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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



Malin Sophie Fischer ([VIDA](#))
Fred Ramos (ADB)

ABD Knowledge Sharing Series: **Infrastructure Planning from Space**
July 22, 2025

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 %

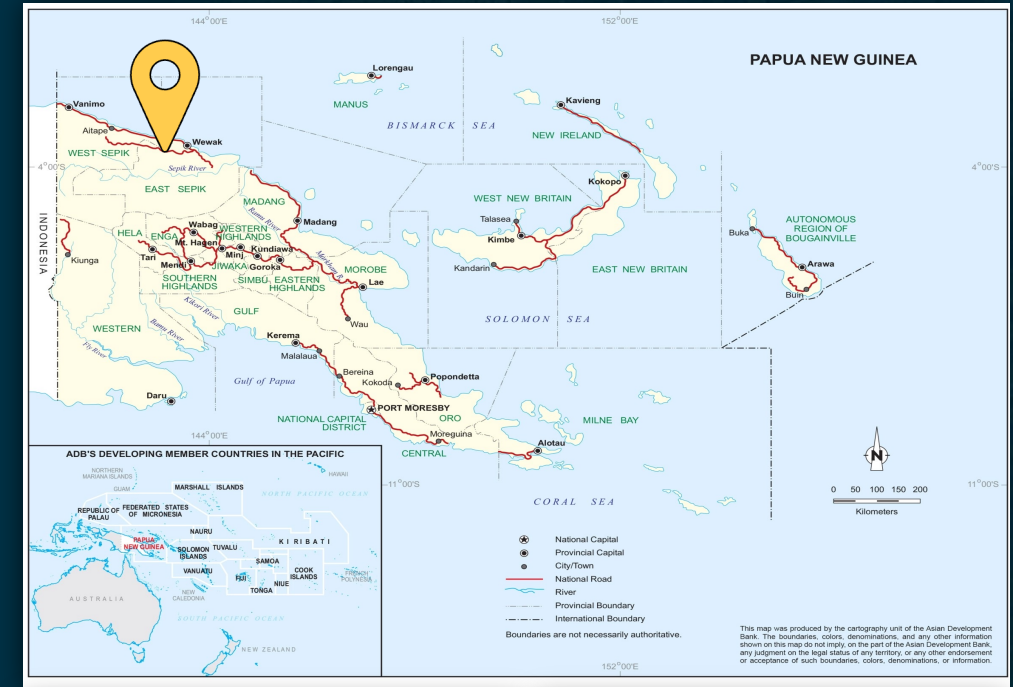
- 900 MW of installed generation capacity:
hydropower (42 %), diesel (41 %), gas fired (12 %), geothermal (5 %)
- Across three main grids and many smaller grids

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



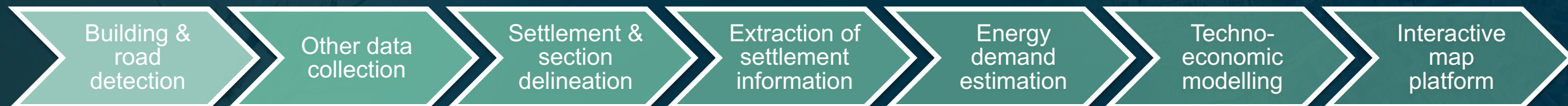
Setting the Scene: Wewak's Grid Access



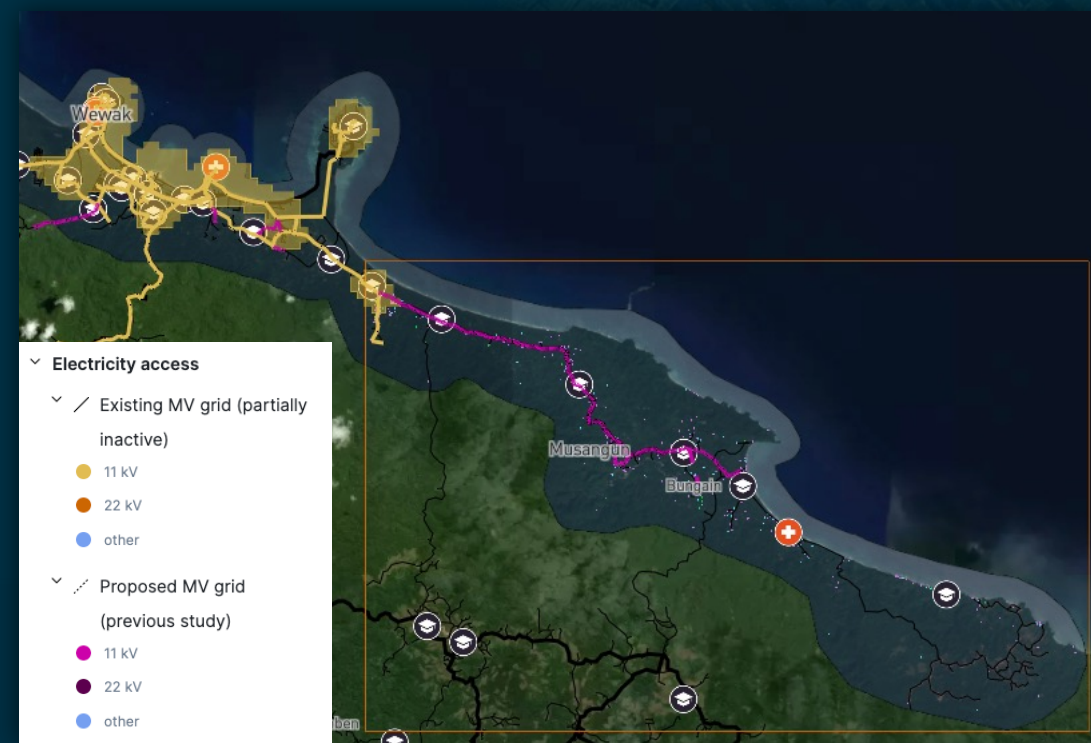
- **Wewak:** Provincial capital of East Sepik, around 30,000 inhabitants
- **Powered by isolated mini-grid:**
 - Operated by PNG Power Ltd. - PPL
 - Current peak load: ~3.1 MW
 - Fully reliant on diesel (20,000 l/day)
 - Aging network (built 1960s) with high losses and low reliability
- ADB & European 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



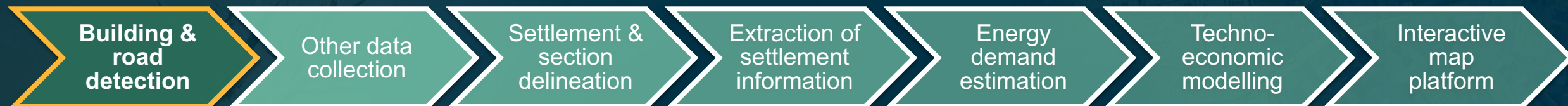
Setting the Scene: Case Study Overview



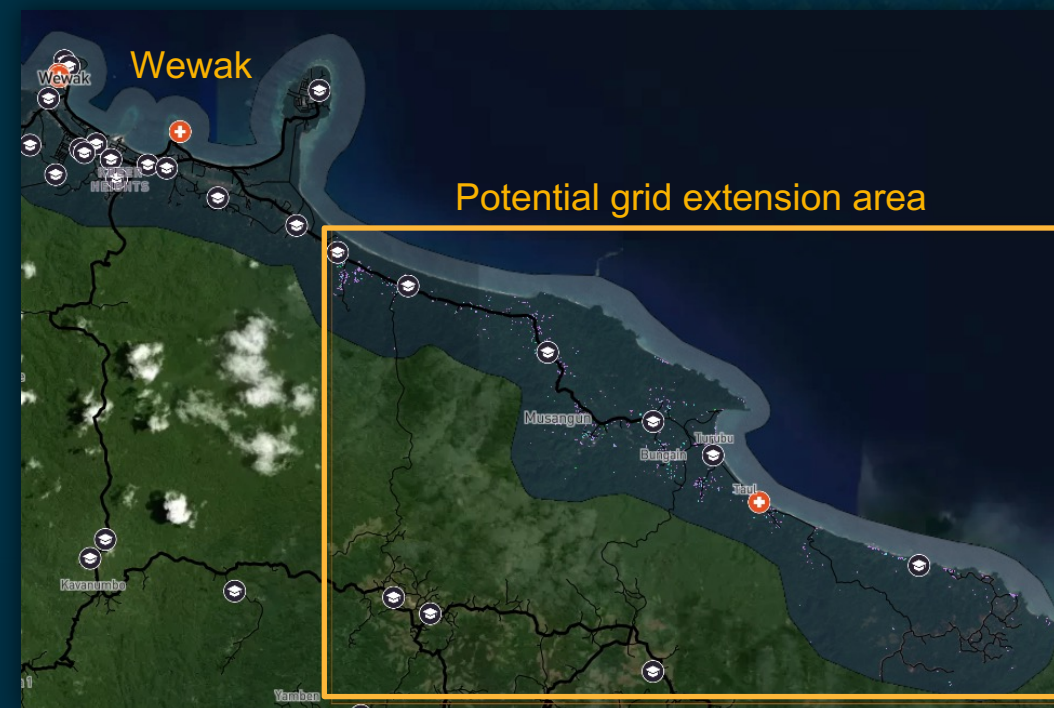
- **Objective:** Assessment of grid extension feasibility towards the south-east of Wewak along the coast
 - **Method:** Techno-economic modelling in combination with geospatial analysis, incl. usage of satellite imagery
→ Potential combination with additional analysis, e.g. on climate vulnerability / 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



- **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



Workflow: Building & Road Detection from Satellite Imagery



Building &
road
detection

Other data
collection

Settlement &
section
delineation

Extraction of
settlement
information

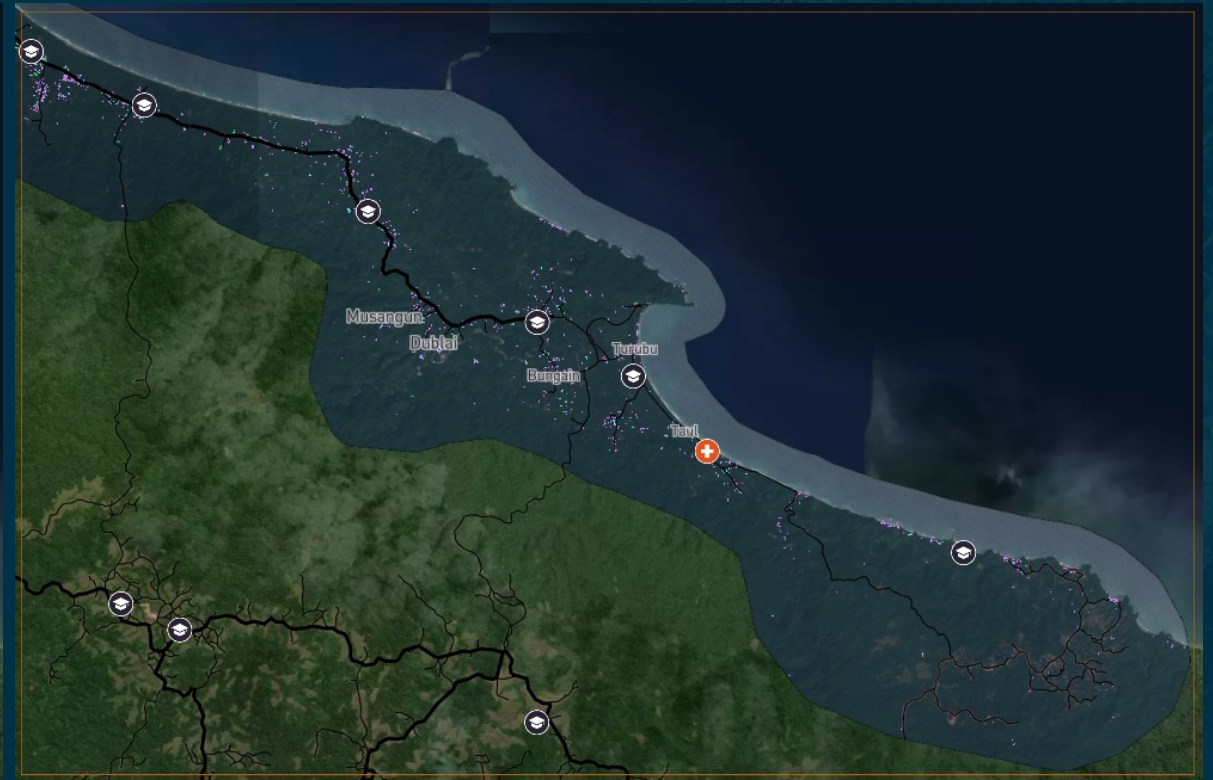
Energy
demand
estimation

Techno-
economic
modelling

Interactive
map
platform

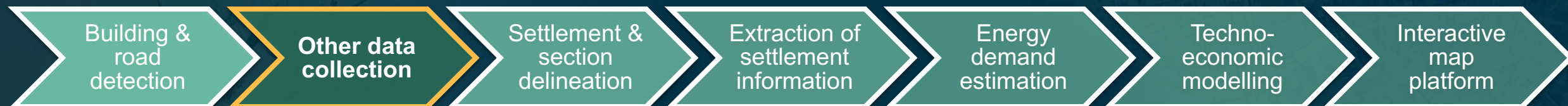


Open data (OSM)



New data (based on satellite imagery)

Workflow: Other Data Collection



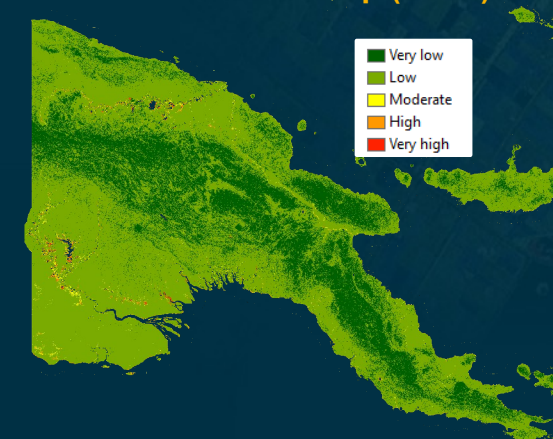
Additional relevant spatial data:

- **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

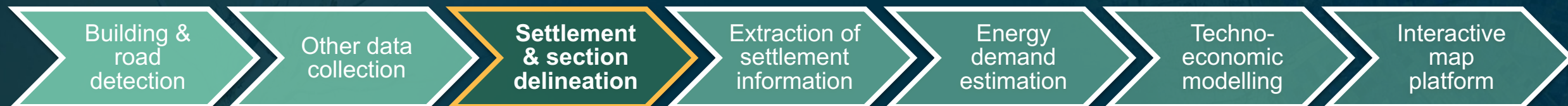
Nightlight 2024 (VIDA)



Flood hazard map (IABG)



Workflow: Settlement & Section Delineation



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



Extraction of settlement characteristics by “overlying” collected map layers

← Back

< Previous site

Next site >

Forok #2

○ -3.6279, 143.7644

Small 209 buildings Section 2

Add to group

Export

Site data

Settlement statistics

Name

Forok #2

Section

2 Section 2

Province

East Sepik

District

Wewak

Built-up area coverage

2.29 %

Number of buildings

209 Small settlement

Large buildings

5

Medium buildings

36

Small buildings

168

Very small structures

0

Households

146

Population

1,006

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

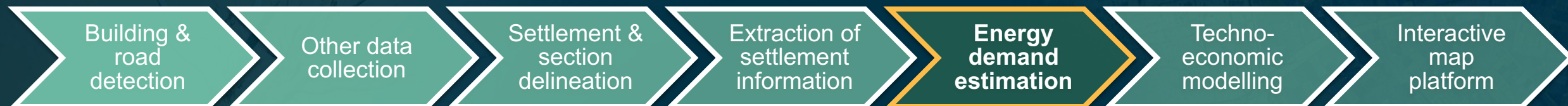
Total number of incidents within 50 km

17

Security risk

high

Workflow: Energy Demand Estimation



Settlement-level energy demand estimation:

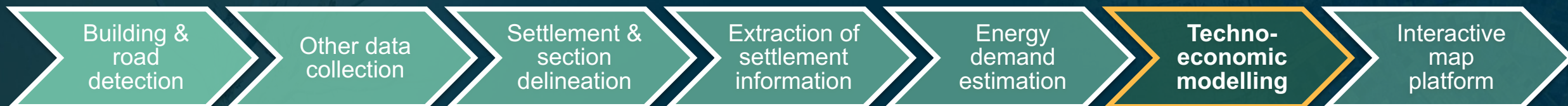
→ based on national data & additional assumptions

- **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

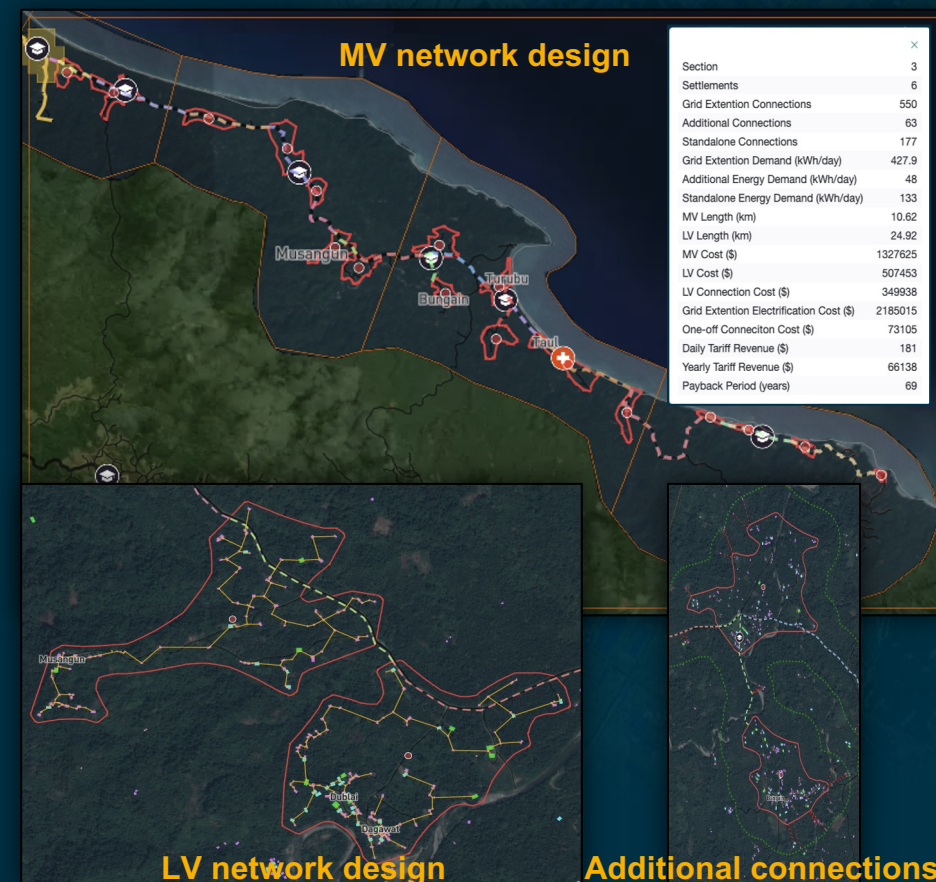
Estimated number of connections	174
Energy demand: Households	131.8 kWh/day
Energy demand: Health facilities	0 kWh/day
Energy demand: Schools	3.4 kWh/day
Energy demand: Total	135.2 kWh/day
Length of basic LV network	6.1 km
Length of MV connection	0.956 km

Workflow: Techno-Economic Modelling



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



Papua New Guinea - Wewak Grid Extension

ESA GDA Clean Energy // ADB

Site list

17 sites

Search sites

Section 1 247 buildings

Section 2 79 buildings

Section 2 209 buildings

Section 2 63 buildings

Section 2 149 buildings

Forok #3

Forok #2

Forok #1

Dagawat

Fit map to workspace

Search map, coordinates...

Layers

- Infrastructure
 - Roads (OSM extended based on satellite imagery)
 - Roads (OpenStreetMap, not extended)
 - Buildings (based on satellite imagery)
- Nightlight areas (2023/2024)
- Grid Extension
 - Proposed MV route
 - Proposed basic LV network
 - Buffer zone for potential additional connections (200m)
 - Potential additional connections
 - Water resources
 - Other
 - Global base la

Report a bug

Live Demo

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

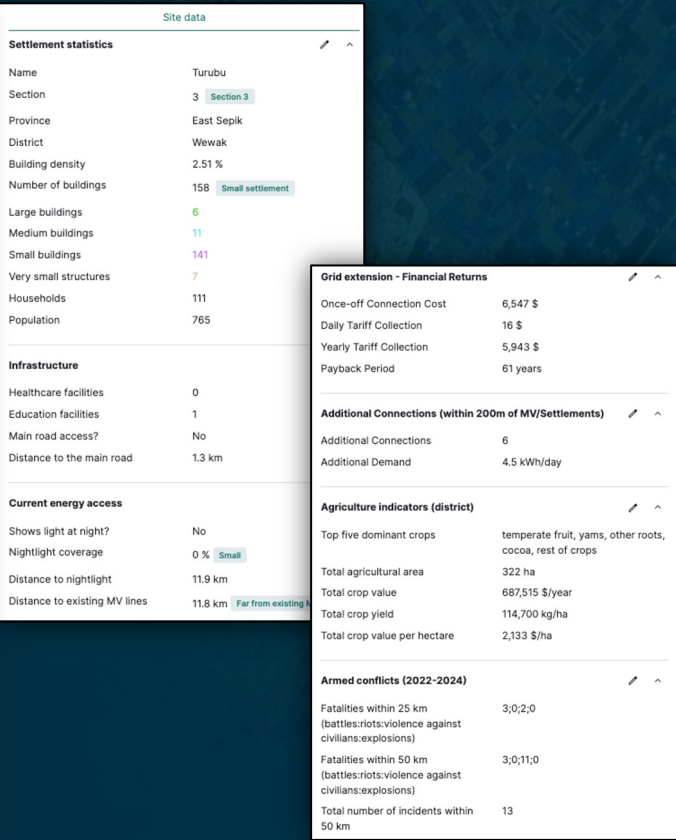
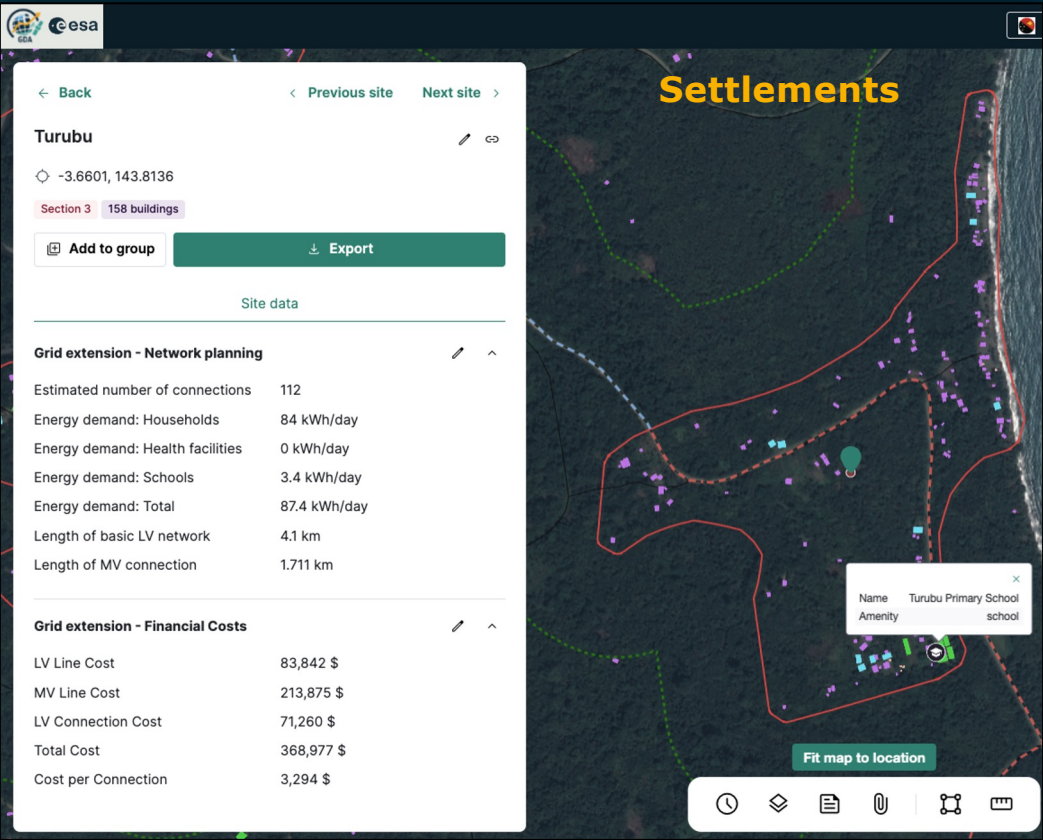
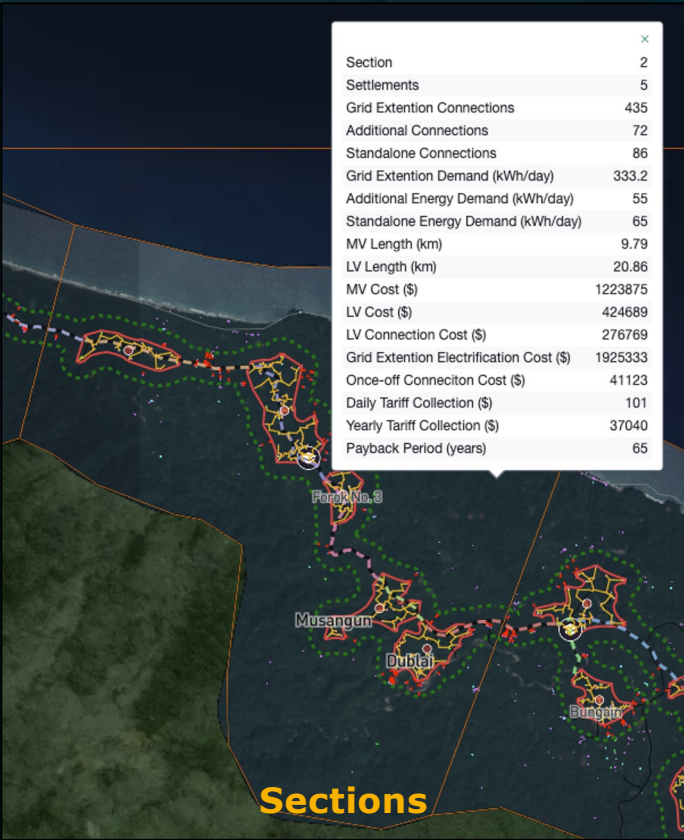


Workflow: Platform Live Demo



The screenshot shows the 'Overview page' of the platform. On the left is a 'Site list' for 'Papua New Guinea - Wewak Grid Extension'. It lists 17 sites, including Mandi, Maur, Musangun, Forok #3, Forok #2, Forok #1, and Dagawat, each with a thumbnail and a count of buildings. The main area is a map of Papua New Guinea with various overlays. On the right is a 'Layers' panel with categories like Infrastructure, Electricity access, and Grid Extension. The top of the interface shows the project name and some navigation buttons.

Workflow: Platform Live Demo



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



Your questions!



Papua New Guinea - Wewak Grid Extension

ESA GDA Clean Energy // ADB

Site list

17 sites

Search sites

Section 1 247 buildings

Section 1 144 buildings

Section 2 121 buildings

Section 2 79 buildings

Section 2 209 buildings

Section 2 63 buildings

Section 2 149 buildings

Mandi

Maur

Musangun

Forok #3

Forok #2

Forok #1

Dagawat

Q&A

Thanks for tuning in!

Contact us:

Malin Sophie Fischer (VIDA): malin@vida.place

Fred Ramos (ADB): framos@adb.org

Peter Baum (ADB): pbaum@adb.org

Layers

Search layer

+ Add layer

Infrastructure

- Roads (OSM extended based on satellite imagery)
- Roads (OpenStreetMap, not extended)
- Buildings (based on satellite imagery)
- Buildings (OpenStreetMap)
- Education facilities
- Healthcare facilities

Electricity access

- Existing MV grid (partially inactive)
- Nightlight areas (2023/2024)

Grid Extension

- Proposed MV route
- Proposed basic LV network
- Buffer zone for potential additional connections (200m)
- Potential additional connections

Water resources

Other

Global base layer

Report a bug

Fit map to workspace

mapbox

Case study by



→ THE EUROPEAN SPACE AGENCY