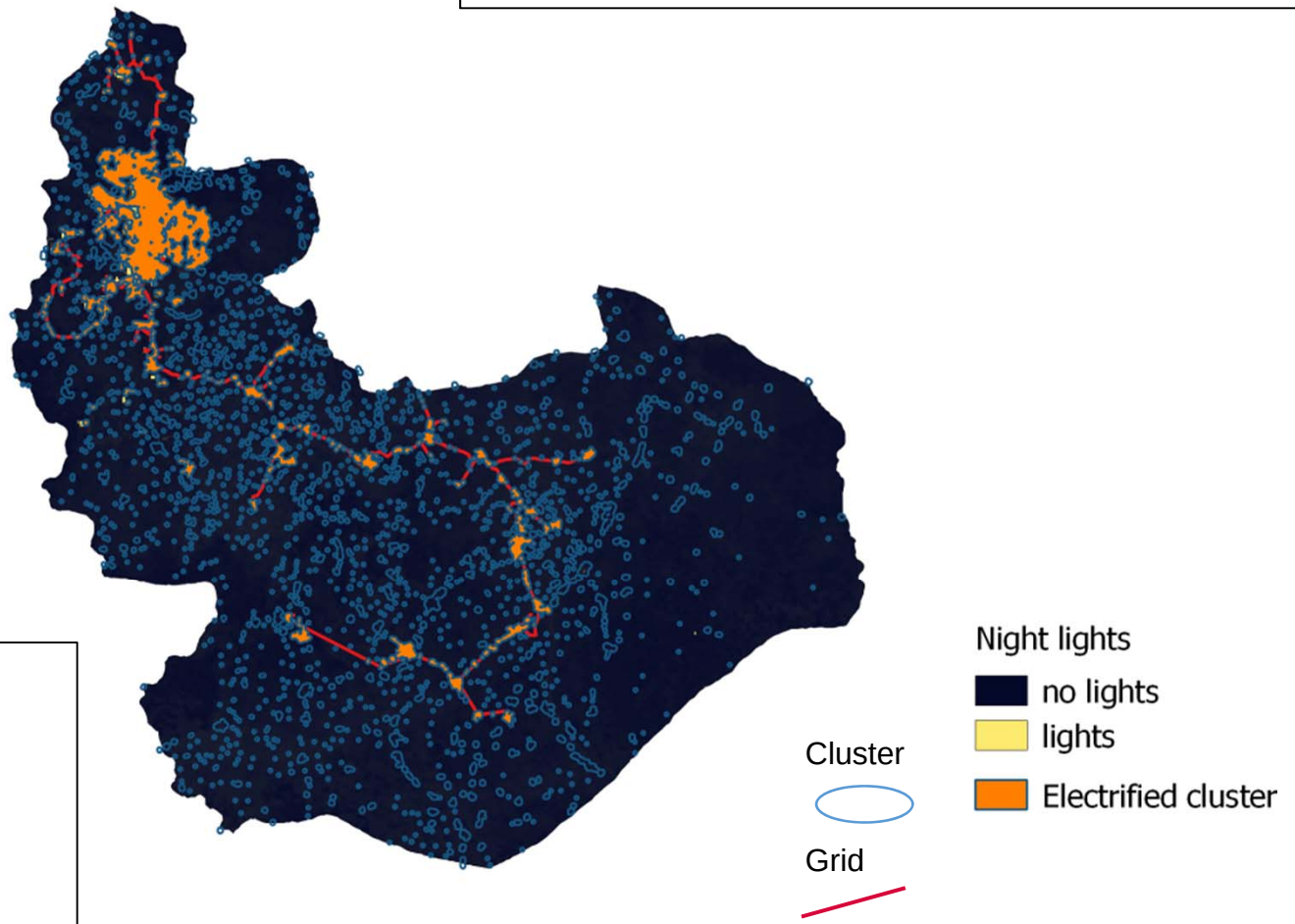
Step 2: Grid data

Grid-connection indicates access to electricity.



Step 2: Final identification of status of electrification

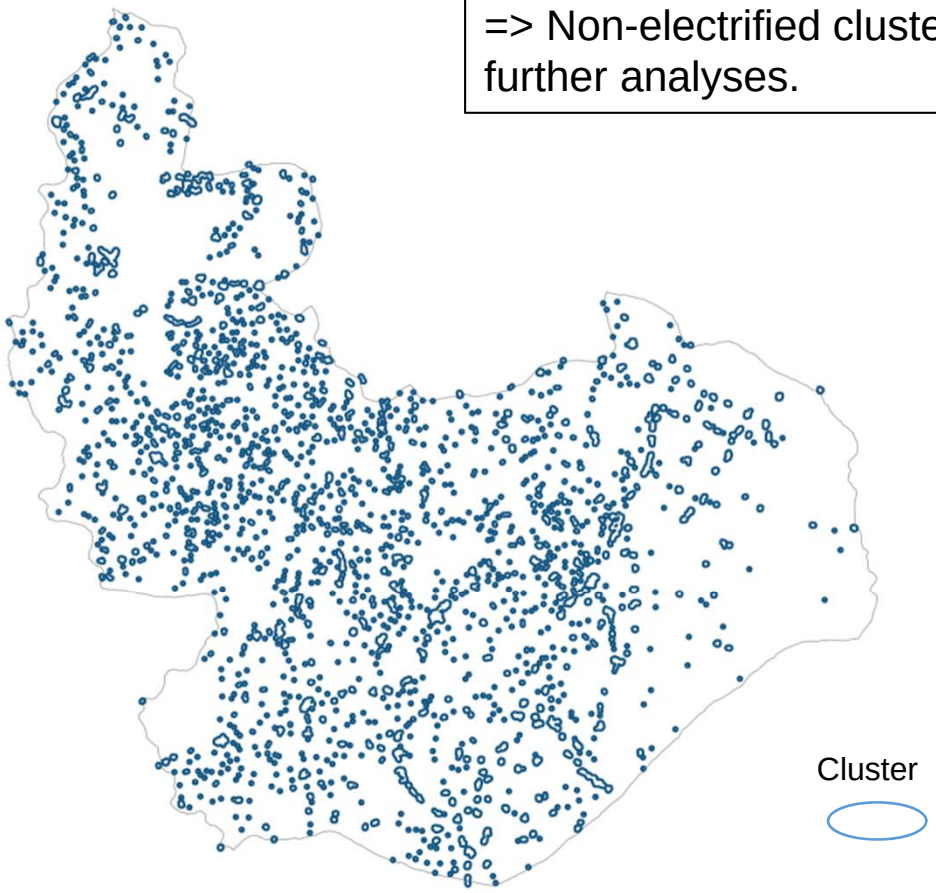
Combination of night ligths and grid data shows electrified clusters.



Results
Clusters electrified:
26; 1 %
People living in electrified clusters:
1.4 mill.; 34 %

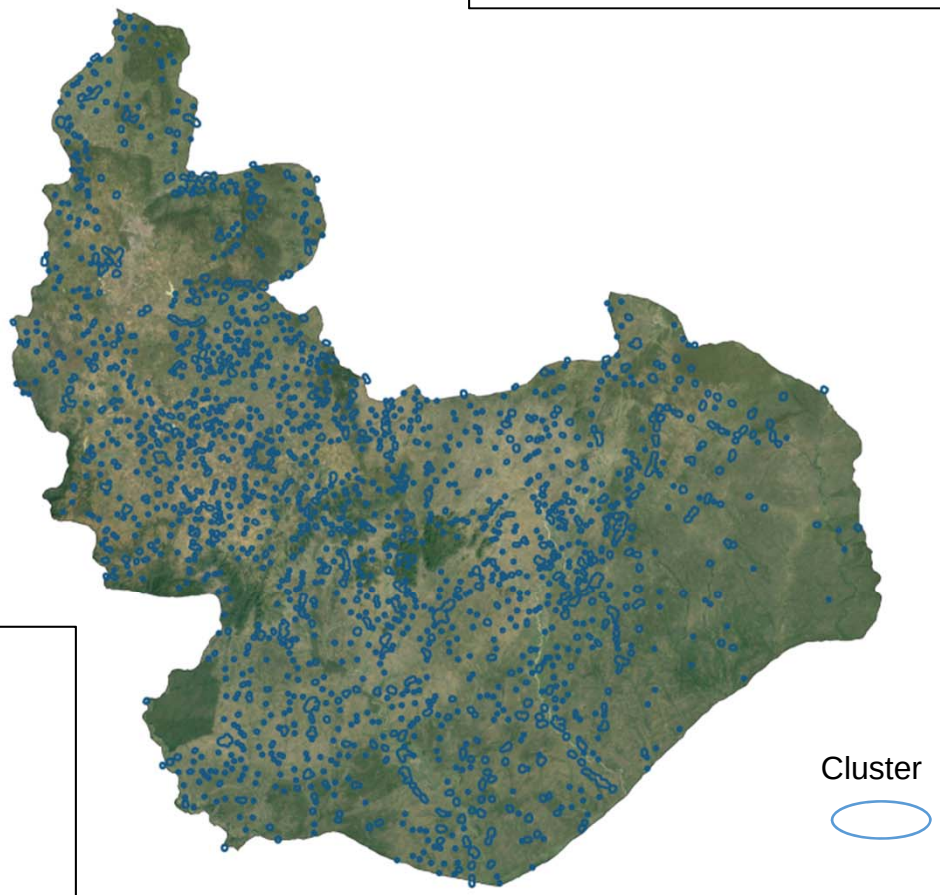
Step 2: Non-electrified clusters

Combination of night ligths and grid data shows electrified clusters.
=> Non-electrified clusters can be derived for further analyses.



Step 3: Demand analysis for each non-electrified cluster

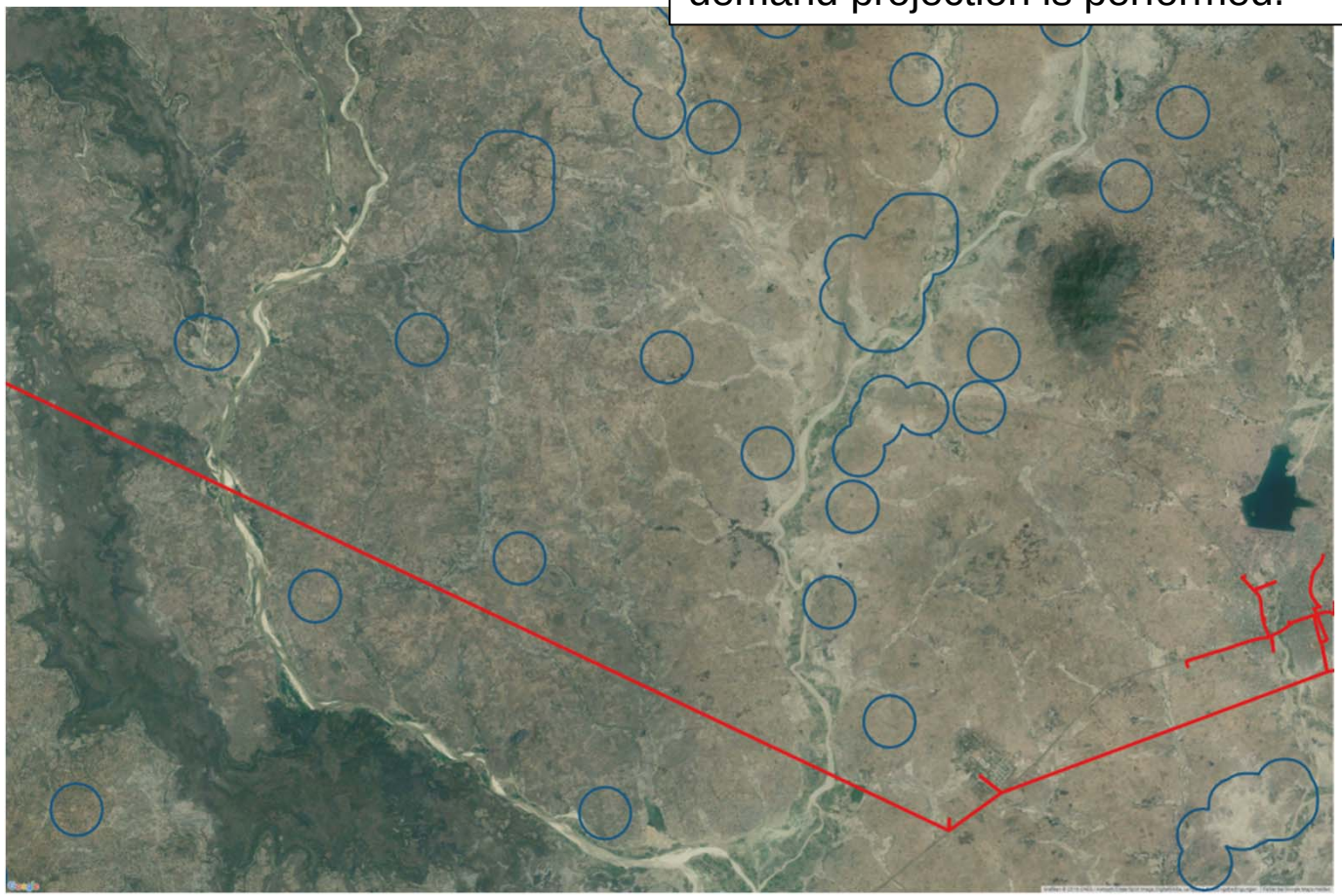
For each non-electrified cluster an individual demand projection is performed.



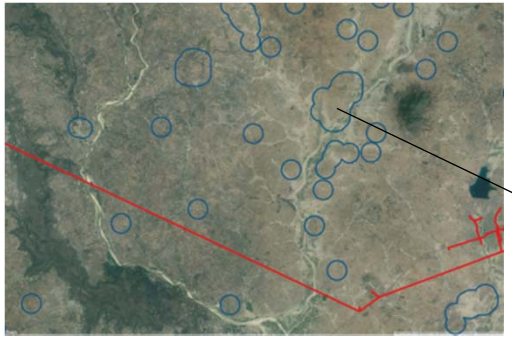
Results
Clusters non-electrified:
1,808; 99 %
People living in non-electrified clusters:
2.4 mill.; 66 %

Step 3: Demand analysis - Zoom

For each non-electrified cluster an individual demand projection is performed.

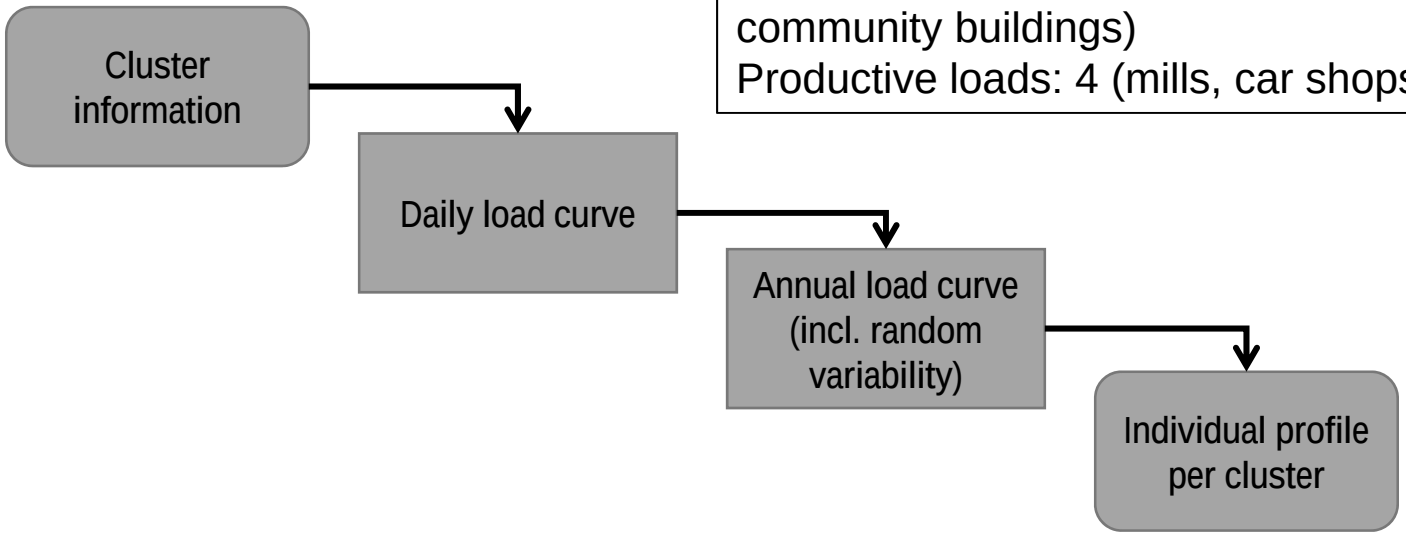


Step 3: Demand analysis - Input

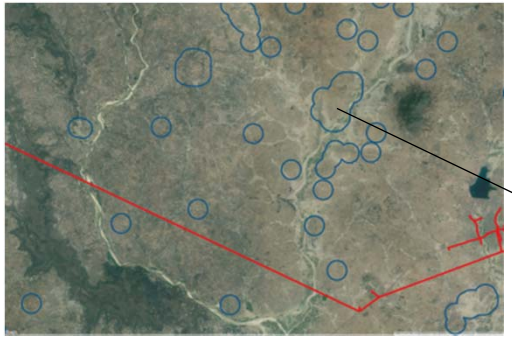


For each non-electrified cluster an individual demand projection is performed.
Socio-economic and infrastructural data are collected and processed.

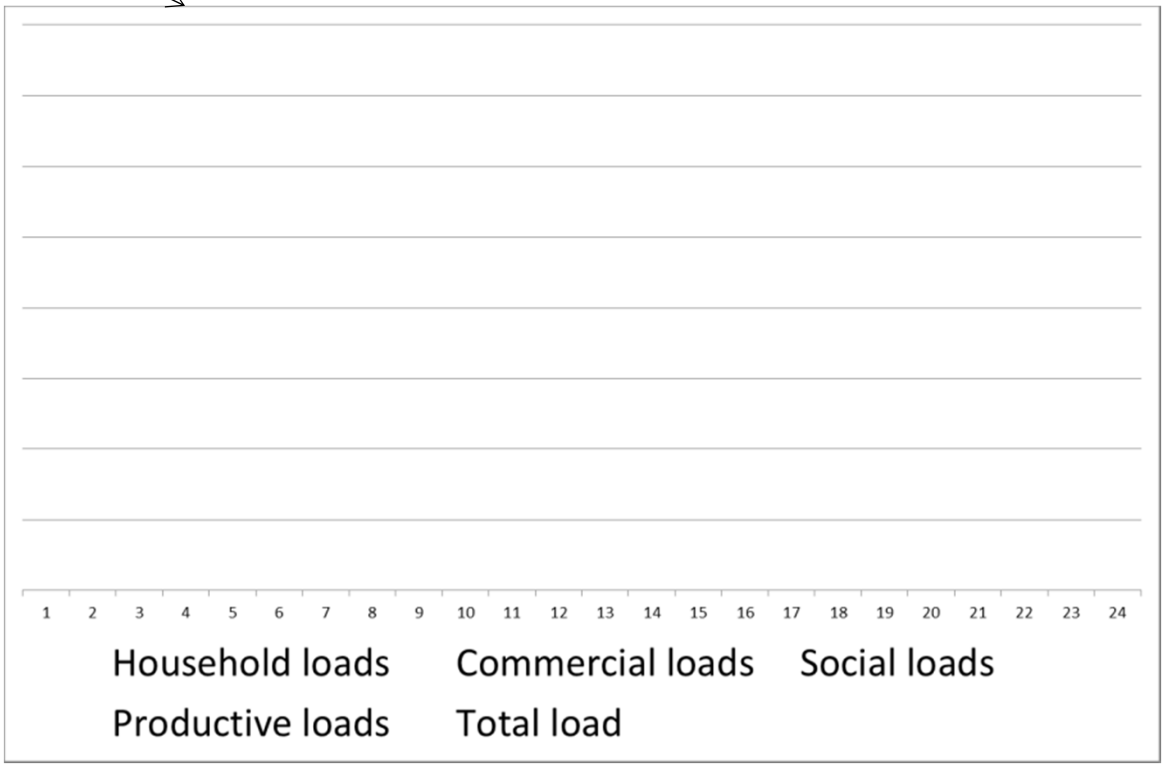
Results – Example village
Population: appr. 1,600 (equals 320 households)
Commercial consumers: 20 (small shops and enterprises)
Social loads: 5 (schools, health station and community buildings)
Productive loads: 4 (mills, car shops and welders)



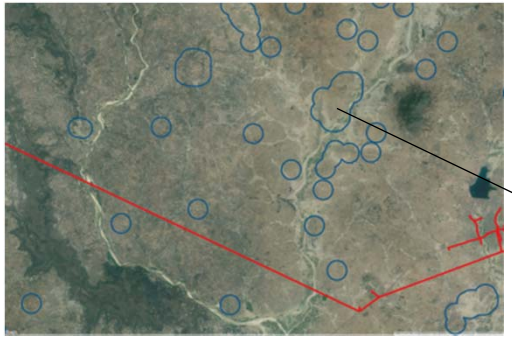
Step 3: Demand analysis



Socio-economic and infrastructural data feed into automatized load projection model.



Step 3: Demand analysis – Household loads



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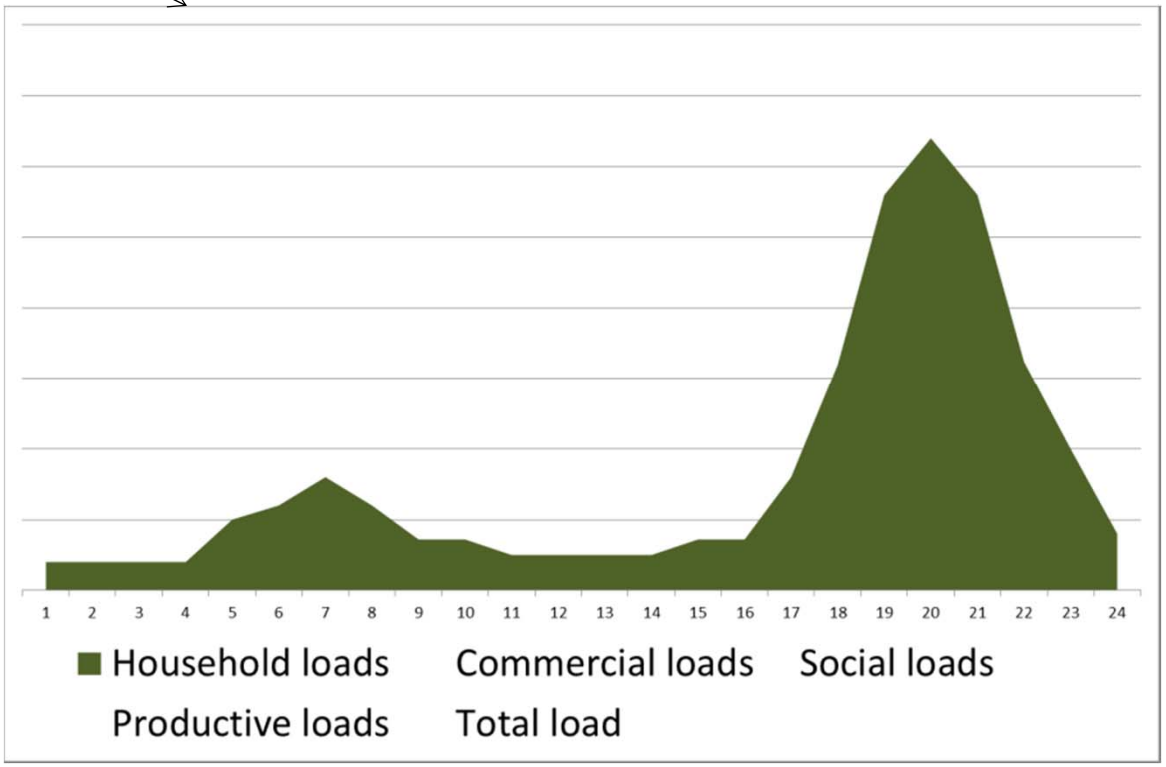
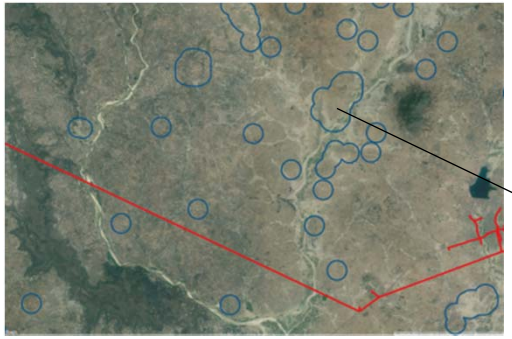


Assumptions

- High evening peak
- Mixture of different household types

Step 3: Demand analysis – Commercial loads



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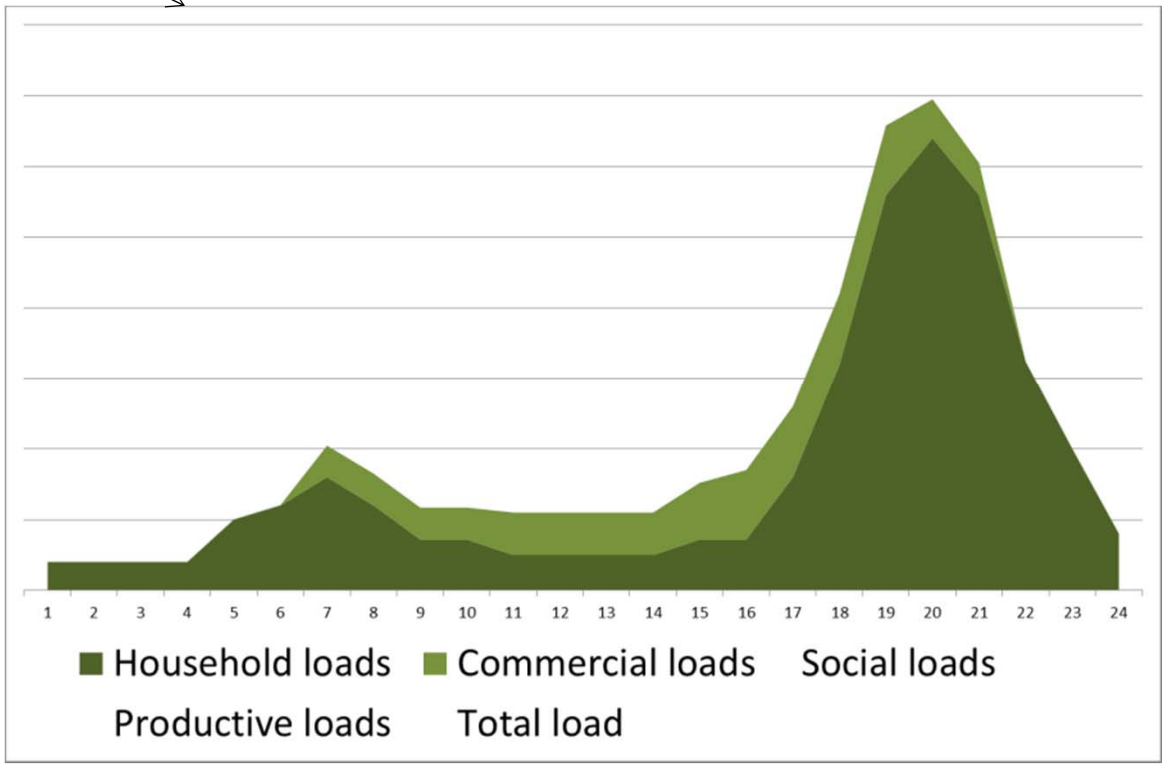
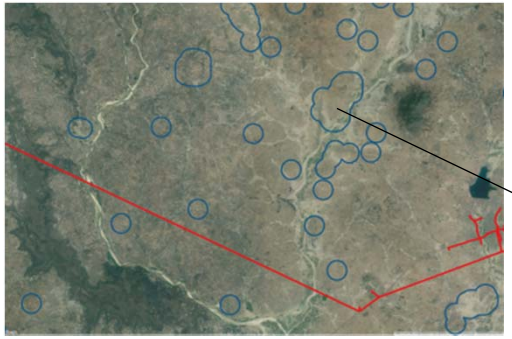


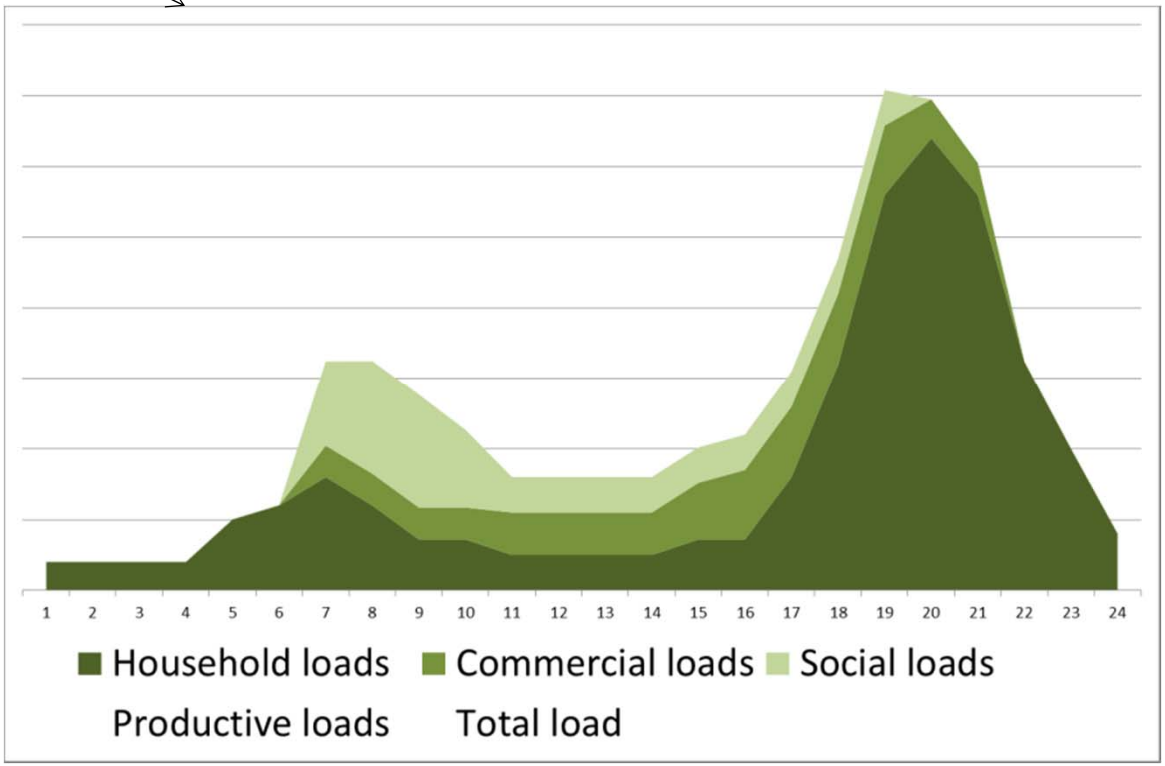
Assumptions

- Small shops and enterprises
- Main load during daytime and evening

Step 3: Demand analysis – Social loads



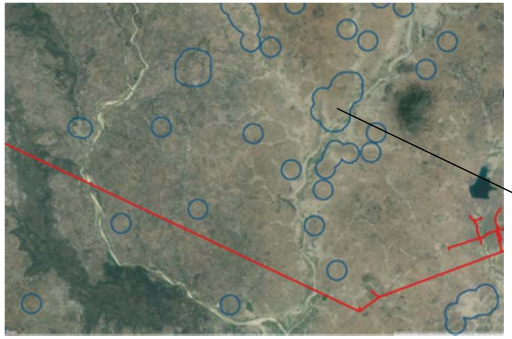
Socio-economic and infrastructural data feed into automatized load projection model.



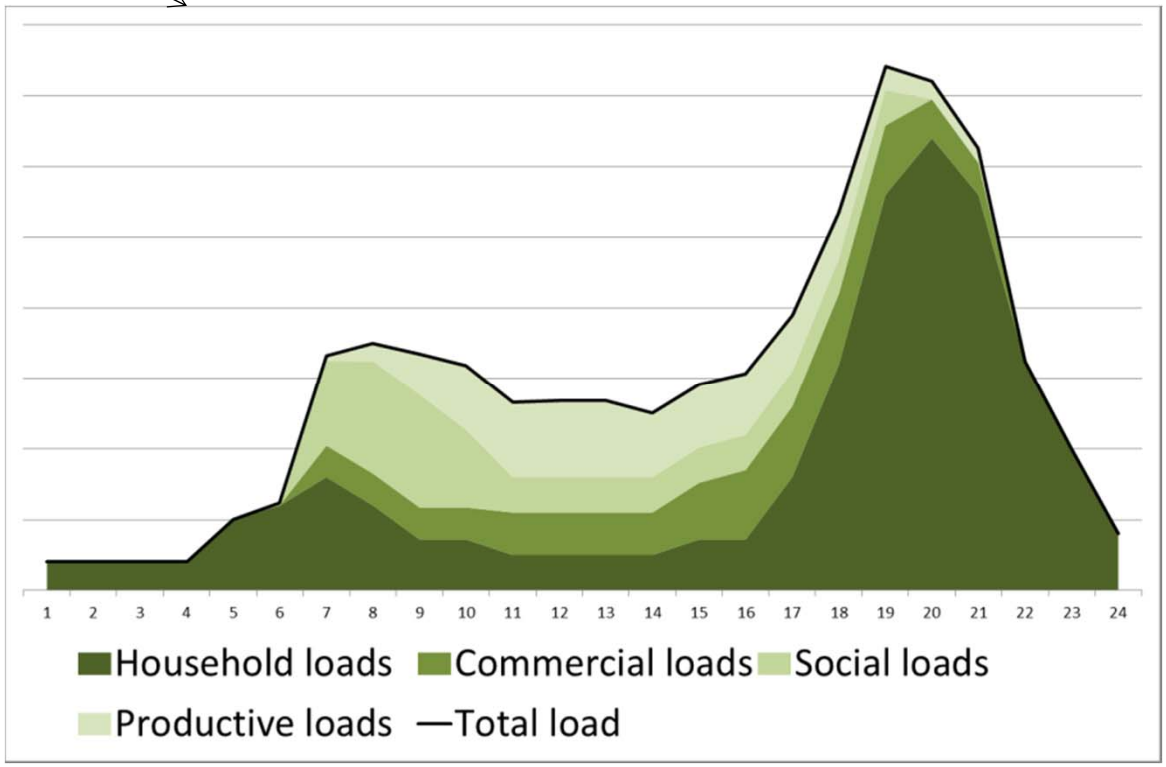
Assumptions

- Schools, health station and community buildings
- Main load before noon and during the day

Step 3: Demand analysis – Productive loads



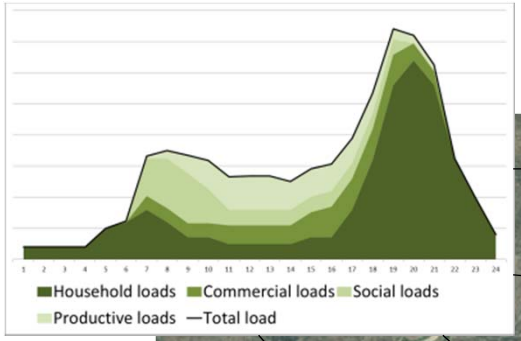
Socio-economic and infrastructural data feed into automatized load projection model.



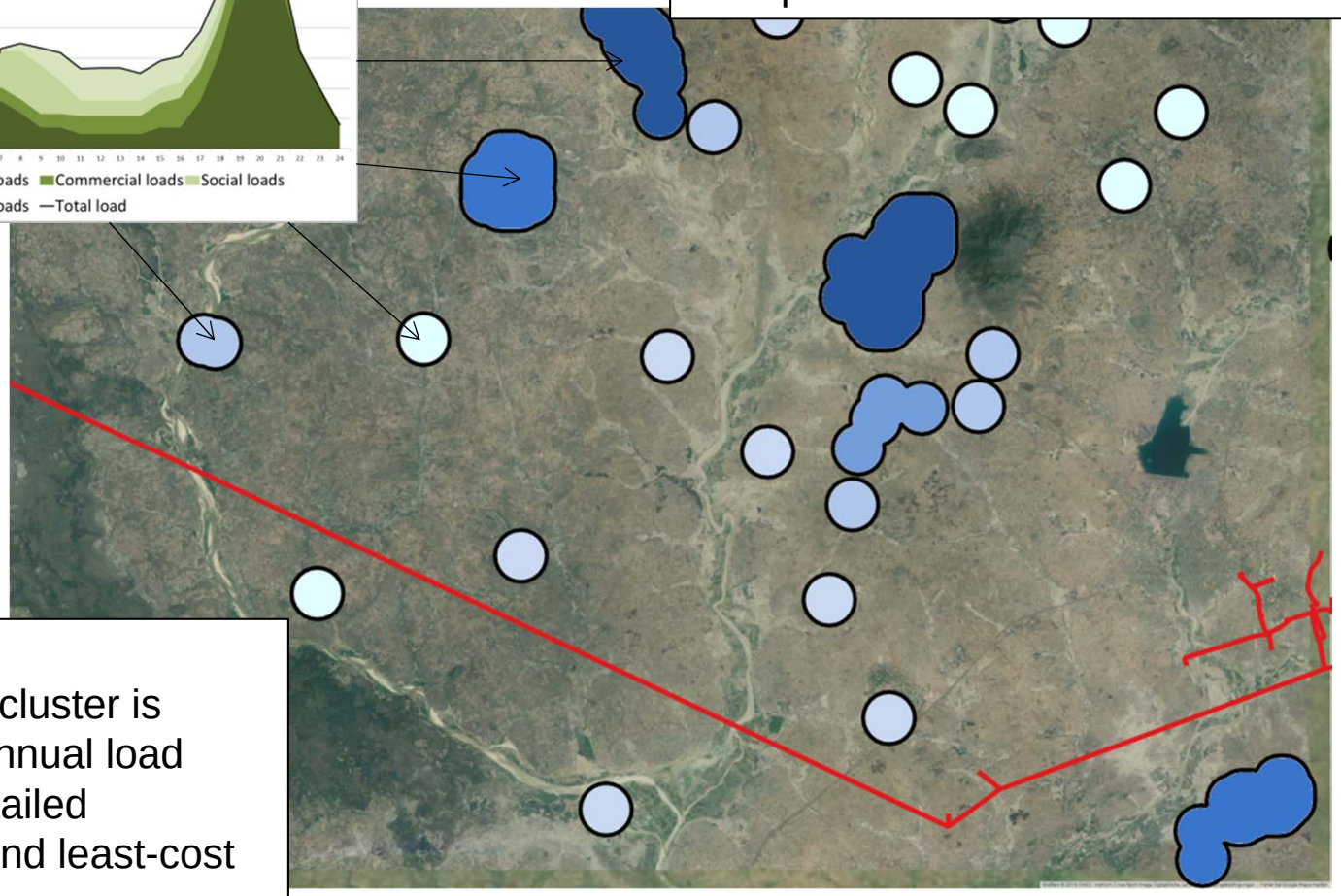
Assumptions

- Mills, car shops and welders
- Main load during the day

Step 3: Demand analysis – Dynamic extrapolation



Load analysis routine is fed back into GIS for extrapolation of results.



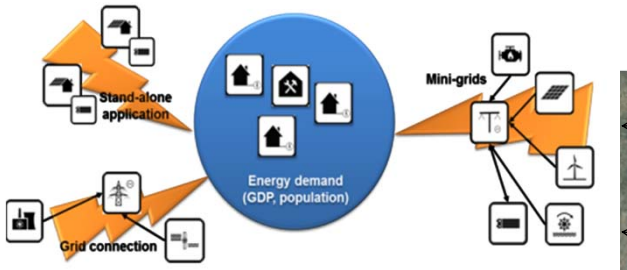
Demand

high

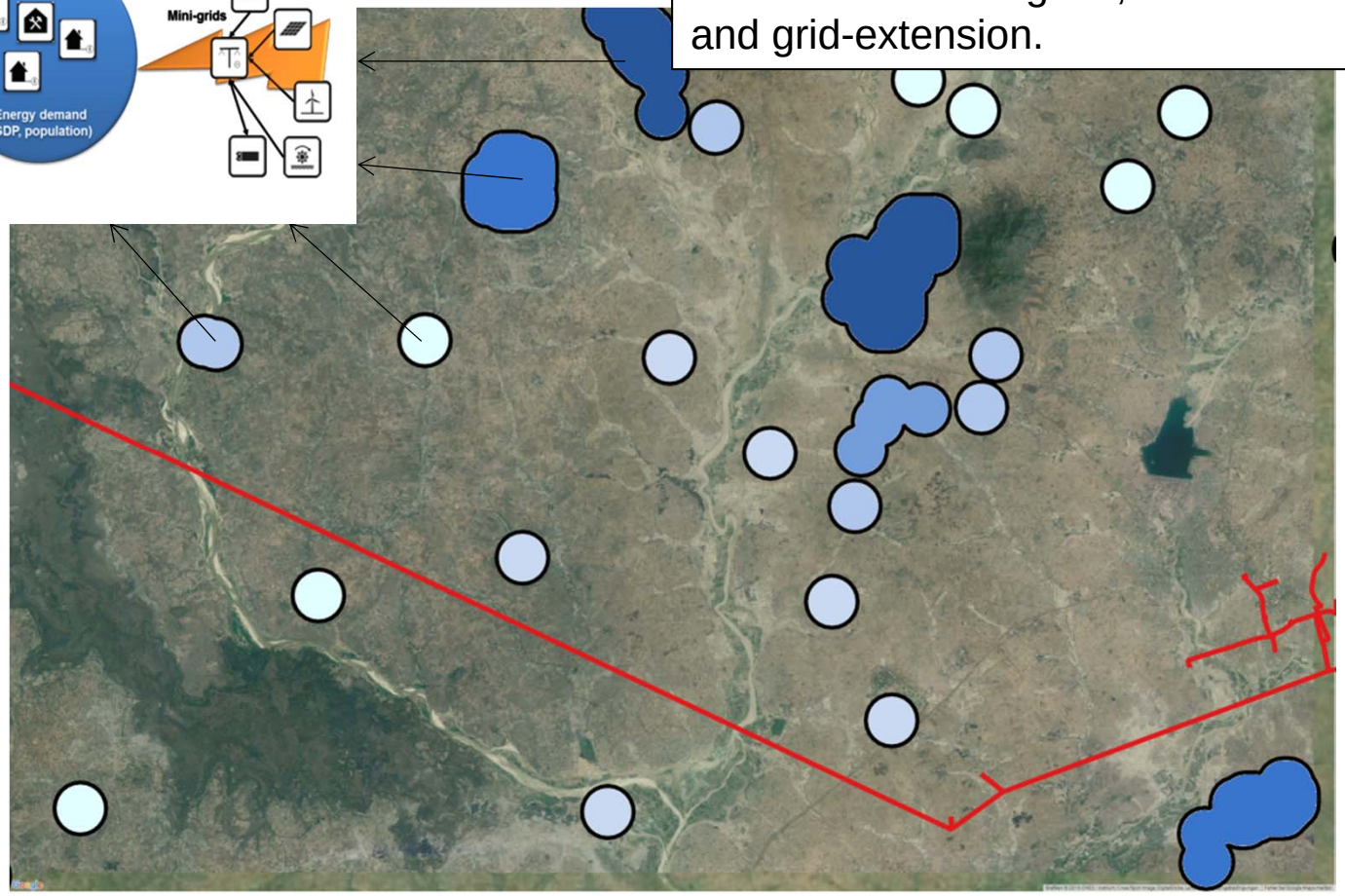
low

Results
Demand per cluster is calculated. Annual load profile for detailed simulations and least-cost analysis.

Step 4: Least-cost analysis – Input data: load



Load demand is fed into least-cost model for simulation of mini-grids, stand-alone systems and grid-extension.

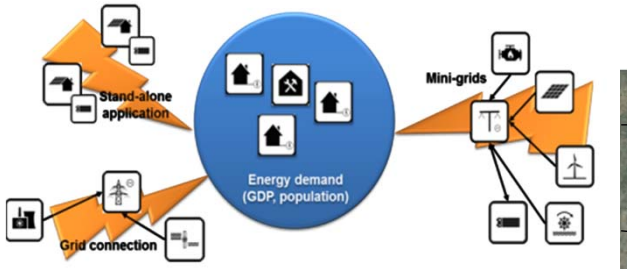


Demand

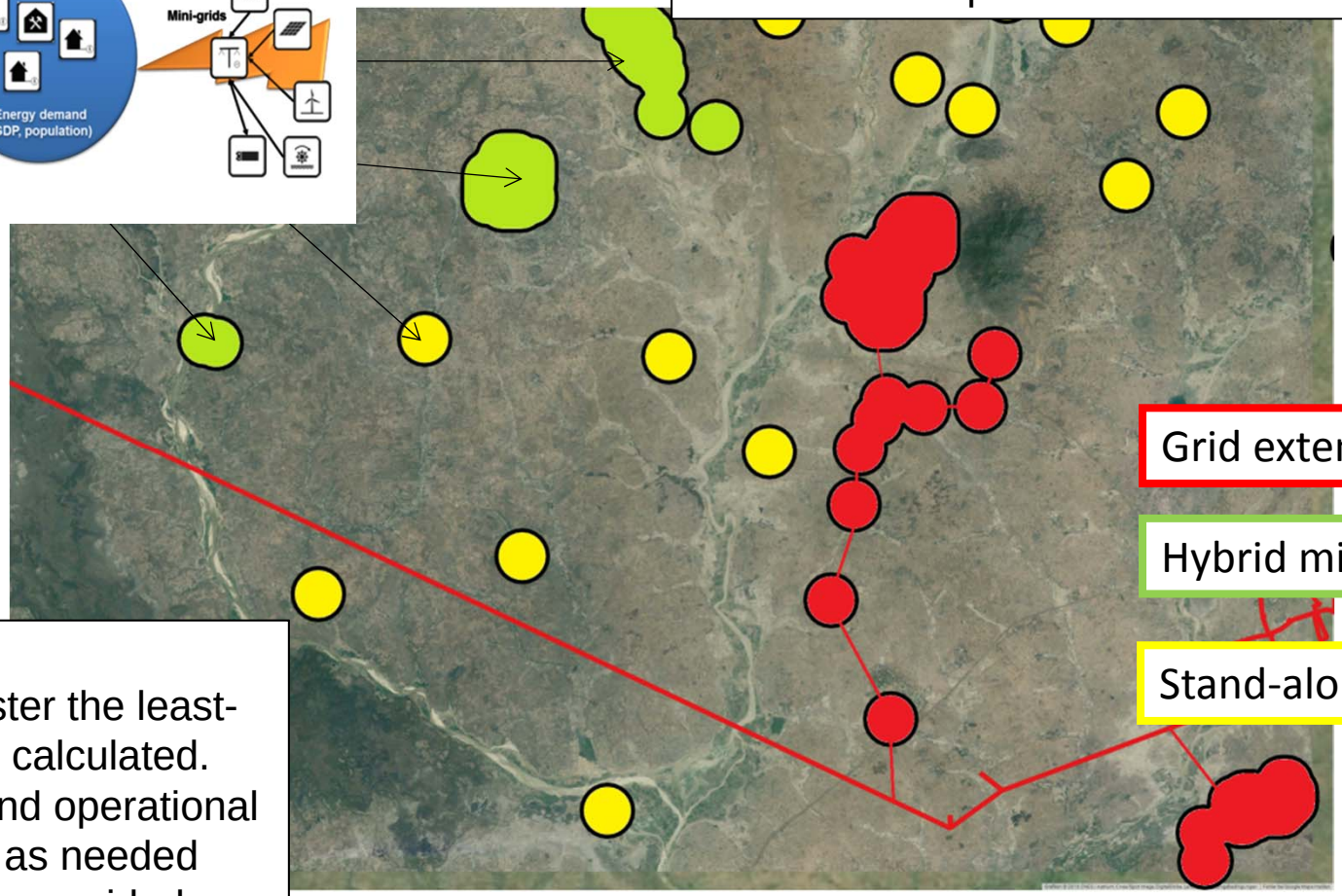
high

low

Step 4: Investment plan



Results for each cluster show least-cost electrification option.



Grid extension

Hybrid mini-grids

Stand-alone

Results
For each cluster the least-cost option is calculated. Investment and operational costs as well as needed capacities are provided.

Conclusion

- Comprehensive electrification modelling is needed to accelerate global access to energy.
- Many different tools exist with strenghts and weaknesses.
- RLI provides an approach based on GIS and energy system modelling.
- Tools are needed to underline the value of decentralized solutions compared to grid extension.
- Tools are needed to properly simulate hybrid mini-grids and show the value of storage options (cf. rural load curve).

Thank you for your attention!

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