Planning Energy Access from Space:

Geospatial Modelling for Grid Expansion (Papua New Guinea)

A case study with ADB under ESA's GDA Clean Energy Programme

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ABD Knowledge Sharing Series: Infrastructure Planning from Space
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Agenda

1. **Setting the Scene**
2. **How Our Approach Works**
3. **From Planning to Action:** The Workflow
4. **Live Demo:** The Platform in Action
5. **Spotlight:** Island Electrification Planning in Micronesia
6. **Your Questions**

Setting the Scene: PNGs Electricity Sector

Electrification rate today: < 20 %

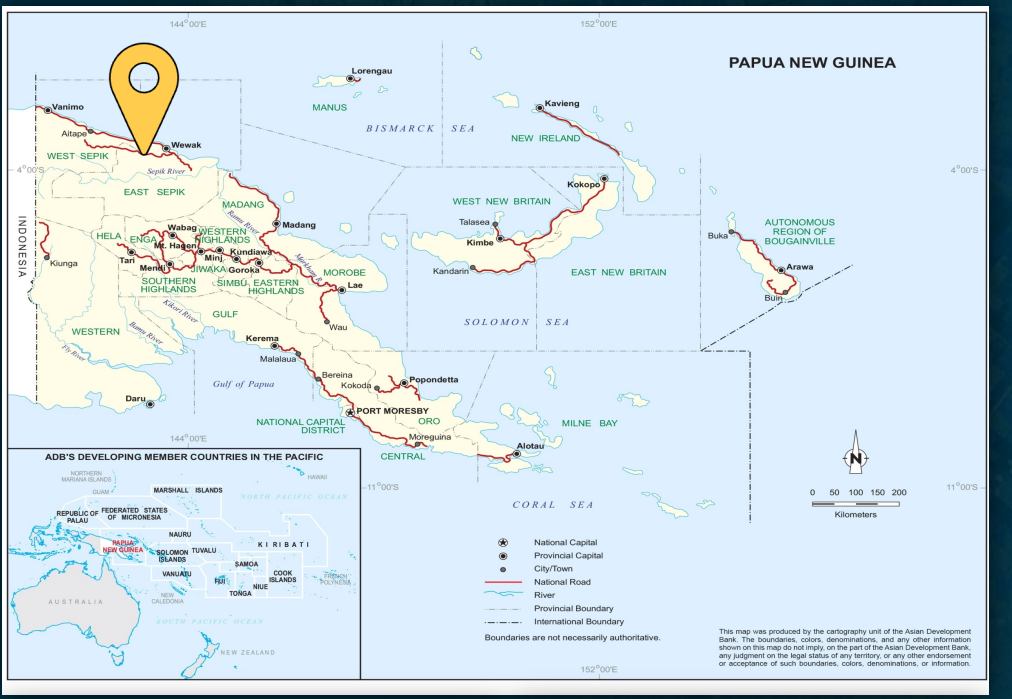
- 900 MW of installed generation capacity: hydropower (42 %), diesel (41 %), gas fired (12 %), geothermal (5 %)
- Across three main grids and many smaller grids

Electrification targets:

- Increase electricity access to 70% by 2030, and 100% by 2050
- 100 % renewable energy by 2050

Challenges:

- Provincial centers are entirely powered through expensive and polluting diesel generation
- Difficult to reach rural population with grid extension due to mountainous terrain and geographical dispersion



Setting the Scene: Wewak's Grid Access

- **Wewak:** Provincial capital of East Sepik, around 30,000 inhabitants
- **Powered by isolated mini-grid:**
  - Operated by PNG Power Ltd. - PPL
  - Current peak load: ~3.1 MW
  - Fully reliant on diesel (20,000 l/day)
  - Aging network (built 1960s) with high losses and low reliability
- ADB & European Union are preparing support to the Government and PPL on rehabilitating and upgrading infrastructure incl. solar & battery system
- Potential to connect many peri-urban and rural areas
  → Connection to this case study

Wewak Town, Provincial capital of East Sepik

Wewak Diesel Power Station and Powerhouse

Setting the Scene: Case Study Overview

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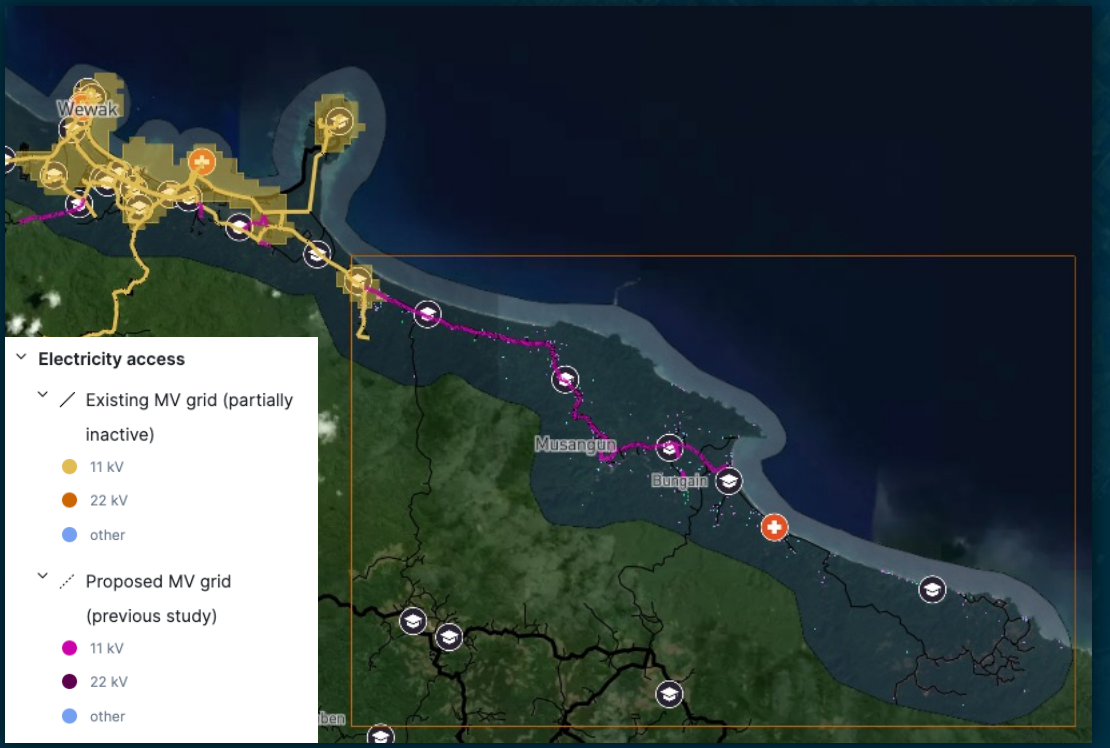
Building & road detection → Other data collection → Settlement & section delineation → Extraction of settlement information → Energy demand estimation → Techno-economic modelling → Interactive map platform

- **Objective:** Assessment of grid extension feasibility towards the south-east of Wewak along the coast
- **Method:** Techno-economic modelling in combination with geospatial analysis, incl. usage of satellite imagery
  → Potential combination with additional analysis,
  e.g. on climate vulnerability / natural hazards
- **Outcome:**
  - Detailed mapping of potential extension area
  - Extension feasibility, required investment, impact
  - Interactive map-based online platform

→ Data-driven financial & technical planning, lower survey costs, stakeholder alignment, scalable & transferable



Workflow: Building & Road Detection from Satellite Imagery

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Building & road detection → Other data collection → Settlement & section delineation → Extraction of settlement information → Energy demand estimation → Techno-economic modelling → Interactive map platform

- **Background:** Information on number and location of buildings and roads are essential for extension analysis
  → open data is incomplete, free images are outdated
- **Objective:** Complete and up-to-date inventory of buildings and roads without on-ground surveys
- **Method:** Satellite imagery analysis
  → Nov 2024; 50 cm resolution; funded by ESA
  → Combination of Machine Learning & manual drawing
- **Result:** 2,822 buildings (open OSM data: 1,530) & 24 km additional roads

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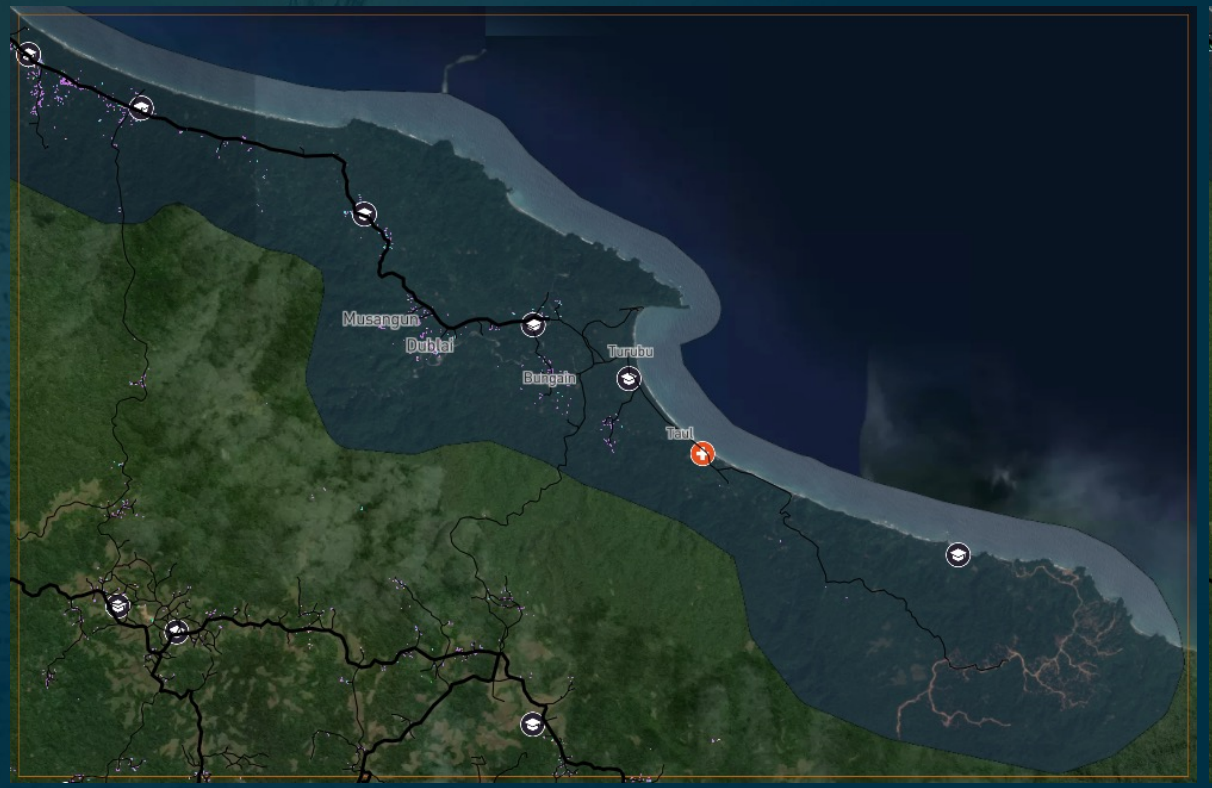

Open data (OSM)

New data (based on satellite imagery)

Workflow: Other Data Collection

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Building & road detection → **Other data collection** → Settlement & section delineation → Extraction of settlement information → Energy demand estimation → Techno-economic modelling → Interactive map platform

Additional relevant spatial data:

- **Education & healthcare facilities** (OpenStreetMap)

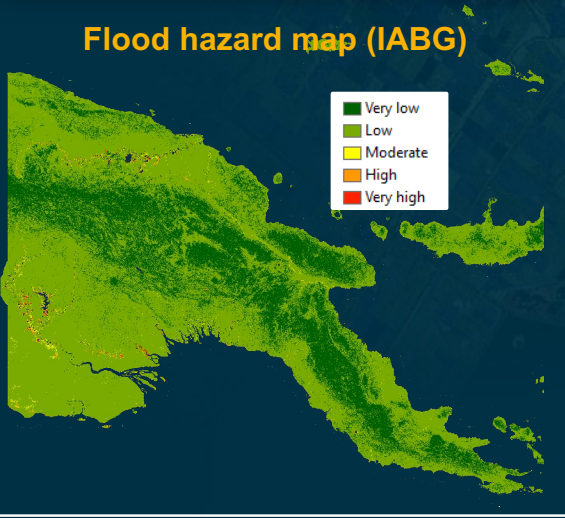
  → 5 primary schools, 1 community health post
- **Nightlight areas** as electrification indicator

  (VIDA's *GridLight* algorithm using NASA nighttime imagery, 2024)
- Armed conflicts (ACLED) & regional agriculture (MapSPAM)
- **Resources & landscape:** Flood risk, rivers & lakes, land use, elevation,

  PV potential, other points of interest
- Potential for further complementation with e.g. natural hazards & climate data

Nightlight 2024 (VIDA)

Flood hazard map (IABG)



Workflow: Settlement & Section Delineation

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Building & road detection → Other data collection → **Settlement & section delineation** → Extraction of settlement information → Energy demand estimation → Techno-economic modelling → Interactive map platform

Settlement delineation:

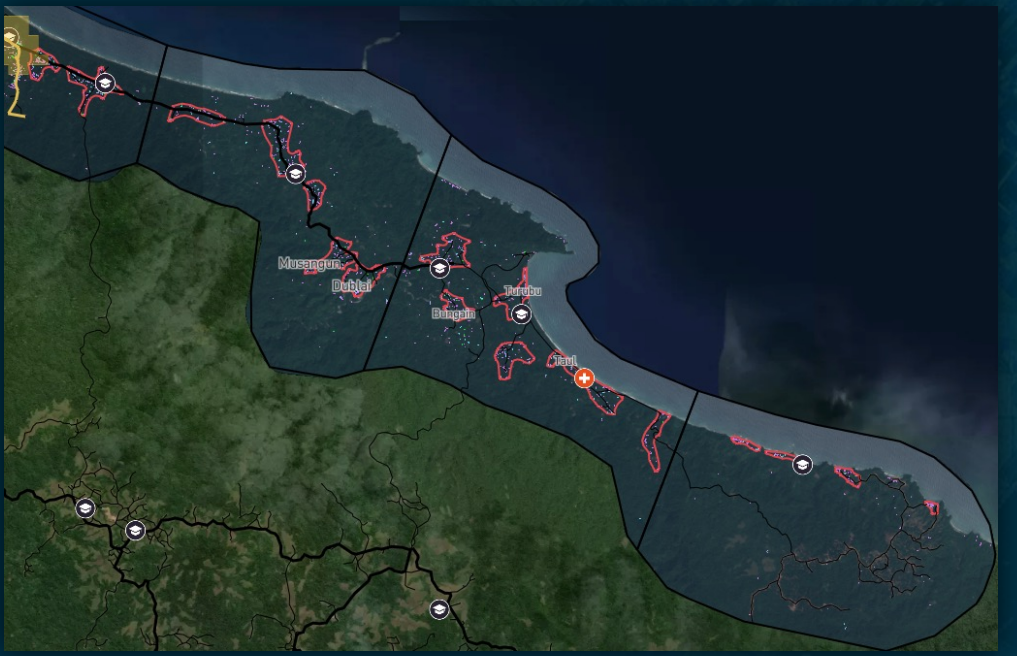
- **Objective:** Identify settlement boundaries to consider for potential grid extension
- **Method:** Building density-based clustering algorithm & manual refinements

→ 17 settlements with 45 to 247 buildings

Section delineation:

- **Objective:** Identify sections along potential grid extension line to provide aggregated analysis
- **Method:** Manual drawing based on settlement proximity

→ 4 sections



Settlements (red) & sections (black)

Workflow: Extraction of Settlement Information

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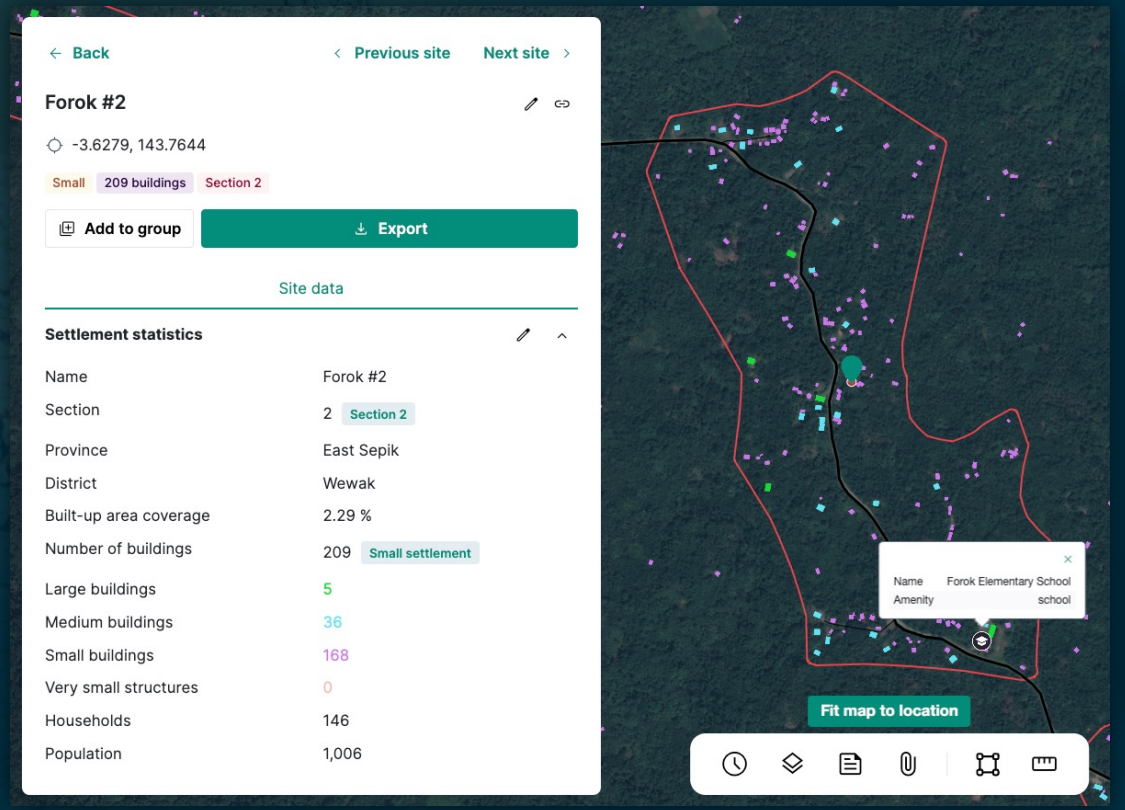
Building & road detection → Other data collection → Settlement & section delineation → **Extraction of settlement information** → Energy demand estimation → Techno-economic modelling → Interactive map platform

Extraction of settlement characteristics by “overlaying” collected map layers



Infrastructure

Healthcare facilities	0
Education facilities	1
Main road access?	Yes
Distance to the main road	0 km

Energy access

Shows light at night?	No
Nightlight coverage	0 % Small
Distance to nightlight	5.3 km
Distance to existing MV lines	5.6 km Medium distance to existing MV line
Distance to proposed MV lines	0 km Close to proposed MV line
Potential PV production	1,421 kWh/kWp

Agriculture indicators (district)

Top five dominant crops	temperate fruit, yams, other roots, cocoa, rest of crops
Total agricultural area	322 ha
Total crop value	687,515 $/year
Total crop yield	114,700 kg/ha
Total crop value per hectare	2,133 $/ha

Armed conflicts (2022-2024)

Fatalities within 25 km (battles:riots:violence against civilians:explosions)	3;0;6;0
Fatalities within 50 km (battles:riots:violence against civilians:explosions)	3;0;15;0
Total number of incidents within 50 km	17
Security risk	high

Workflow: Energy Demand Estimation

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Building & road detection → Other data collection → Settlement & section delineation → Extraction of settlement information → **Energy demand estimation** → Techno-economic modelling → Interactive map platform

Settlement-level energy demand estimation:

→ based on national data & additional assumptions

- **Household consumption**
  - Small & medium buildings: 750 Wh/day
  - Large buildings: 1,000 Wh/day
- **Education facilities** (primary schools): 3.4 kWh/day
- **Healthcare facilities** (health post): 7.9 kWh/day
- **No additional demand** from e.g. businesses, mobile towers, productive uses due to lack of information / lower relevance in rural context
  → Could be customized in the future
- **Potential additional demand** from nearby buildings outside of settlement

Grid extension - Network planning	
Estimated number of connections	174
Energy demand: Households	131.8 kWh/day
Energy demand: Health facilities	0 kWh/day
Energy demand: Schools	3.4 kWh/day
Energy demand: Total	135.2 kWh/day
Length of basic LV network	6.1 km
Length of MV connection	0.956 km

Workflow: Techno-Economic Modelling

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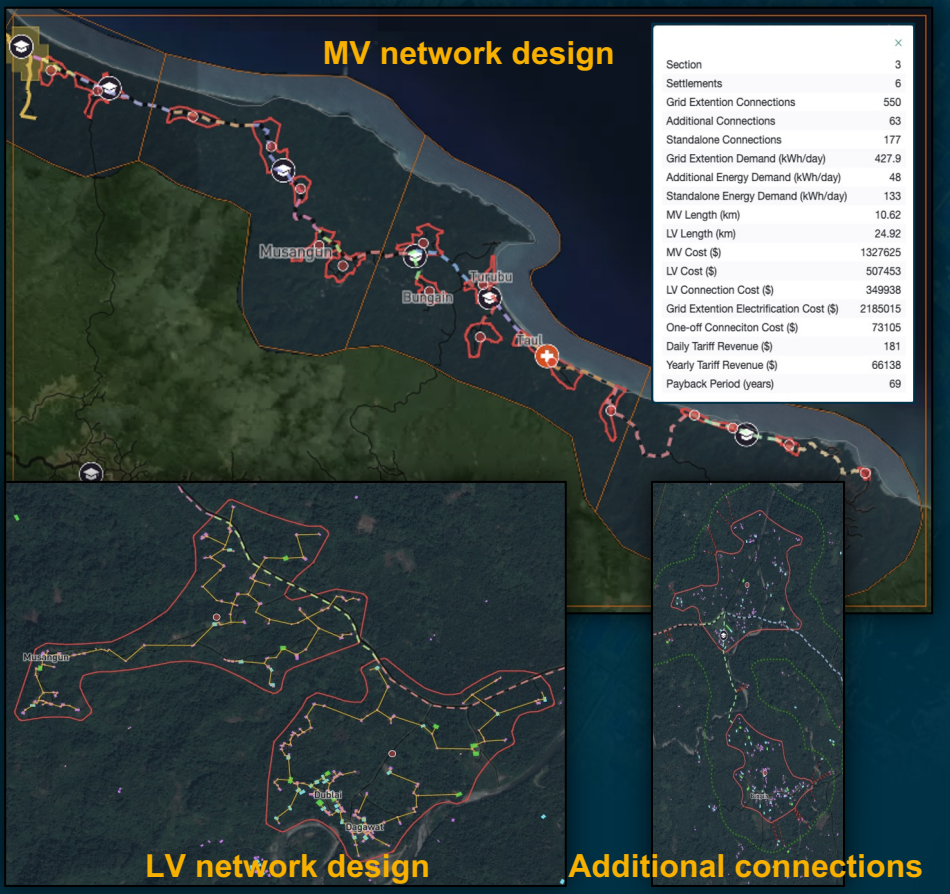
Building & road detection → Other data collection → Settlement & section delineation → Extraction of settlement information → Energy demand estimation → **Techno-economic modelling** → Interactive map platform

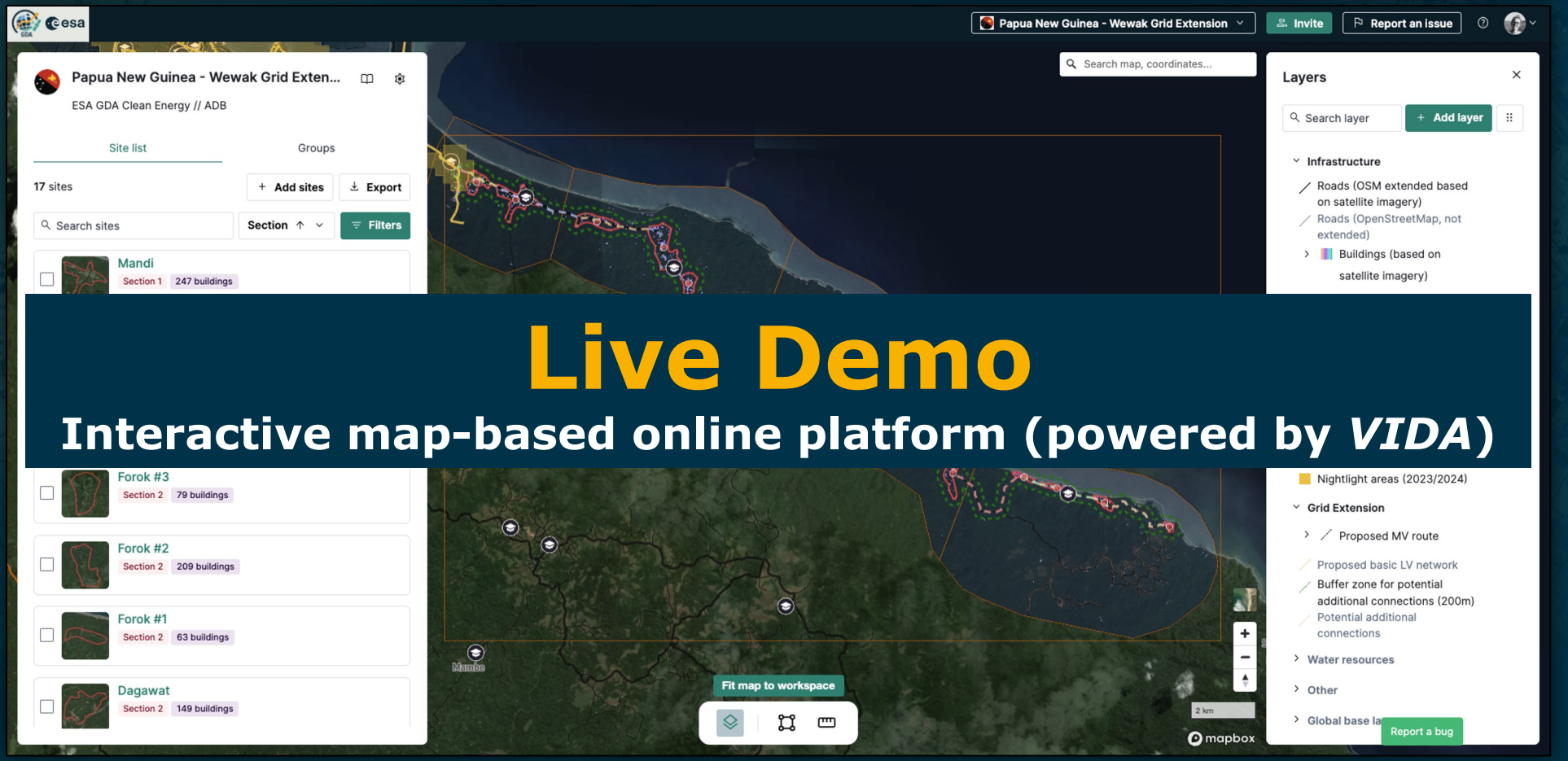
Objective: Evaluate the techno-economic viability of grid extension at both a settlement and section level, and required investment.

- **Geospatial Network Design:**
  - **Medium Voltage:** Along main roads connecting settlements
  - **Low Voltage:** Connecting each building
- **Cost Estimation:** Based on network, connections, local assumptions
- **Revenue estimation:** Derived from customer base, projected electricity demand, and national electricity tariffs.
- **Cost-Benefit Analysis:** Compare estimated costs and projected revenue to derive payback period and potential subsidy amounts.
- **Additional & standalone connections:** Identify potential additional customers and remote households to connect with standalone systems.



Workflow: Platform Live Demo

Building & road detection → Other data collection → Settlement & section delineation → Extraction of settlement information → Energy demand estimation → Techno-economic modelling → **Interactive map platform**



Live Demo

Interactive map-based online platform (powered by *VIDA*)

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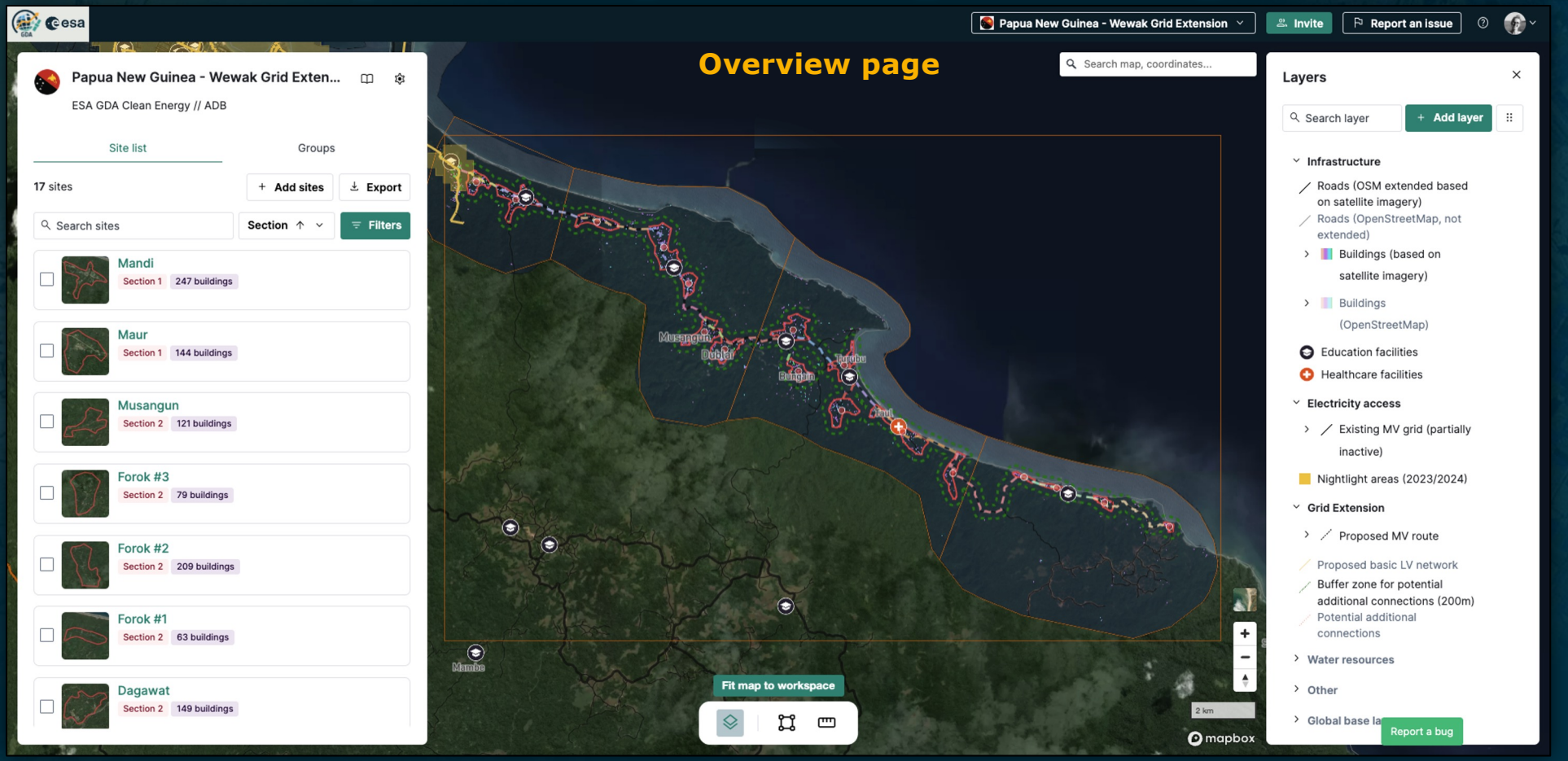

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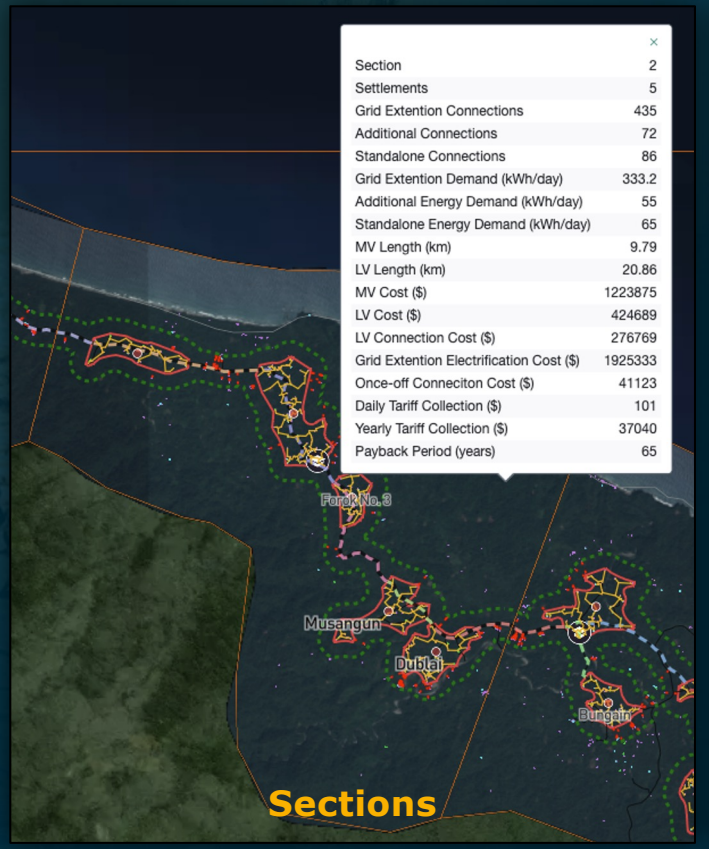
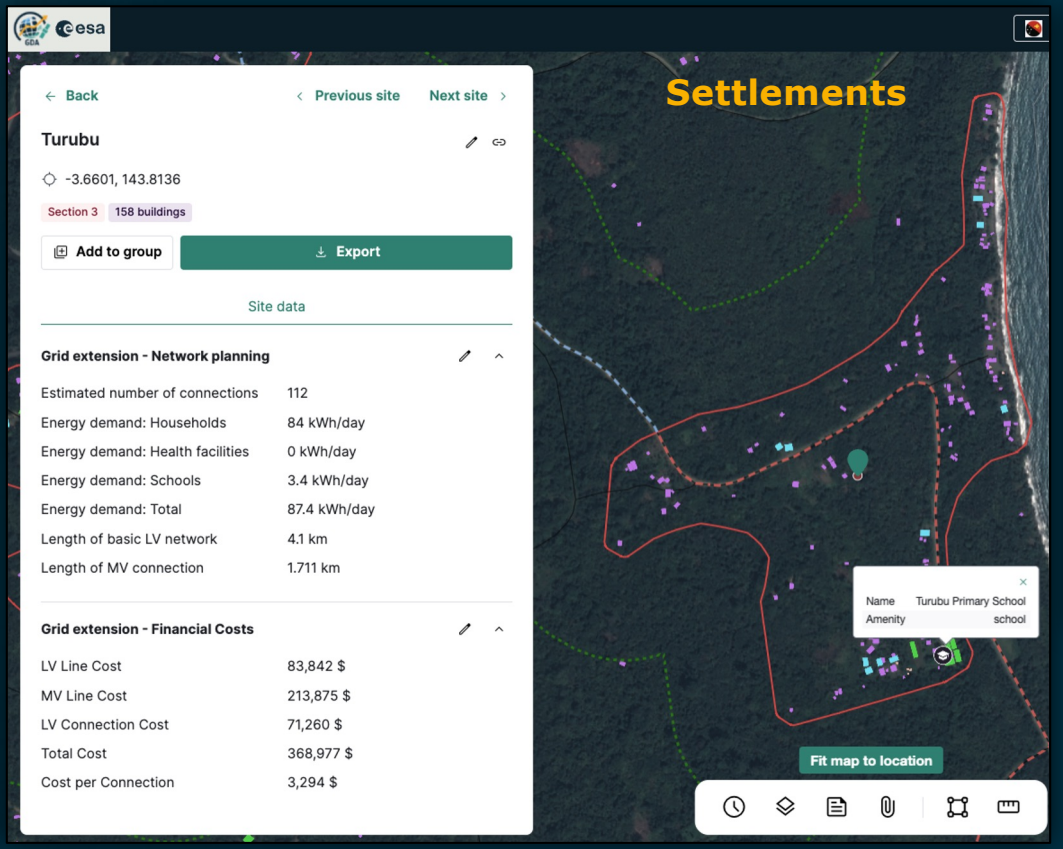
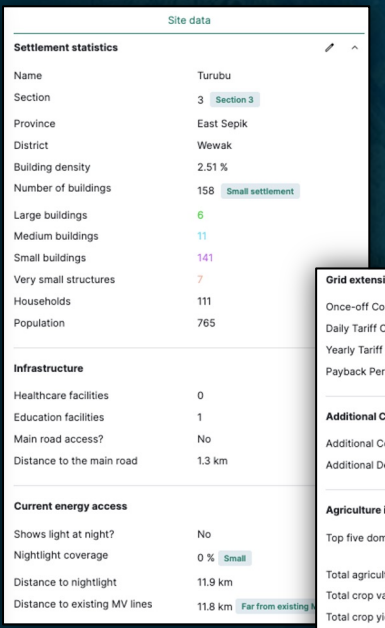
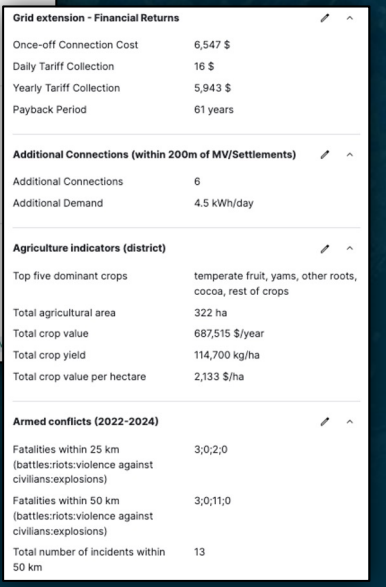




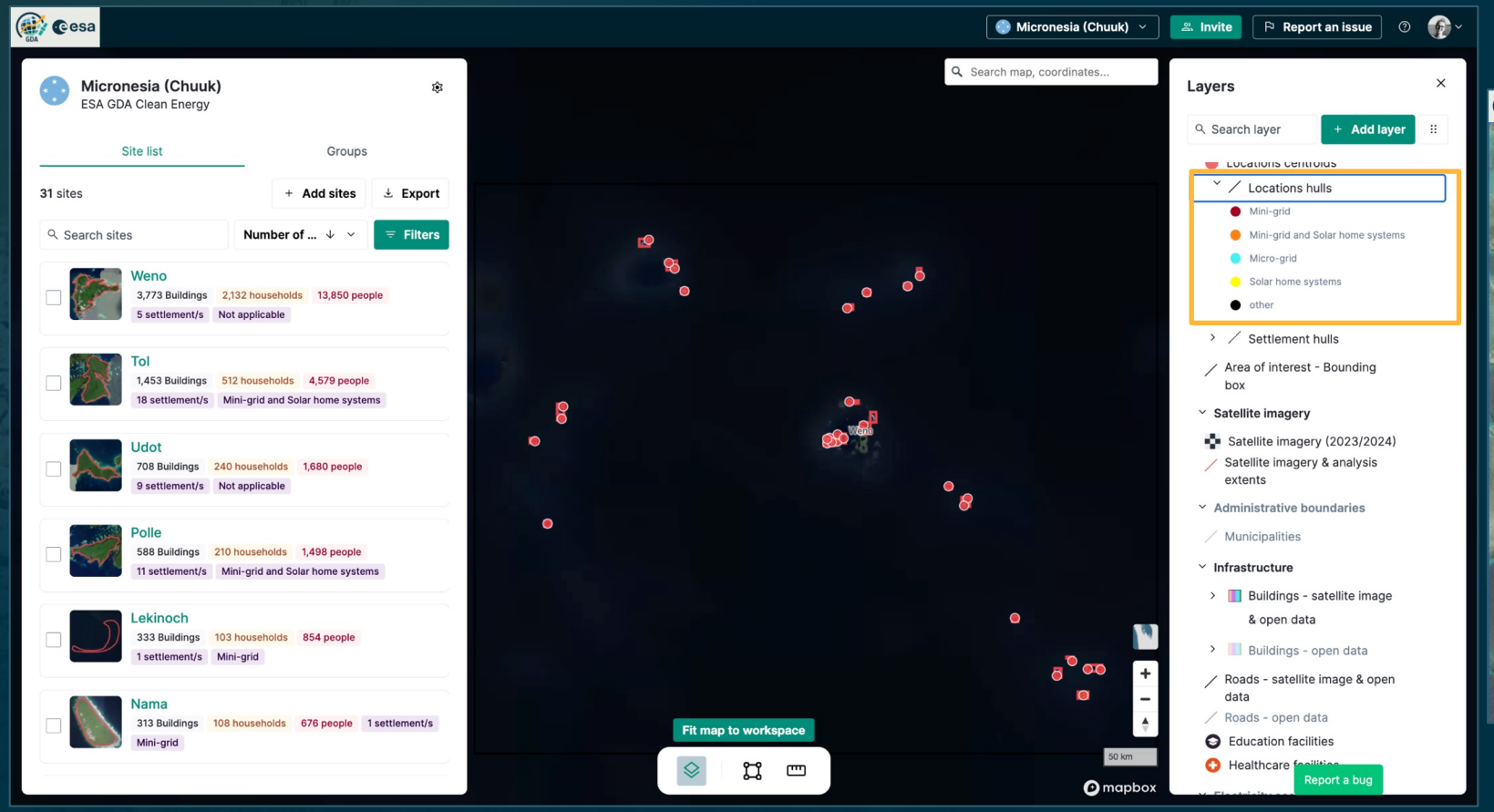


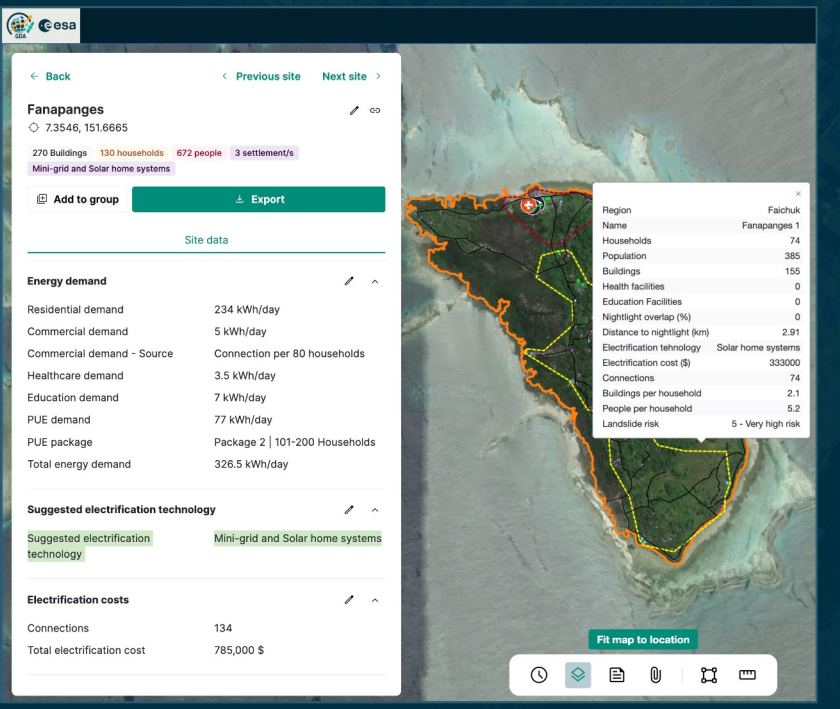


Spotlight: Island Electrification Planning in Micronesia

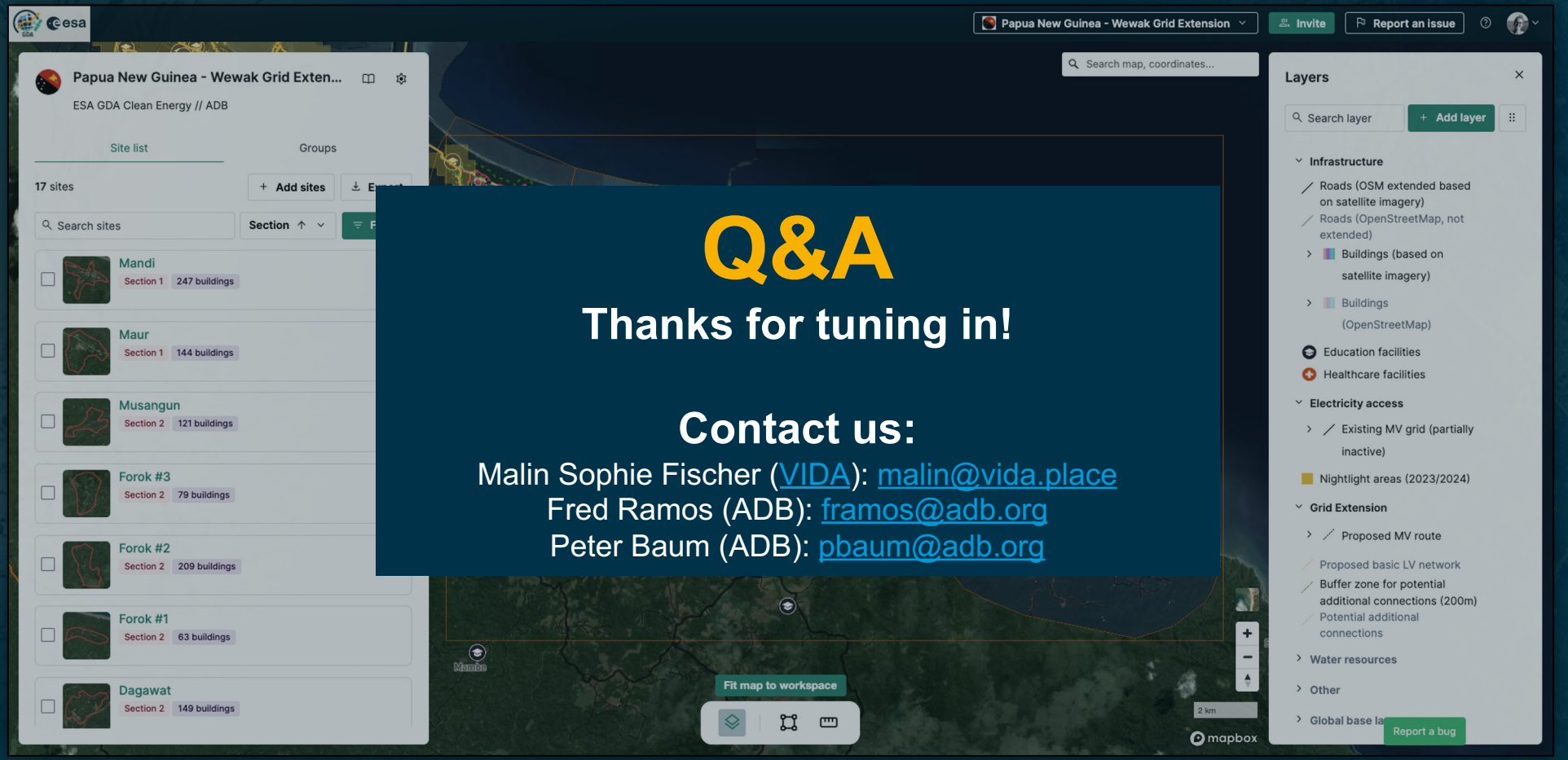
Similar approach, different application: Least-cost Electrification Planning for Islands across Micronesia

→ Mapping population, identifying optimal electrification technologies, estimate required investment → save survey expenses





Your questions!



Q&A

Thanks for tuning in!

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