ASIAN DEVELOPMENT BANK

Mapping Rice Paddy Boundaries in Cambodia

2023 January 11

QED | https://qed.ai

Climate Resilient Rice Commercialization Sector Development Program, RICESDP
Asian Development Bank (ADB)

Introduction to QED.ai

Meet the Team

WHY

Building data systems and AI to empower *other* organizations pursuing the health and agricultural SDGs (2,3,6,15)

WHO

~25 software engineers and data scientists
+ analysts and domain experts in health and agronomy

HOW

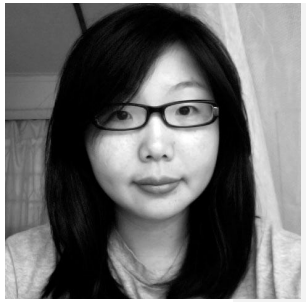
- **forte: technologies for challenging environments**
- **since 2012, has supported projects in 13 countries**

Mateusz Urbańczyk
Software Architect

M.S. Comp. Sci, Univ. of Wrocław
B.S. Comp. Sci, Univ. of Wrocław

Leah Goeke, MPH
Epidemiologist

M.P.H. Epi (Pitt)
B.A. Bio+Anthro (Bucknell)
Ex-CDC, RPCV Zambia



Dr. Jiehua Chen
Chief Statistician and Co-Founder

Ph.D. Stat (Stanford)
M.S. Econ (Stanford)
B.S. Math+Phys. (Tsinghua)
Ex-Columbia Univ.

Dr. William Wu
Chief Executive and Co-Founder

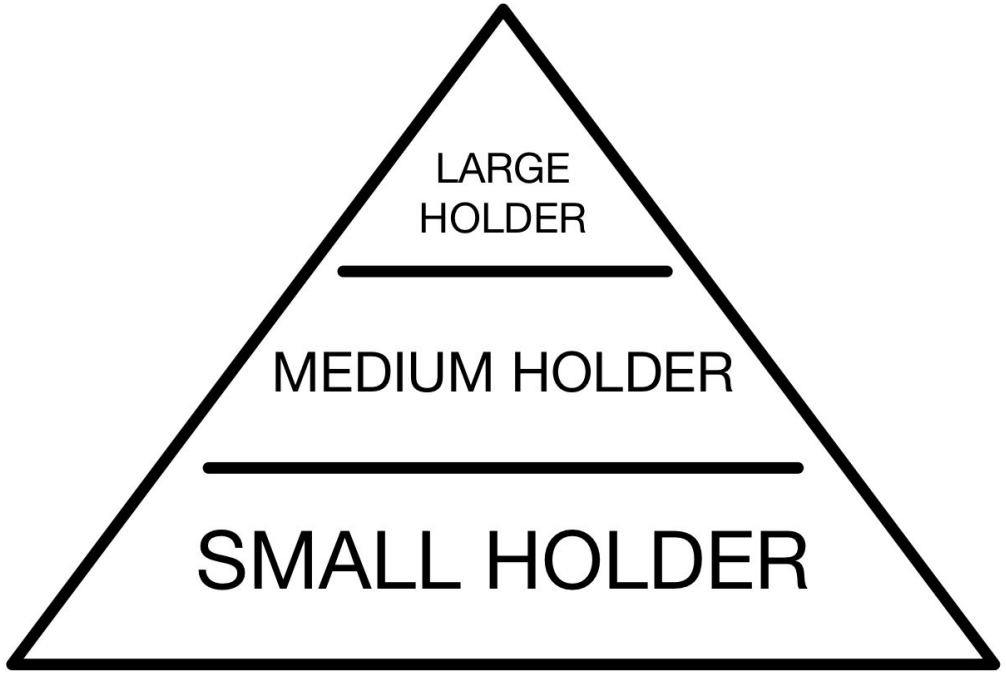
Ph.D. EE (Stanford)
M.S. Math (Stanford)
B.S. EECS (Berkeley)
Ex-NASA JPL

Motivations for Working in Agricultural Development:

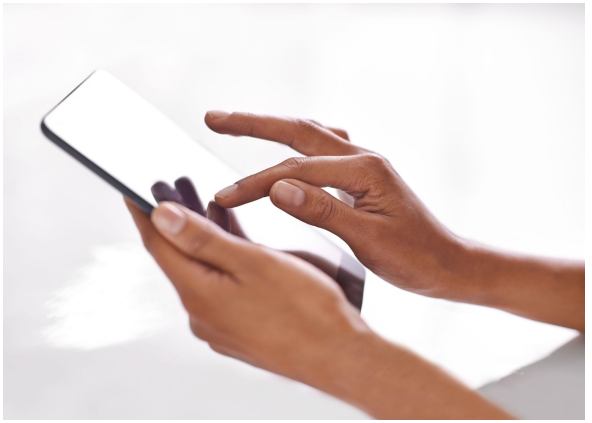
Smallholder Farmers in Africa

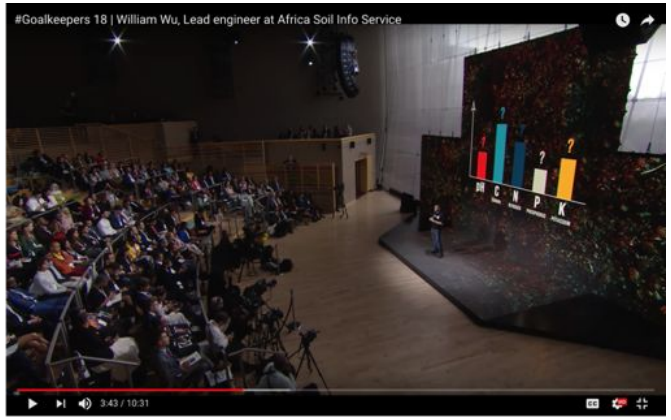
- **Count:** 2.5 Billion
- **Gender:** 75% female
- **Plot Size:** < 2ha
- **Income:** $1-2/day

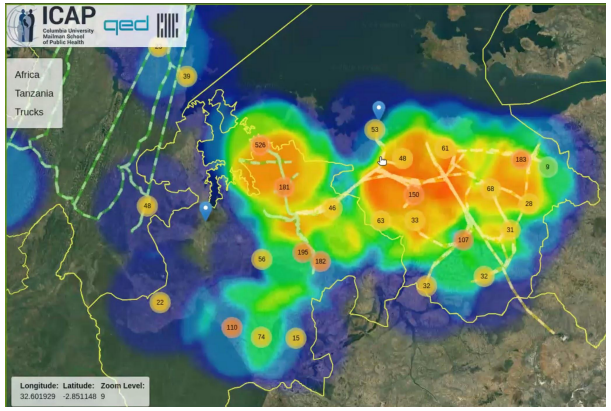
- SHFs generate 30-34% of all the world's food
- SHFs generate 80% of food in third world countries
- 1B hectares of African arable land is uncultivated
- Health is directly affected by food security and agribusiness



Technologies To *Overcome* Data Scarcity





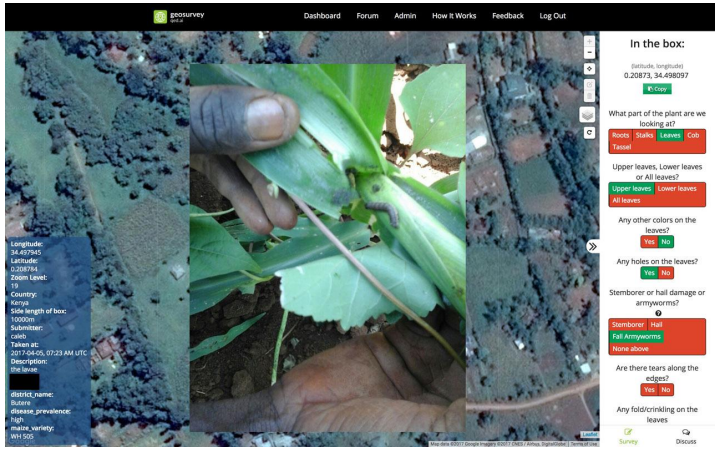


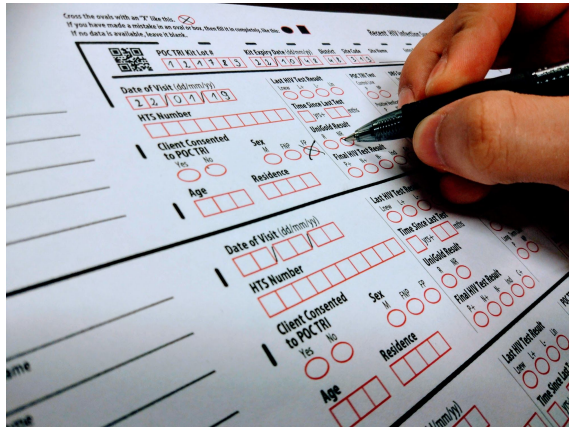
digital soil mapping

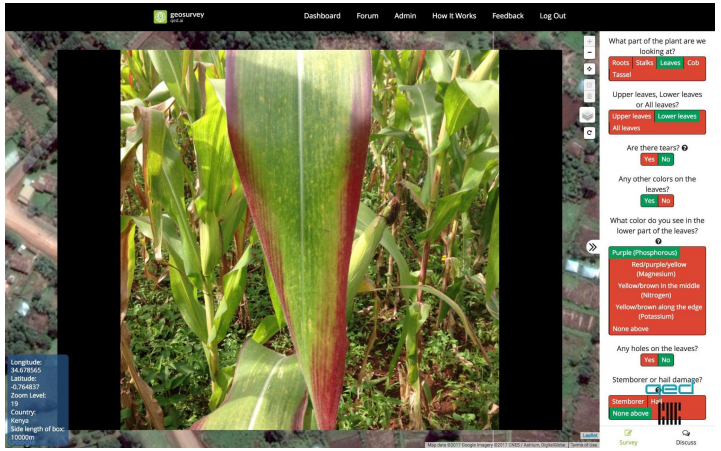
land cover mapping for sustainable development

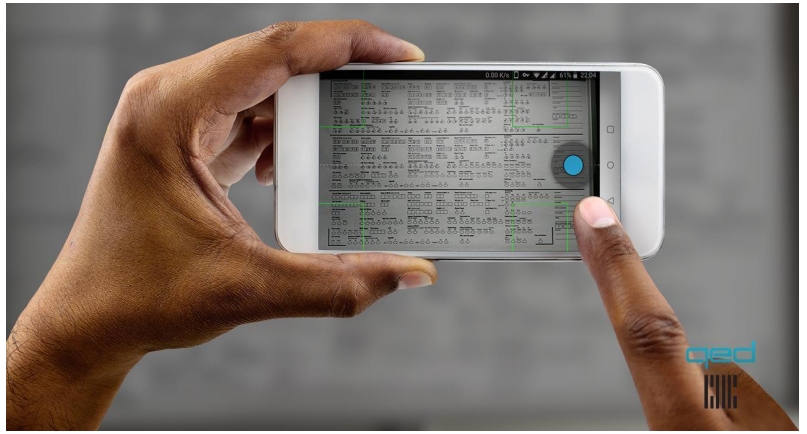
mobile data collection and visualization

Technologies To *Overcome* Data Scarcity









plant health surveillance

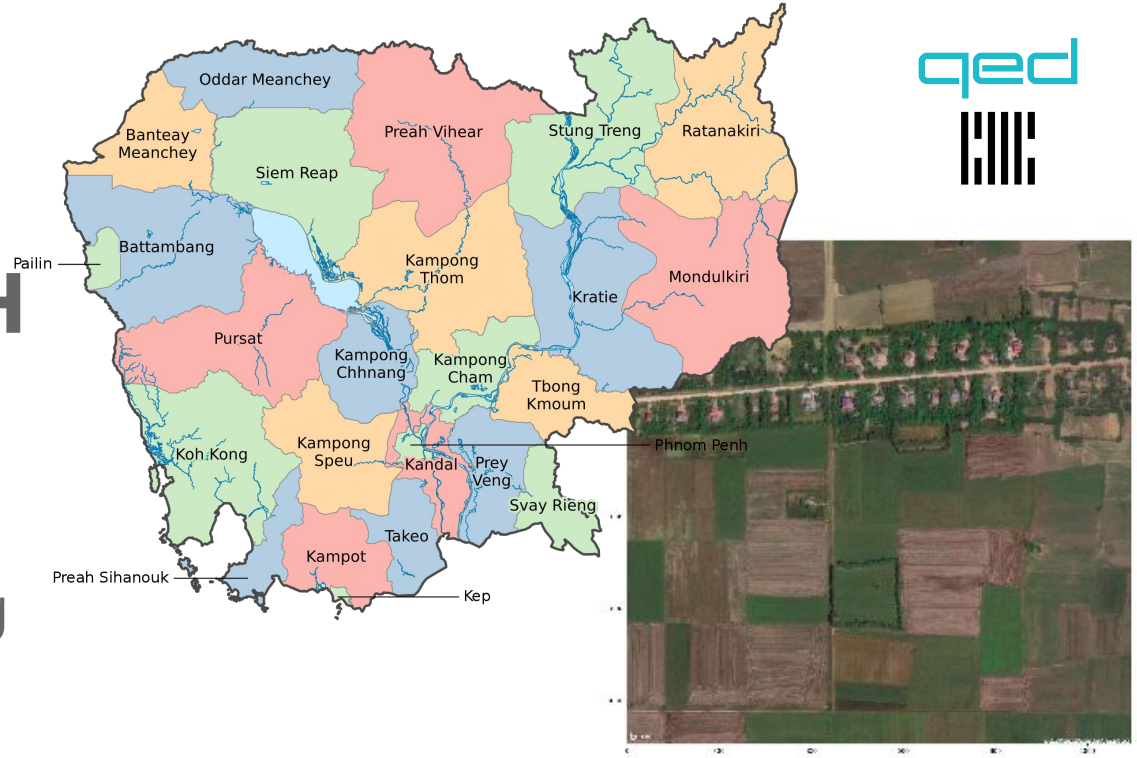
proximal sensors (carbon, NIR)

ScanForm: write on paper and digitize the data with a smartphone!

Objectives in Cambodia (2020 Engagement with ADB)

Objectives

- **Mapping Rice Paddies in KH**
  - Remotely generate polygonal boundaries for rice paddies in nine selected areas (~16,000 ha, spanning ~16,000 farming families)



region #	1	2	3	4	5	6	7	8	9
name	**Prey Sangha**	**Anglong Run**	**Ta Mao**	**Chhuk Ksach**	**Ta Soong**	**Chamkar Kouy**	**Ansong**	**Rumlech**	**Anlong Char**
district	Bavel	Thma Koul	Thma Koul	Baray	Baray	Svay Antor	Kampong Trabaek	Sithor Kandal	Preah Sdach
province	Battambang	Battambang	Battambang	Kampong Thom	Kampong Thom	Prey Veng	Prey Veng	Prey Veng	Prey Veng
area (ha)	1150	1435	1038	1650	2070	2100	1510	2380	3000

Motivations

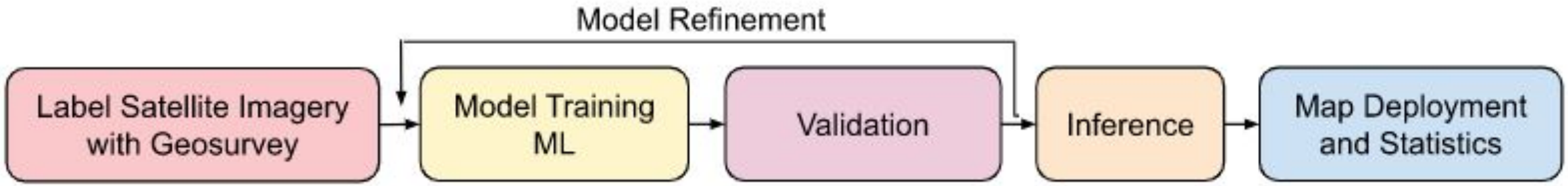
- Yield Prediction
- Crop Type Mapping
- Land Registration and Titling
- Investment Planning

Plot boundaries have many different use cases, both for agricultural research and for agribusiness strategy. They are in high demand.

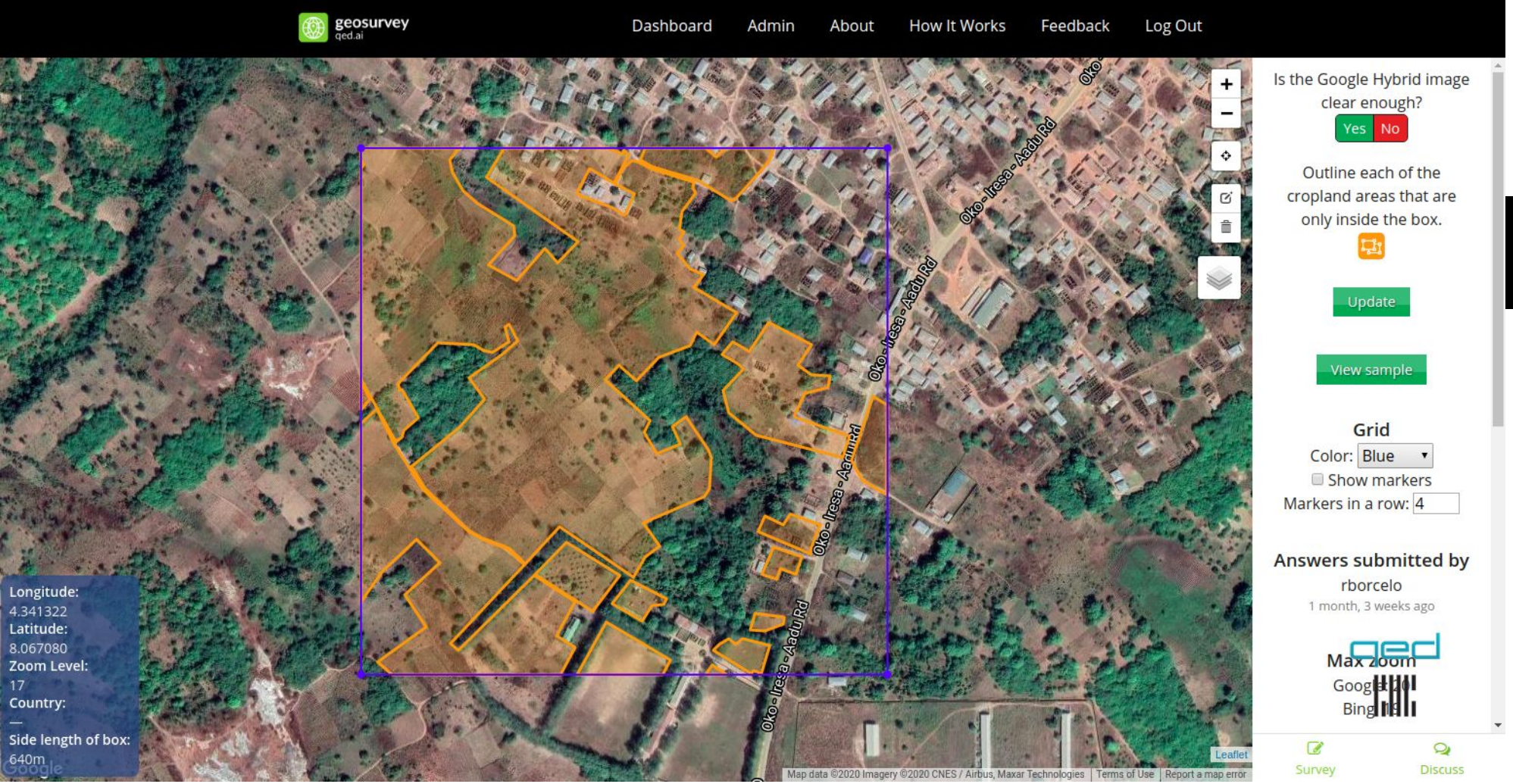
Methods: Overview

Overview of Methodology

- Surveying
- Modeling
- Inference
- Map Deployment



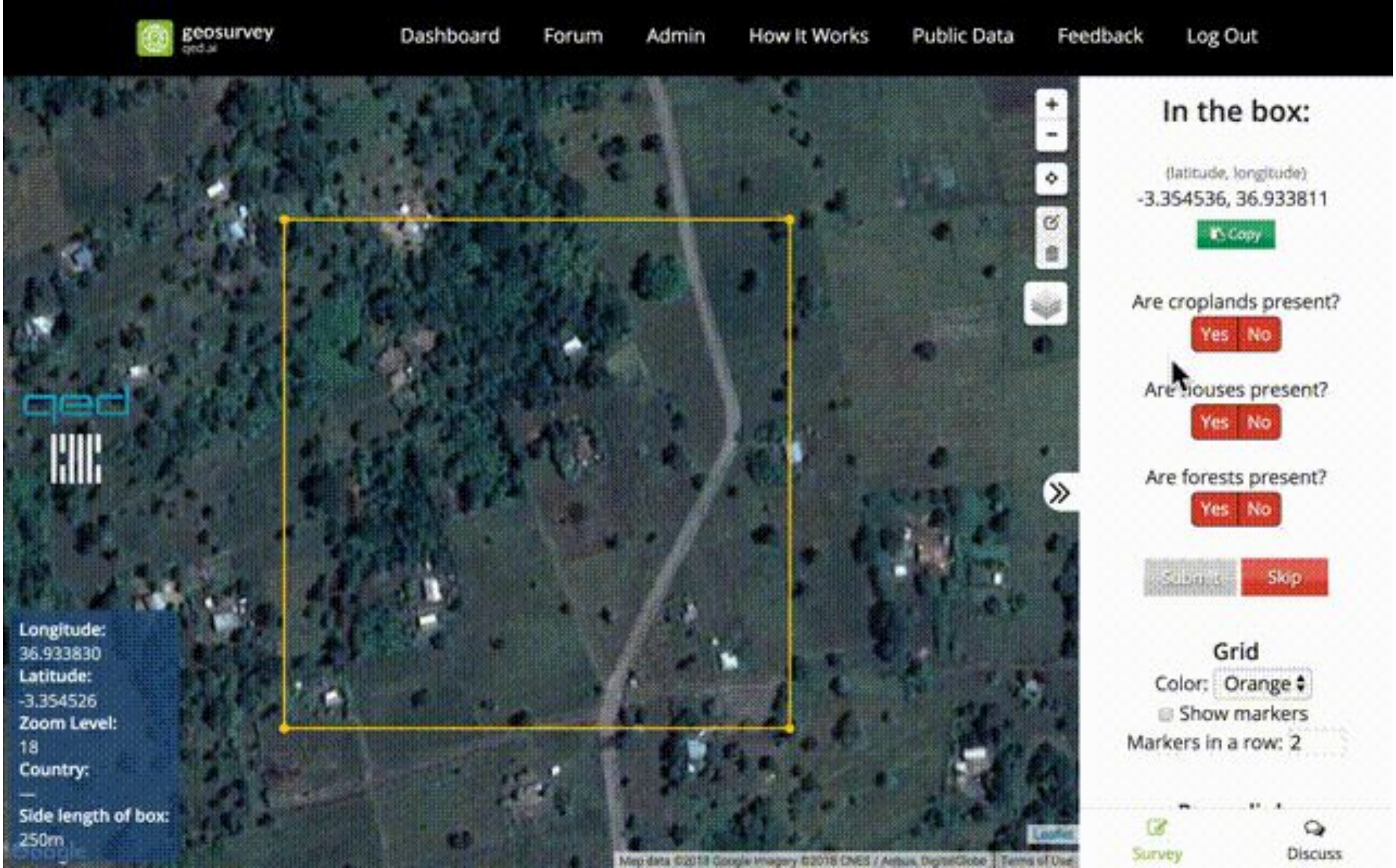
Methods: Geosurvey



Geosurvey

Left: Screenshot from Geosurvey, in Oyo State, NG. A surveyor has highlighted the croplands in orange.

- **Scalably annotate imagery (satellites/drones/phones)**
- **Rapidly train artificial intelligence**


geosurvey
qed.ai
Dashboard
Forum
Admin
How It Works
Public Data
Feedback
Log Out
In the box:
(latitude, longitude)
-3.354536, 36.933811
Copy
Are croplands present?
Yes
No
Are houses present?
Yes
No
Are forests present?
Yes
No
Skip
Grid
Color: Orange
Show markers
Markers in a row: 2
Survey
Discuss
Longitude:
36.933830
Latitude:
-3.354526
Zoom Level:
18
Country:
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Side length of box:
250m
Map data ©2018 Google Imagery ©2018 CNES / Airbus, DigitalGlobe
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geosurvey
qed.ai
Menu
Longitude:
102.966024
Latitude:
13.305199
Zoom Level:
16
Country:
—
Side length of box:
640m
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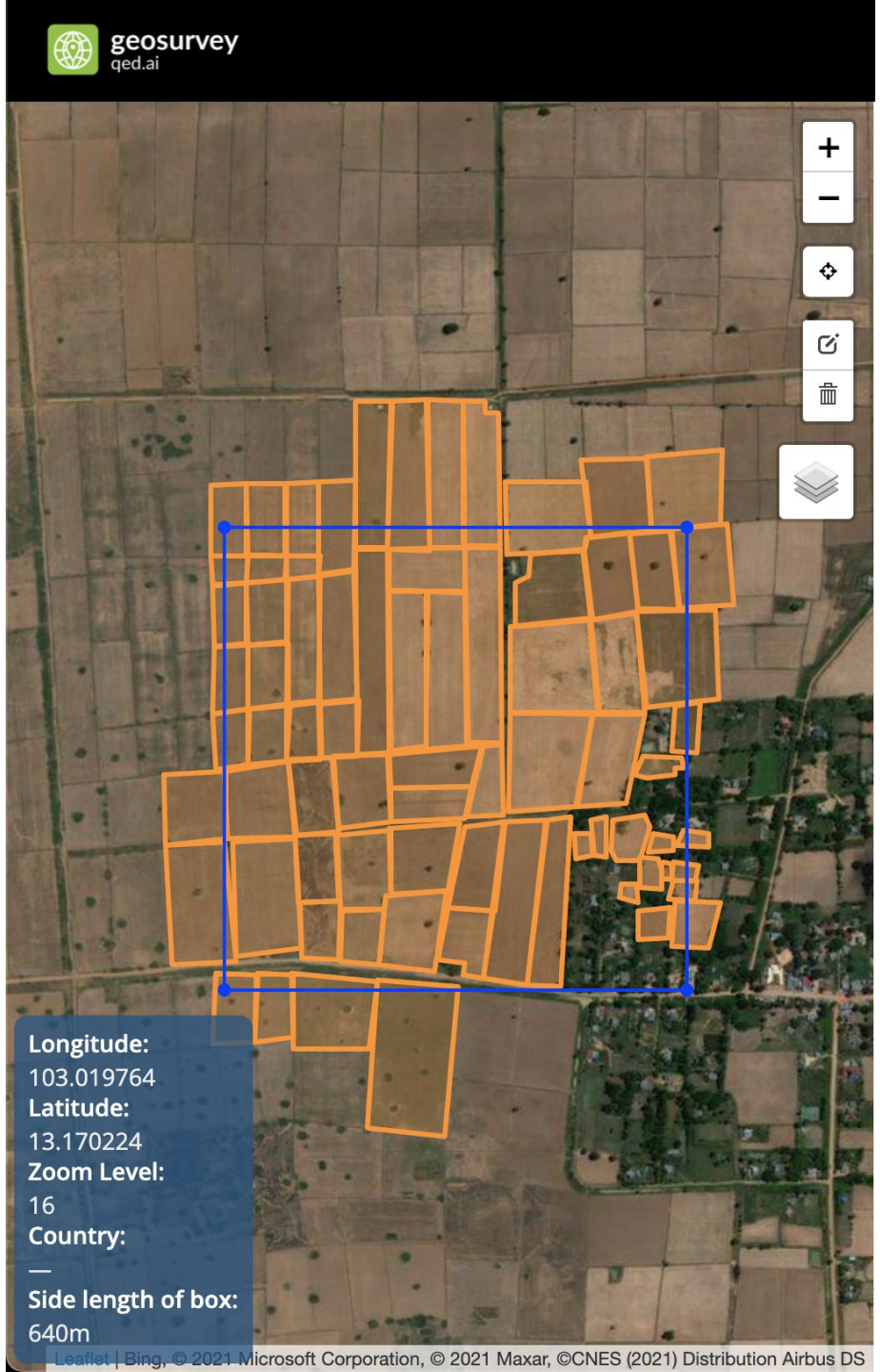
Outline each rice field separately. If the field is intersecting with blue rectangle outline also its parts outside of rectangle.
Update
View sample
Grid
Color: Blue
Show markers
Markers in a row: 4
Survey
Discuss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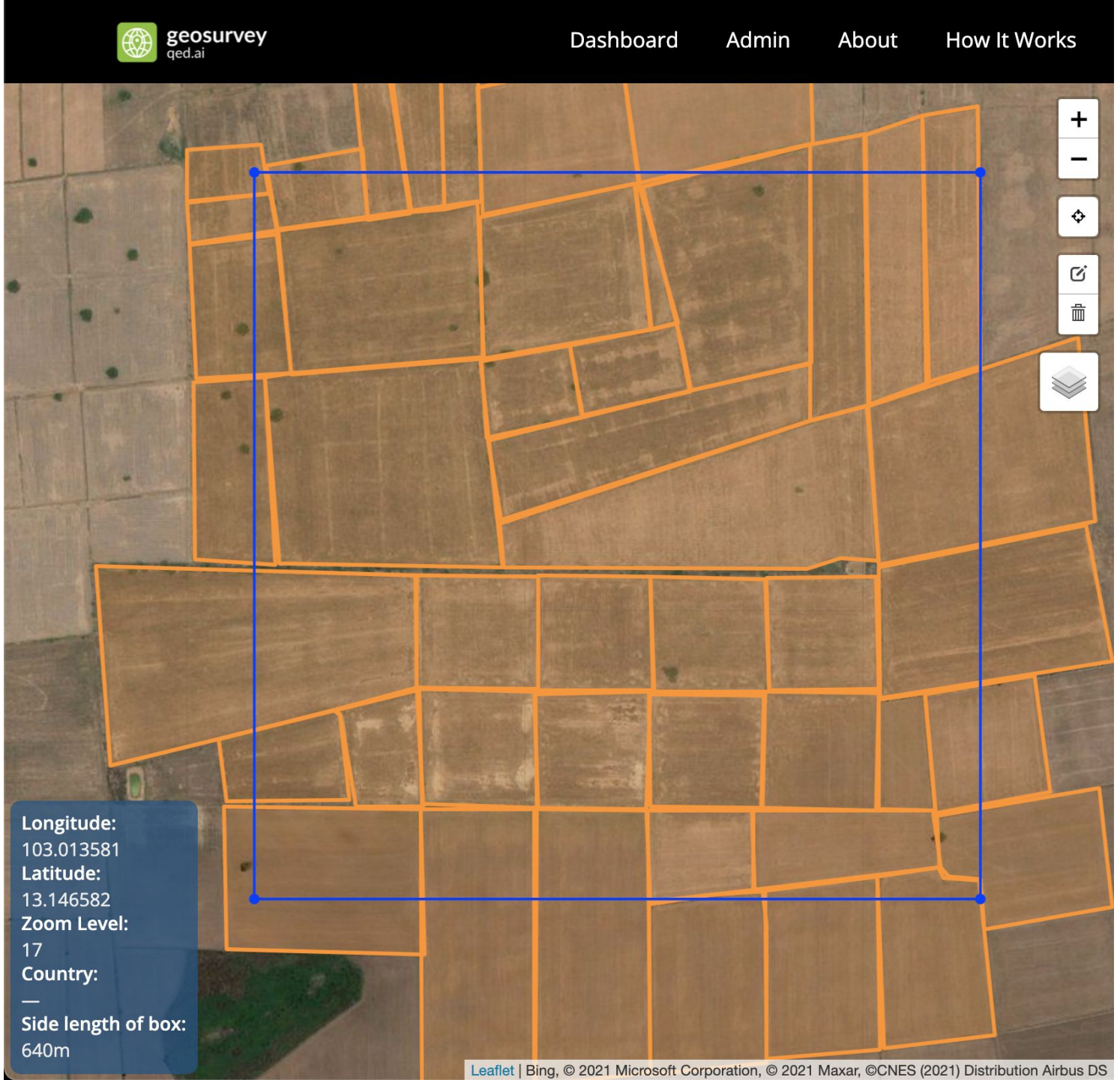
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How It Works
Longitude:
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Zoom Level:
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640m
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Hi, wwu

Home / Past Surveys / Cambodia Southern Plots — Samples

Cambodia Southern Plots

Status | Edit | Samples | Results | Teams | Discussions | Diagnoses

Username contains: | Latitude greater or equal to: | Latitude less than or equal to: | Longitude greater than or equal to: | Longitude less than or equal to: | Created after or on: Select Date..

Created before or on: Select Date.. | Submission count greater than or equal to: | Submission count less than or equal to: | Filter

Order by: Uploaded at descending

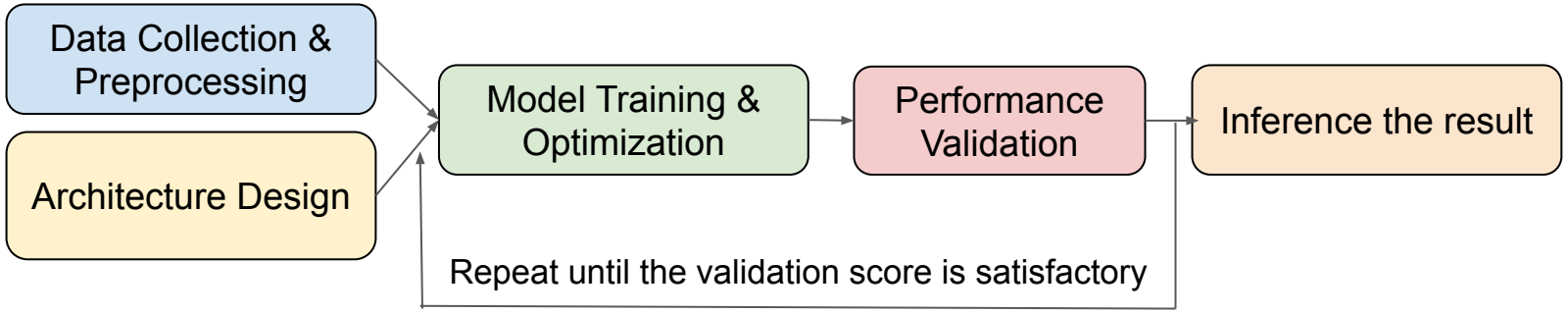
- **Why not just map *all* rice in KH manually like this?**

- **Reason:**
  - **~3M hectares of rice in KH**
  - **Approximate time to trace all rice paddies: 23.1 years on a 40 hr work week (over ~160K USD)**
  - **Once humans are done, the map is outdated!**

Artificial intelligence can make this effort more scalable and sustainable!

Methods: Artificial Intelligence

AI Pipeline



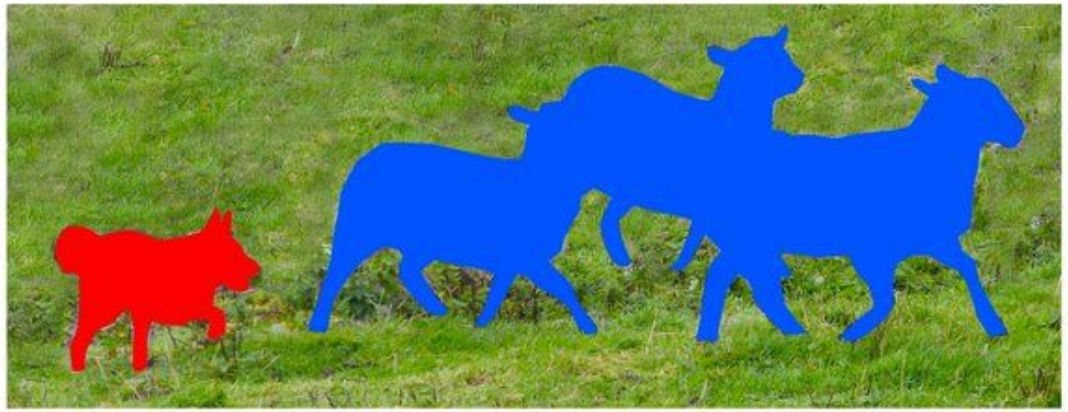
Input Image

Desired Output

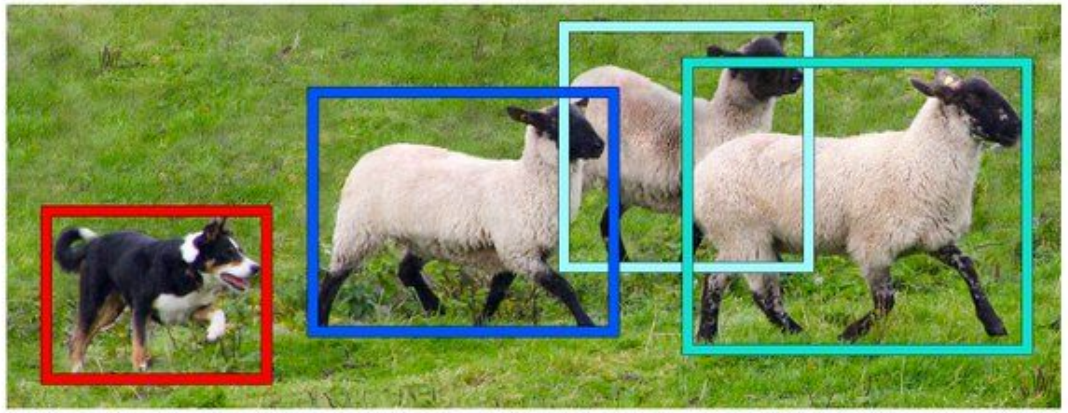
Evolution of some ideas in computer vision

...

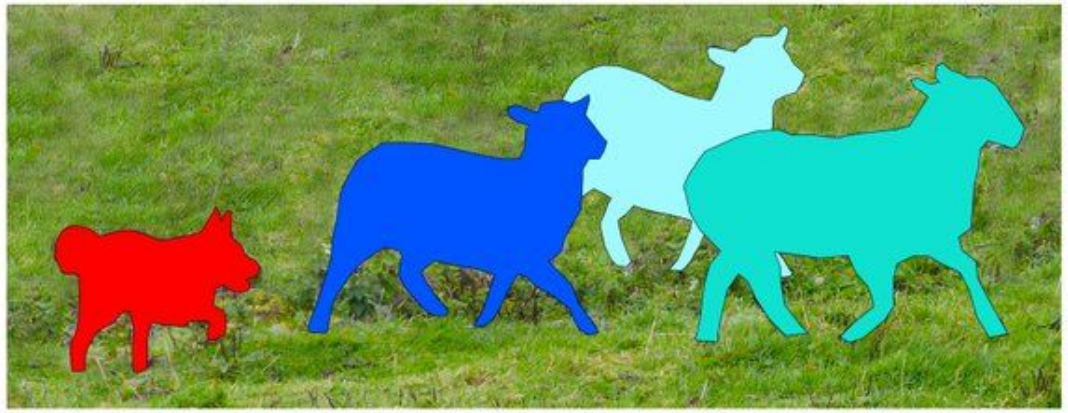
Image Recognition



Semantic Segmentation

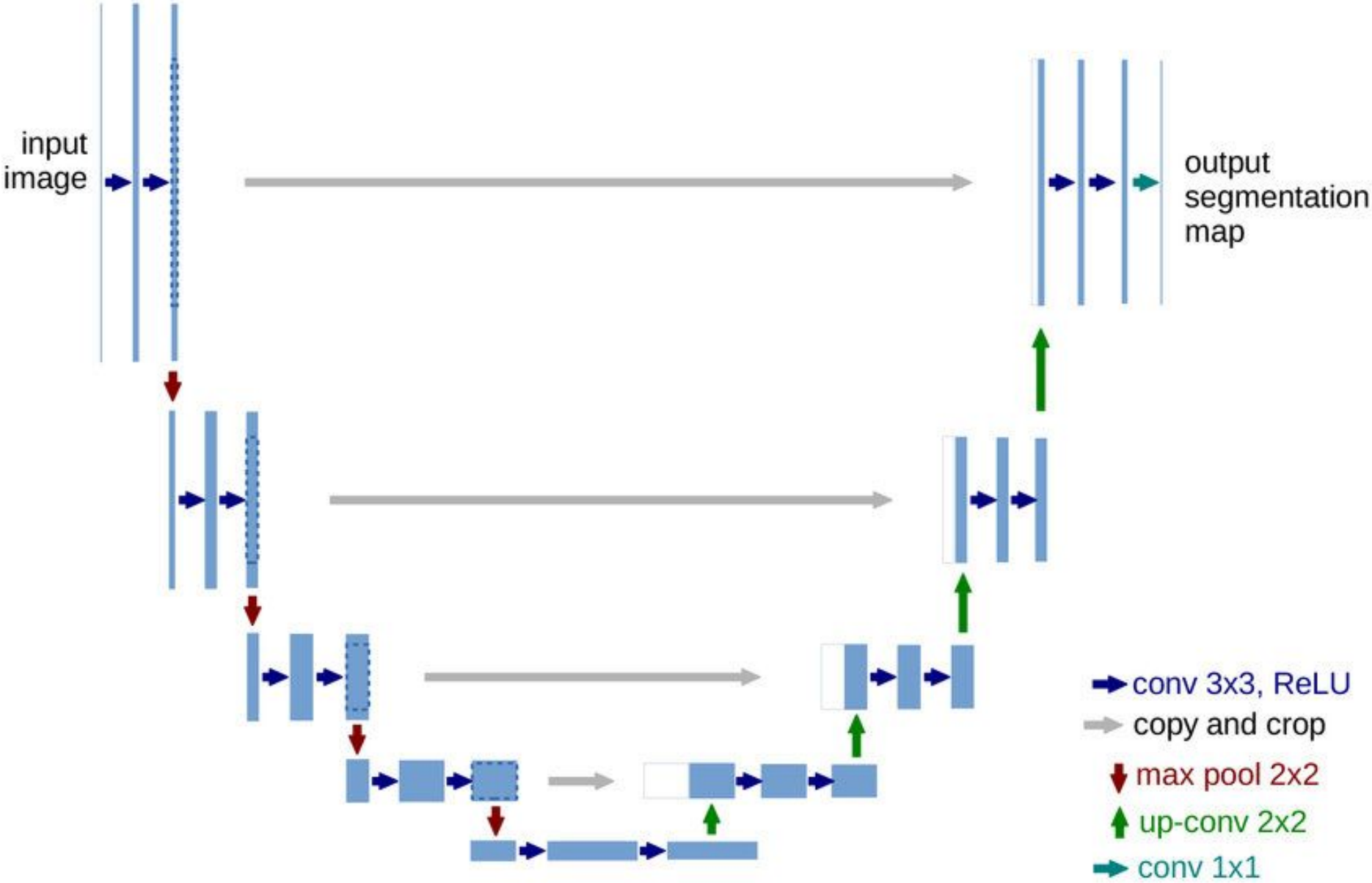


Object Detection

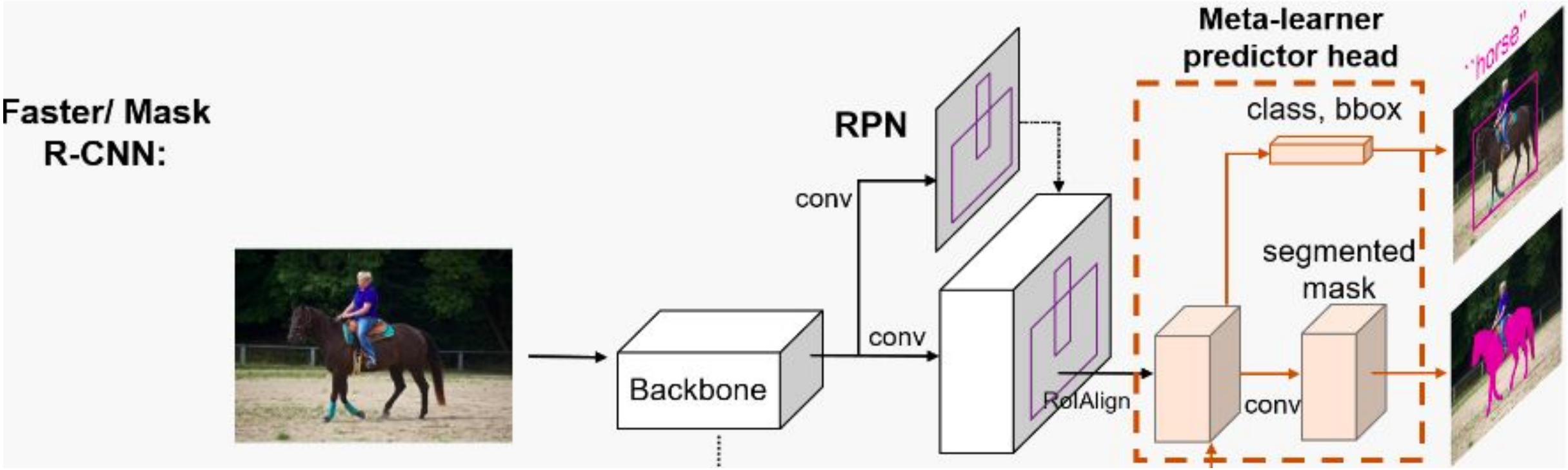


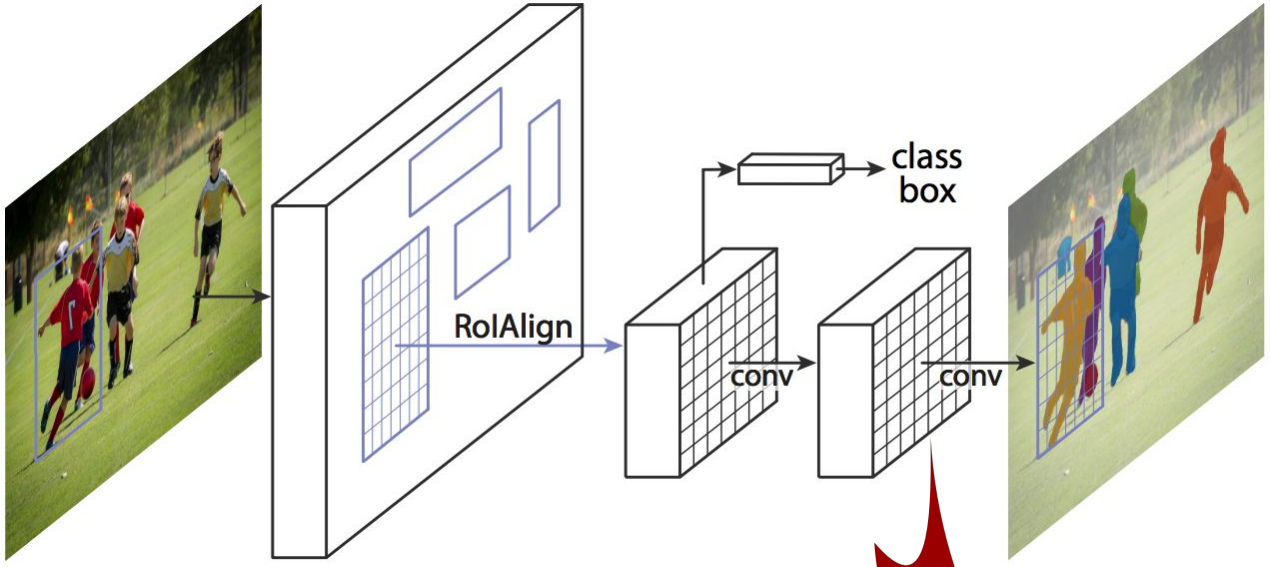
Instance Segmentation

U-Net


input image
output segmentation map
conv 3x3, ReLU
copy and crop
max pool 2x2
up-conv 2x2
conv 1x1

Mask R-CNN


Faster/ Mask R-CNN:
RPN
conv
conv
Backbone
RoIAlign
Meta-learner predictor head
class, bbox
segmented mask
conv
"horse"



apply state-of-the-art from other fields (surveillance, sports, military) to Ag Dev

Preliminary Performance for A.I.

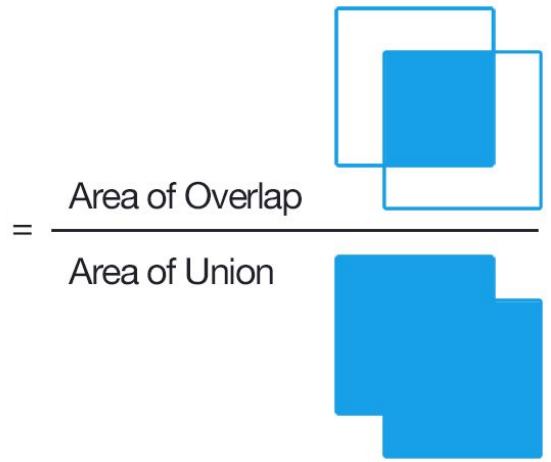
Map	Res	Accuracy	Precision	Recall	F1-Score	IoU	mAP
QED Rice Boundaries, KH	0.3m	**83.8%**	**96.7%**	**80.3%**	**87.8%**	**78.2%**	**64.5%**

cheatsheet for nerds:

		Actual	
		Positive	Negative
Predicted	Positive	True Positive	False Positive
	Negative	False Negative	True Negative

acc = (tp + tn) / (tp + tn + fp + fn)
prec = tp / (tp + fp)
recall = tp / (tp + fn)
f1 = 2 × prec × recall / (prec + recall)
iou = tp / (tp + fn + fp)

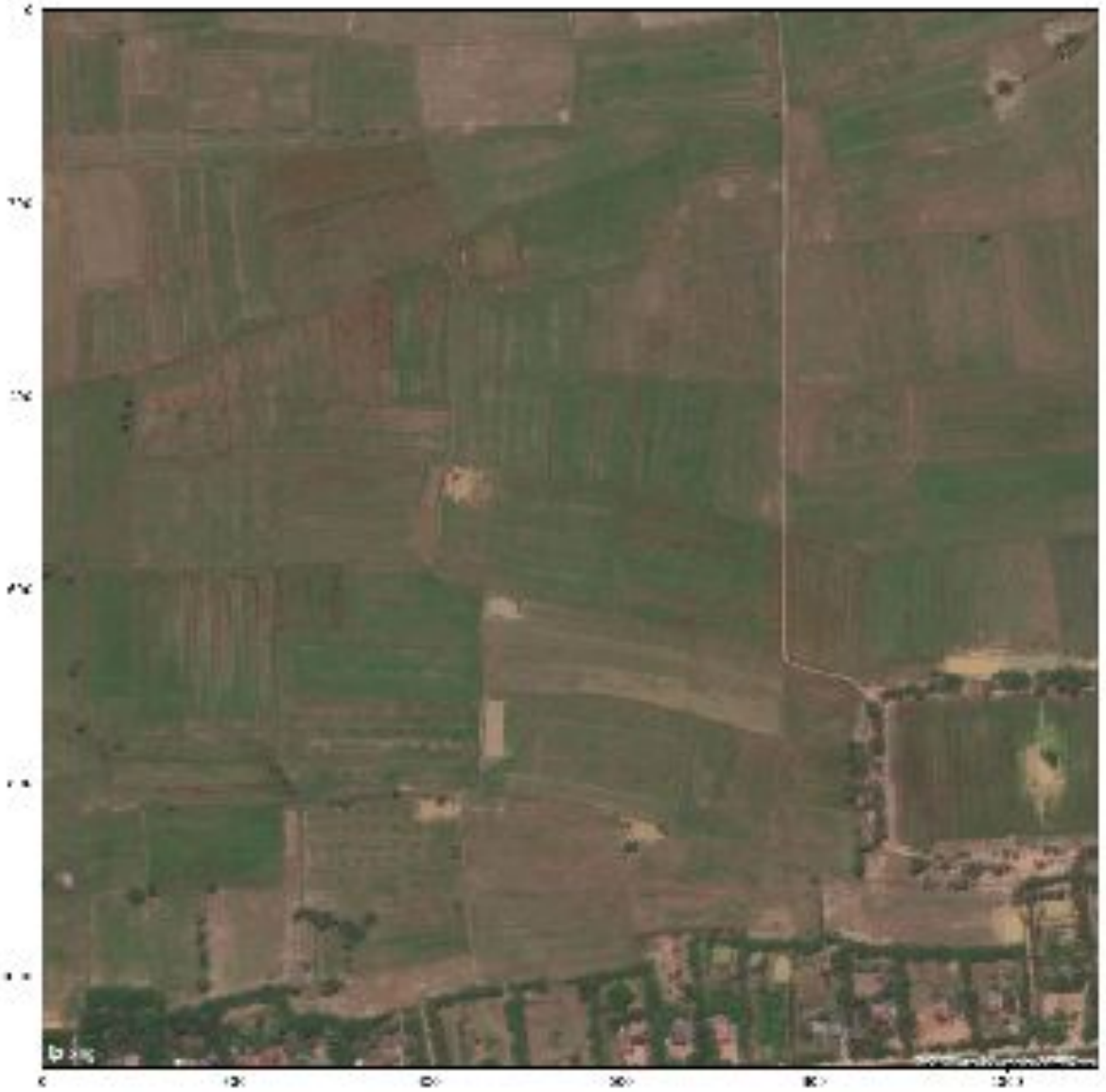
iou = tp / (tp + fn + fp)



mAP = over-complicated!
… seeing is believing ...

Visuals (satellite on left, AI on right)

QUANTITATIVE ENGINEERING DESIGN



Visuals (satellite on left, AI on right)

QUANTITATIVE ENGINEERING DESIGN

Visuals (satellite on left, AI on right)

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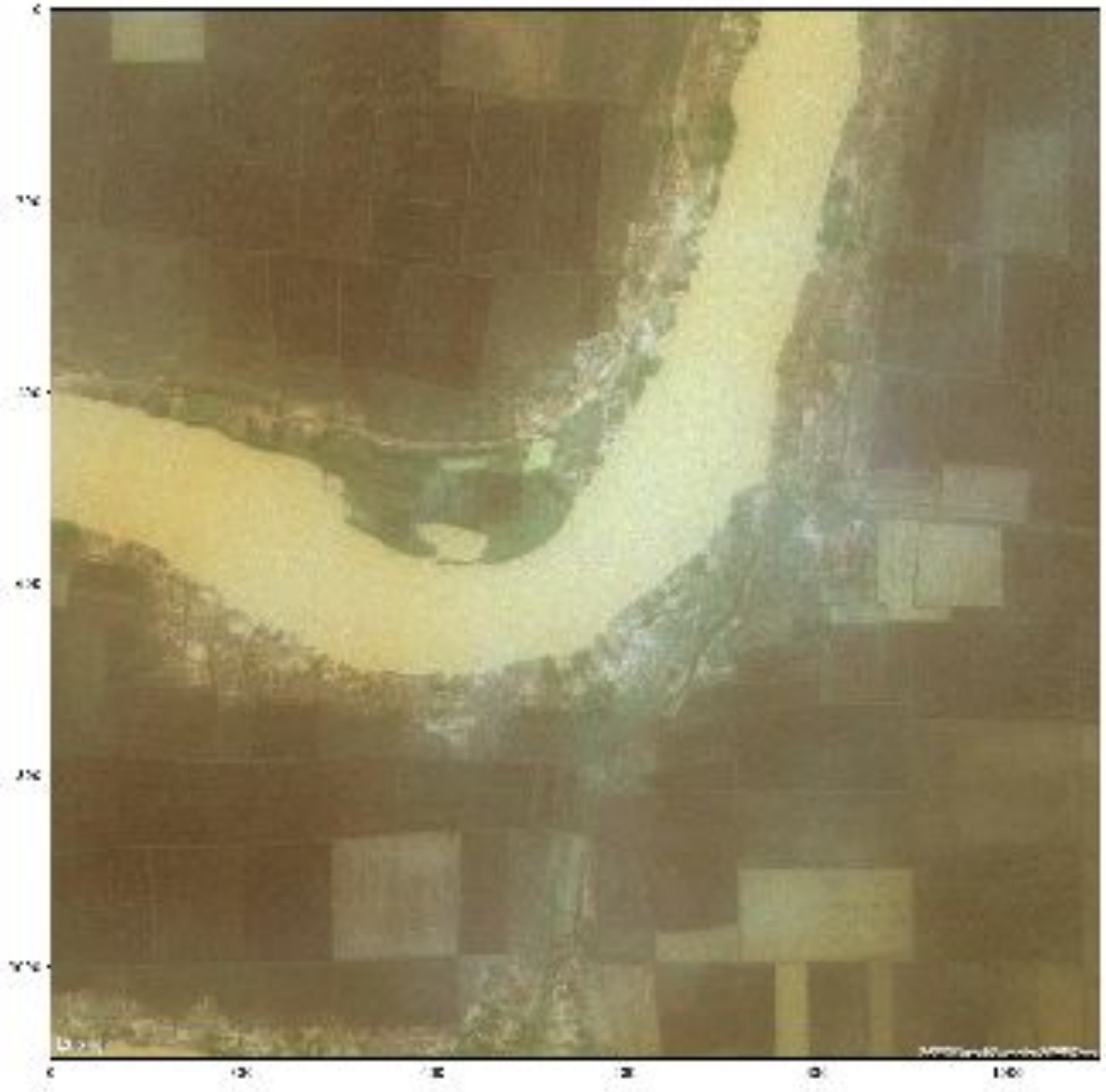
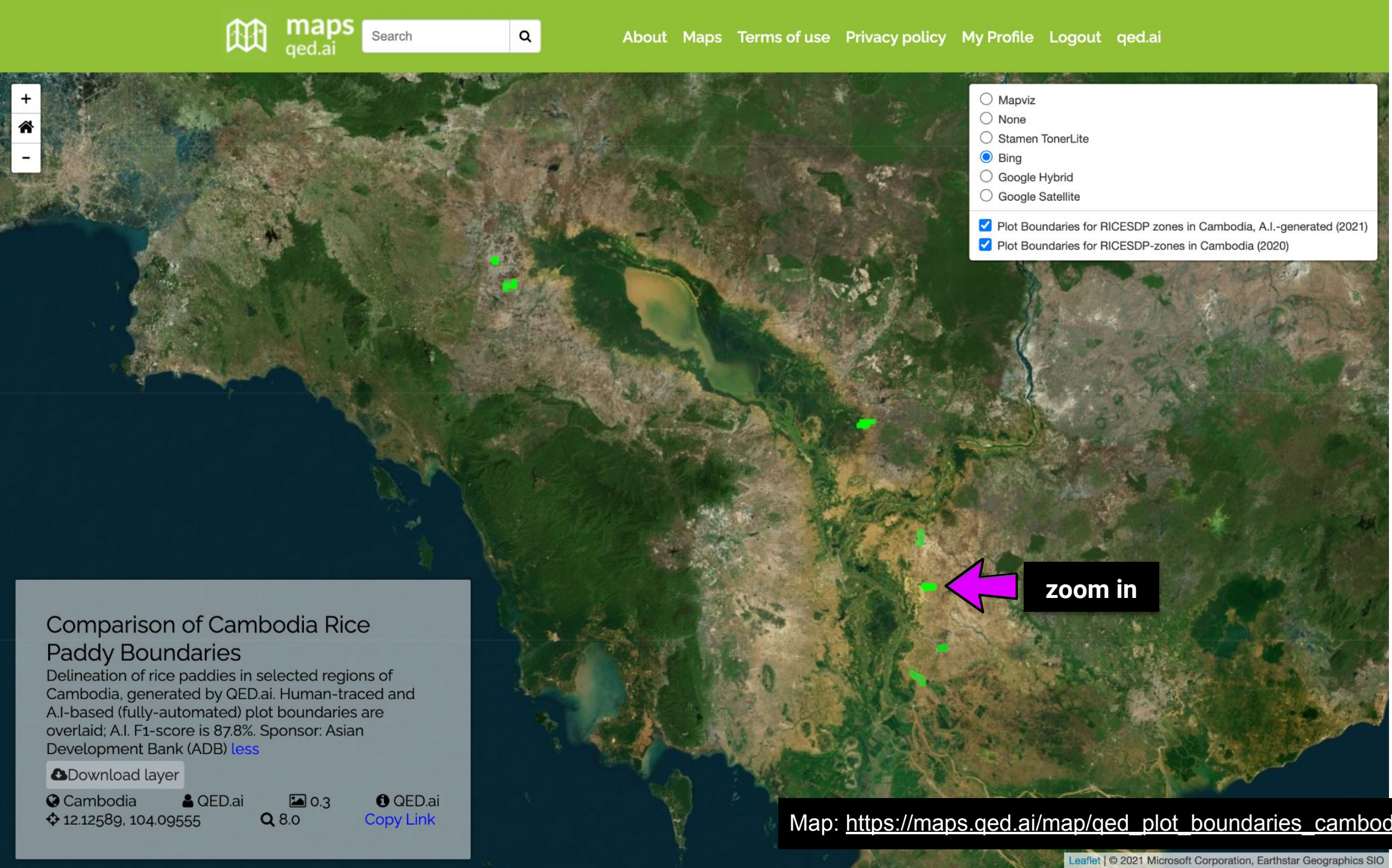
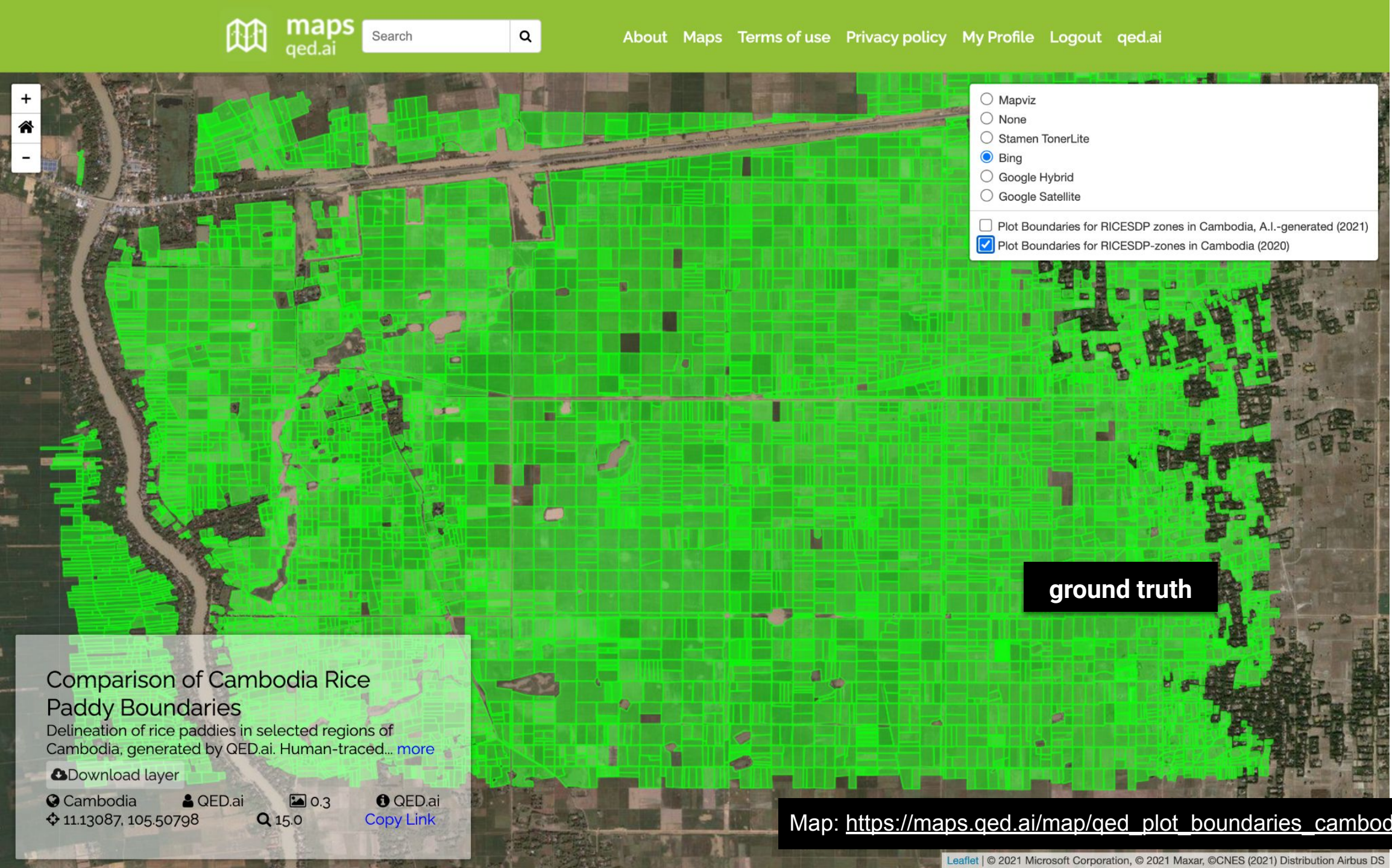


Methods: Map Visualization



Map: https://maps.qed.ai/map/qed_plot_boundaries_cambodia_composite



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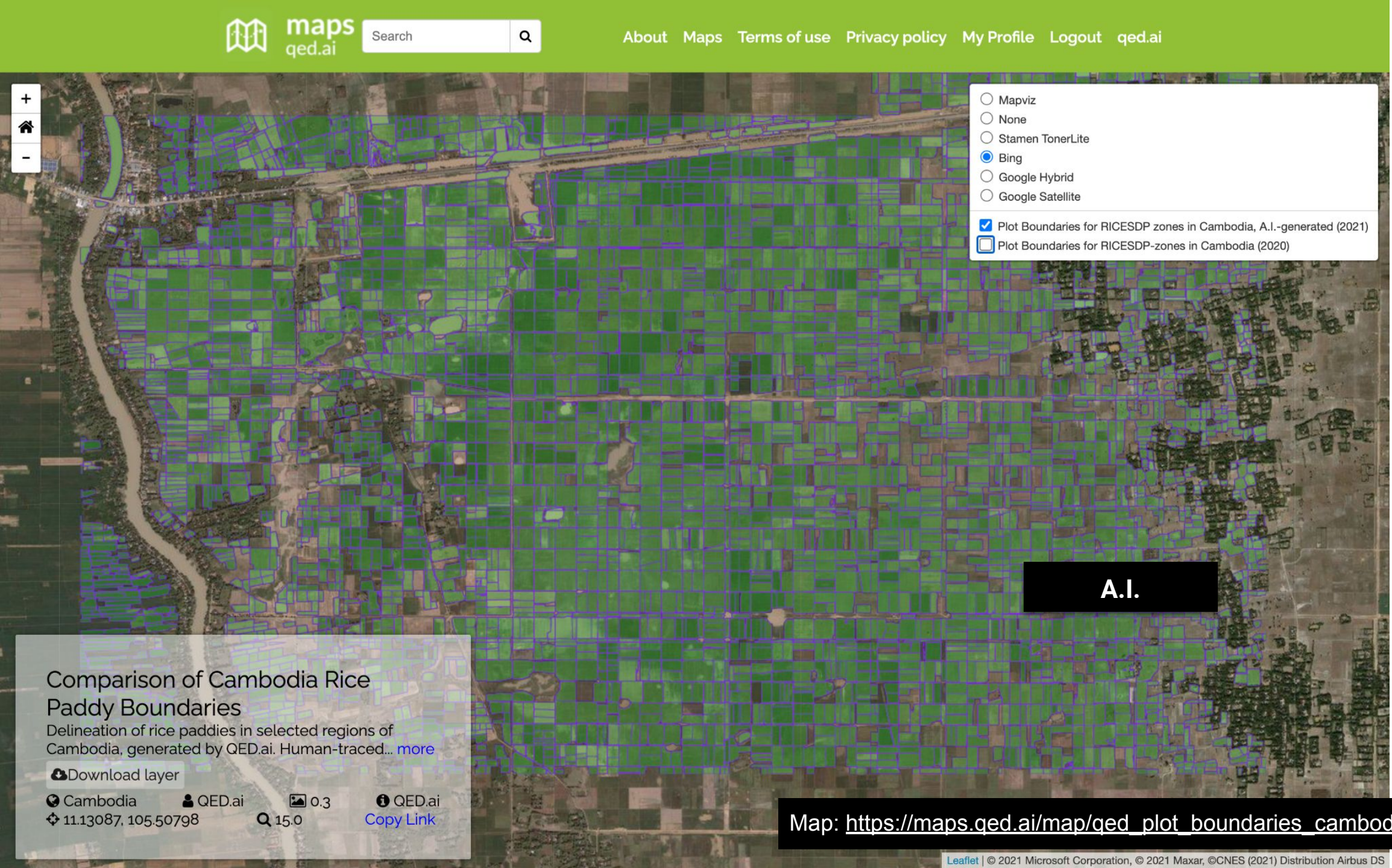

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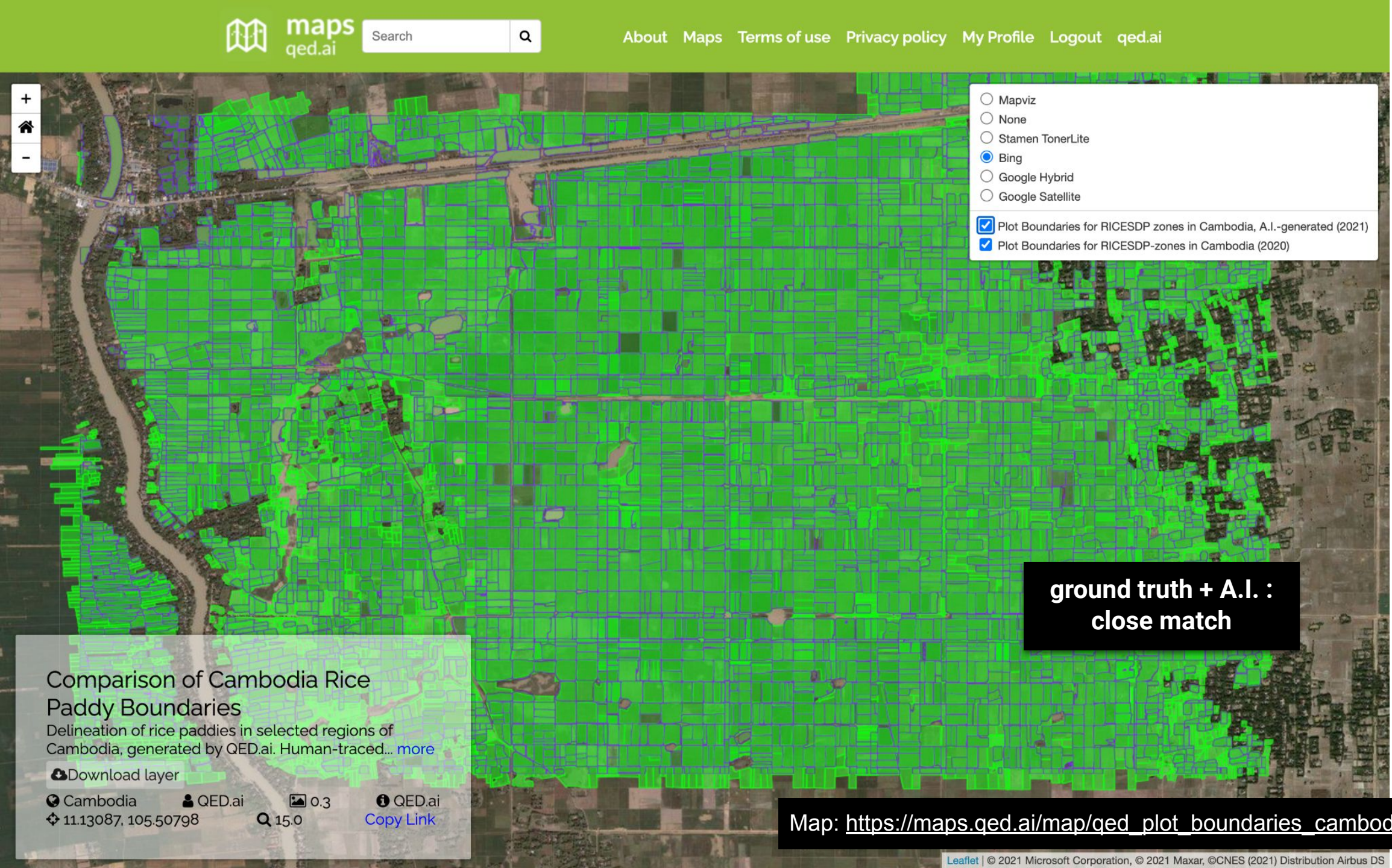
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Stamen TonerLite
Bing
Google Hybrid
Google Satellite
Plot Boundaries for RICESDP zones in Cambodia, A.I.-generated (2021)
Plot Boundaries for RICESDP-zones in Cambodia (2020)
ground truth + A.I. : close match
Comparison of Cambodia Rice Paddy Boundaries
Delineation of rice paddies in selected regions of Cambodia, generated by QED.ai. Human-traced... more
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Cambodia
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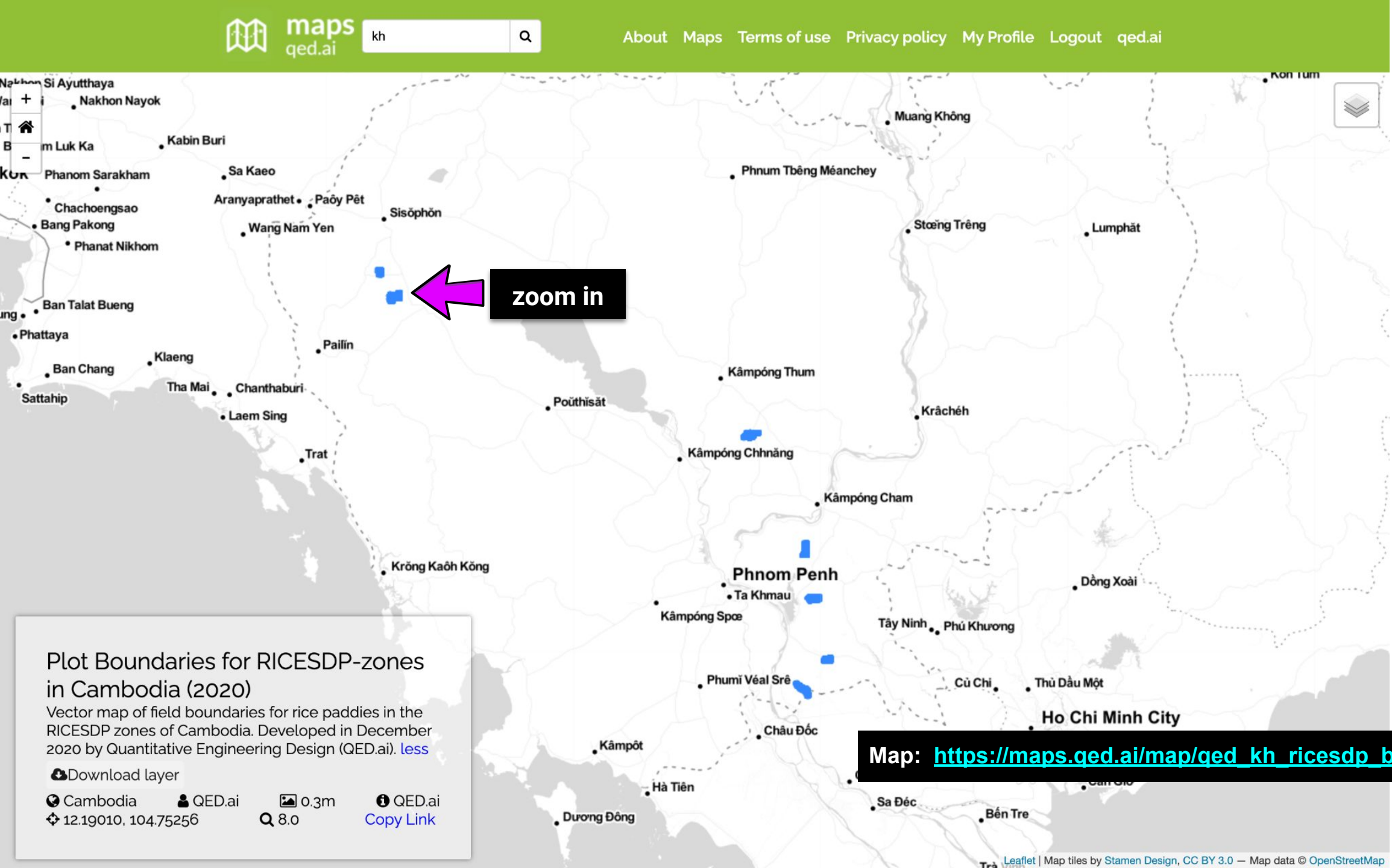
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Plot Boundaries for RICESDP-zones in Cambodia (2020)
Vector map of field boundaries for rice paddies in the RICESDP zones of Cambodia. Developed in December 2020 by Quantitative Engineering Design (QED.ai). less
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Cambodia
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0.3m
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12.19010, 104.75256
8.0
Copy Link
Map: https://maps.qed.ai/map/qed_kh_ricesdp_boundaries
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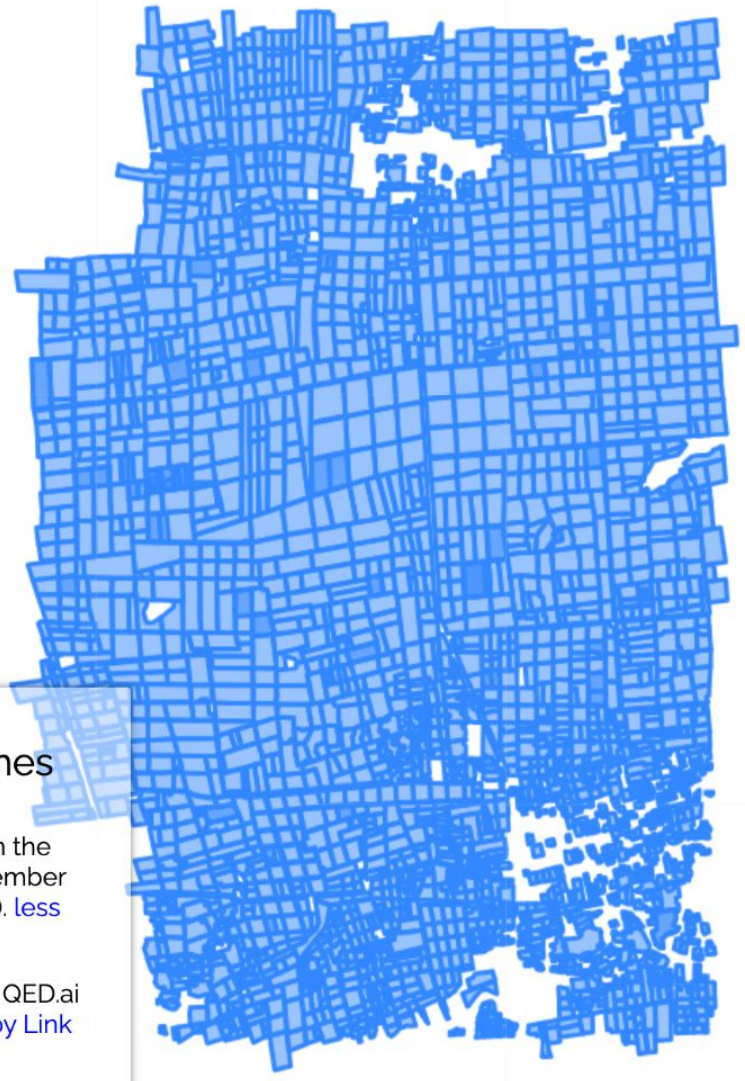


Plot Boundaries for RICESDP-zones in Cambodia (2020)

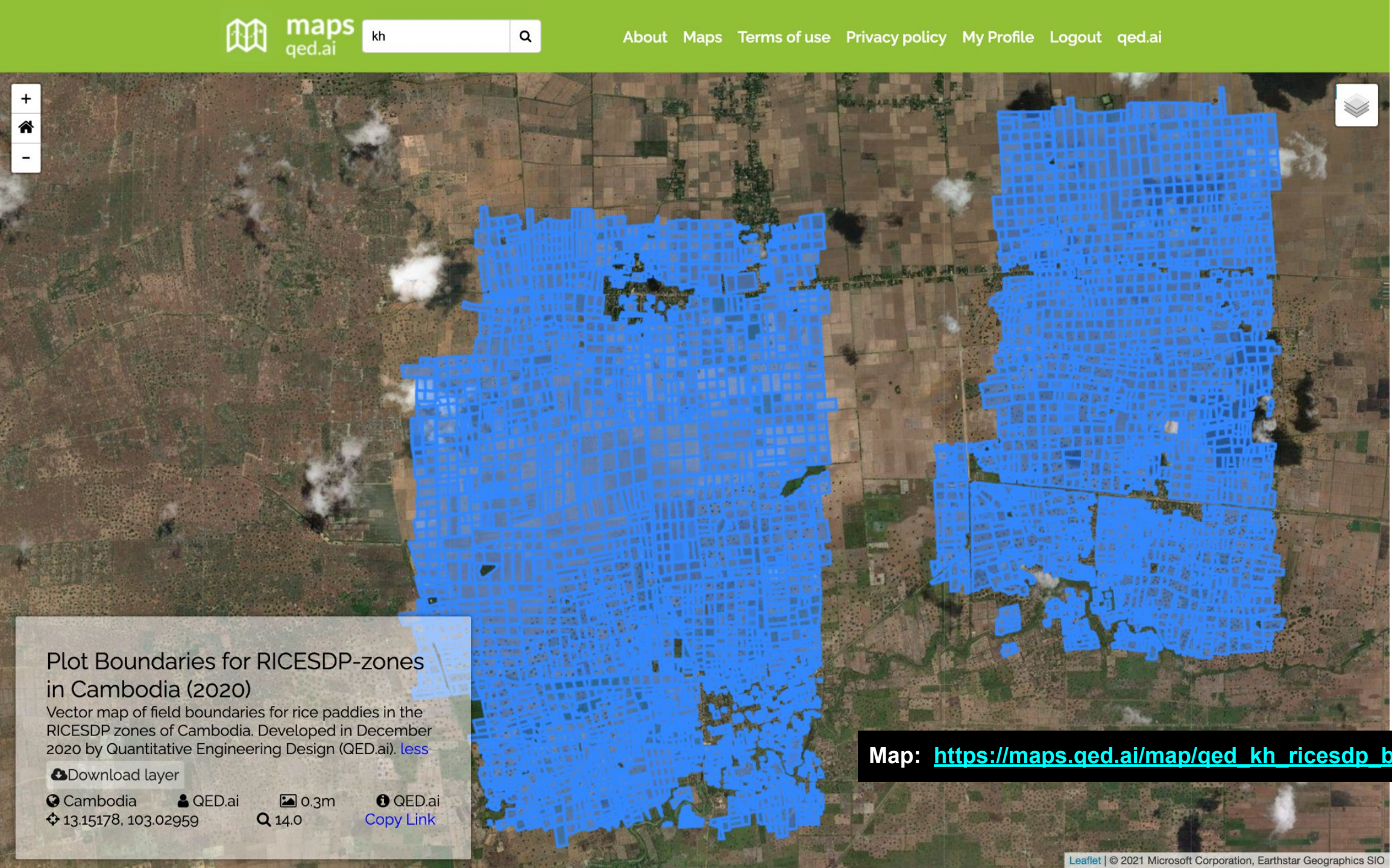
Vector map of field boundaries for rice paddies in the RICESDP zones of Cambodia. Developed in December 2020 by Quantitative Engineering Design (QED.ai). less

Download layer

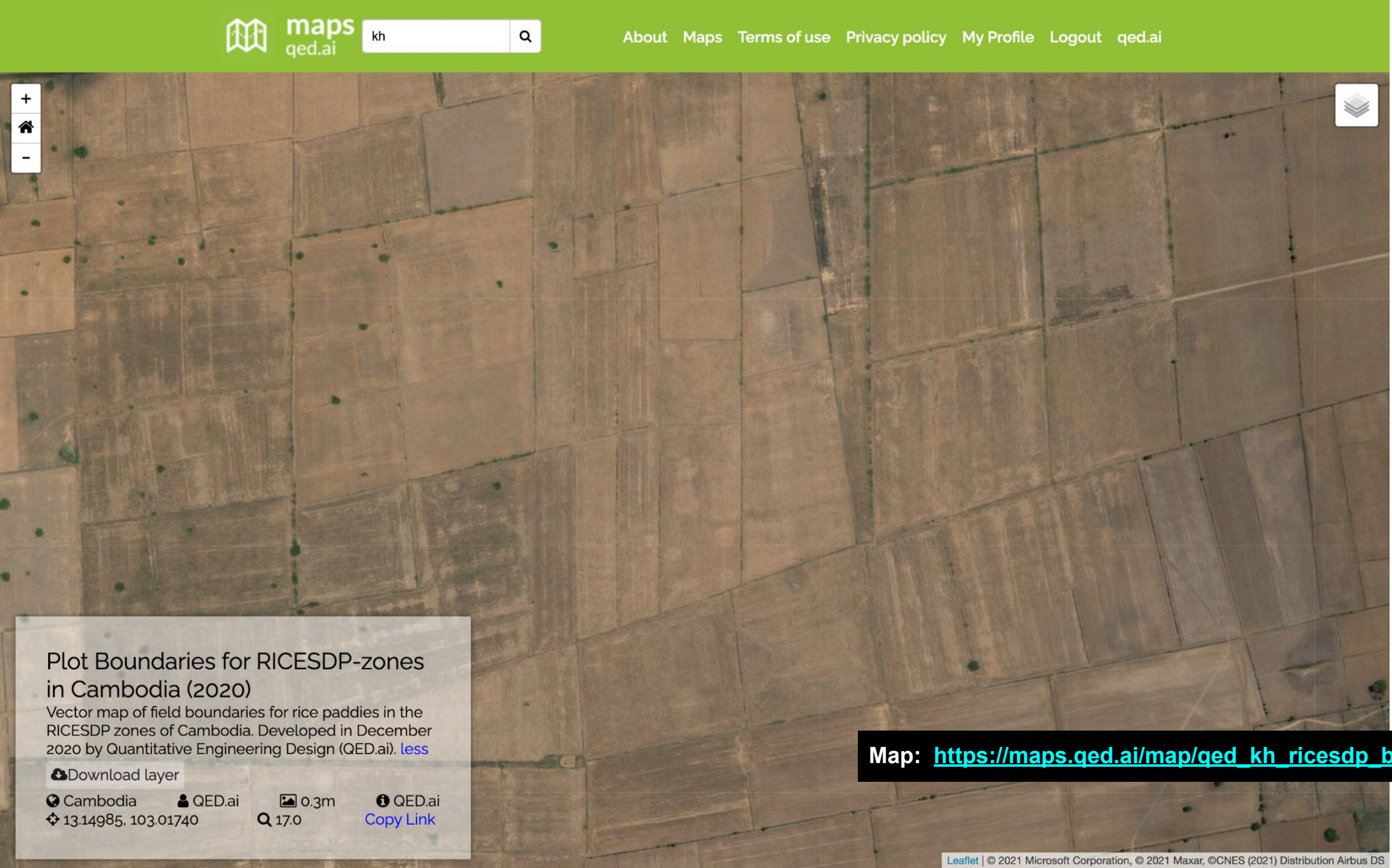
Cambodia | QED.ai | 0.3m | QED.ai

13.15178, 103.02959 | 14.0 | Copy Link

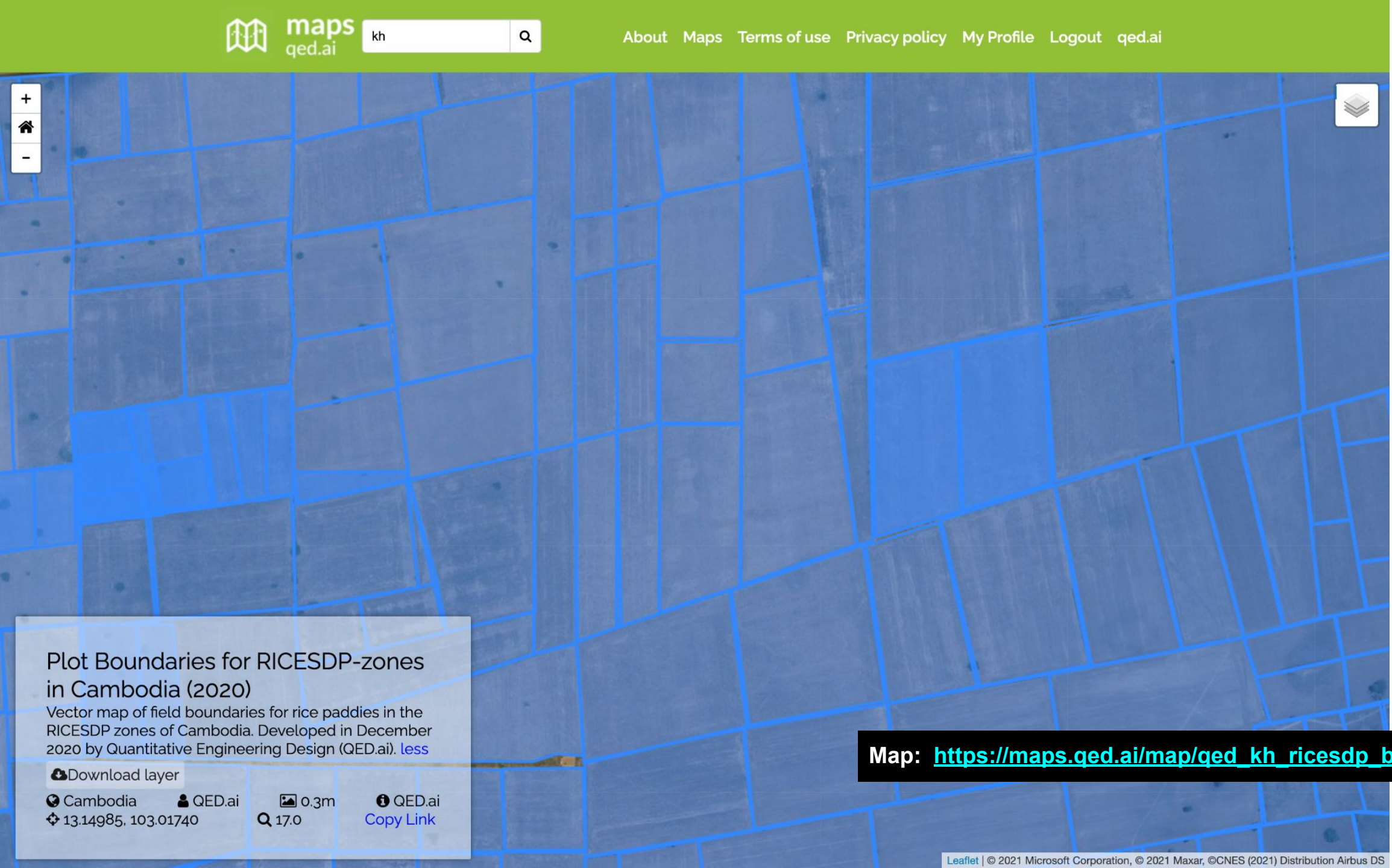
Map: https://maps.qed.ai/map/qed_kh_ricesdp_boundaries



Map: https://maps.qed.ai/map/qed_kh_ricesdp_boundaries



Map: https://maps.qed.ai/map/qed_kh_ricesdp_boundaries



Map: https://maps.qed.ai/map/qed_kh_ricesdp_boundaries

Plot Summary Statistics in Cambodia

Region Name	Number of Plots	Total Cropland Area [ha]	Average size of a Plot [ha]
Prey Sangha	2998	968.24	0.3229
Anglong Run	1933	1332.16	0.6892
Ta Mao	1443	911.42	0.6316
Chhuk Ksach	7427	1155.93	0.1556
Ta Soong	3264	1573.14	0.4819
Chamkar Kouy	8161	1852.14	0.2269
Ansong	5324	1269.92	0.2385
Rumlech	10253	2038.42	0.1988
Anlong Char	8093	1983.01	0.2450
Total	48896	13084.39	0.2675

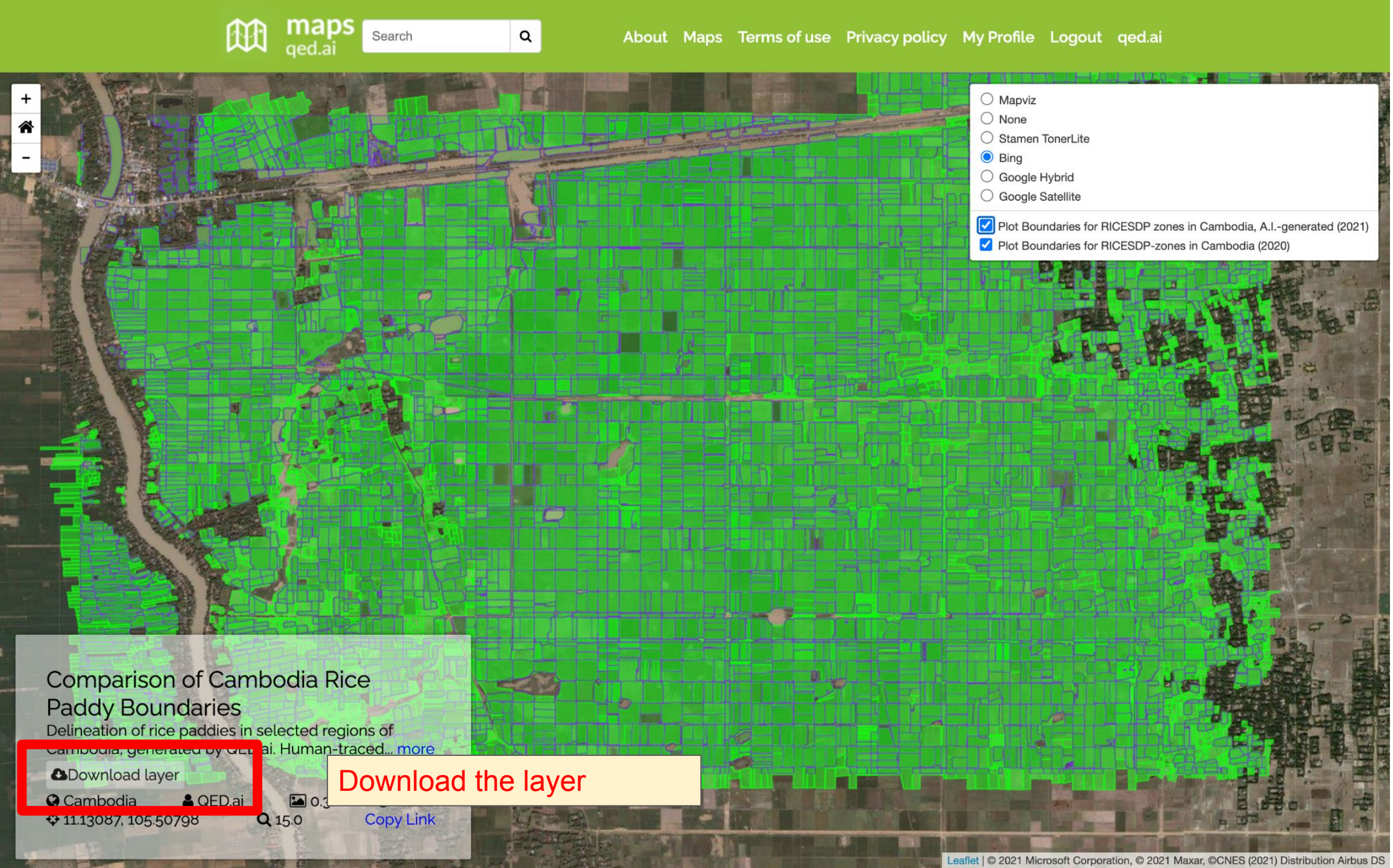
Let’s jump straight to the map

Lab: Inspect Data With QGIS

Steps:

1. Visit maps.qed.ai
2. Type “Cambodia”
3. Select “Cambodia Rice Paddy Boundaries”:

https://maps.qed.ai/map/qed_plot_boundaries_cambodia_split_region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None
Stamen TonerLite
Bing
Google Hybrid
Google Satellite
Plot Boundaries for RICESDP zones in Cambodia, A.I.-generated (2021)
Plot Boundaries for RICESDP-zones in Cambodia (2020)
Comparison of Cambodia Rice Paddy Boundaries
Delineation of rice paddies in selected regions of
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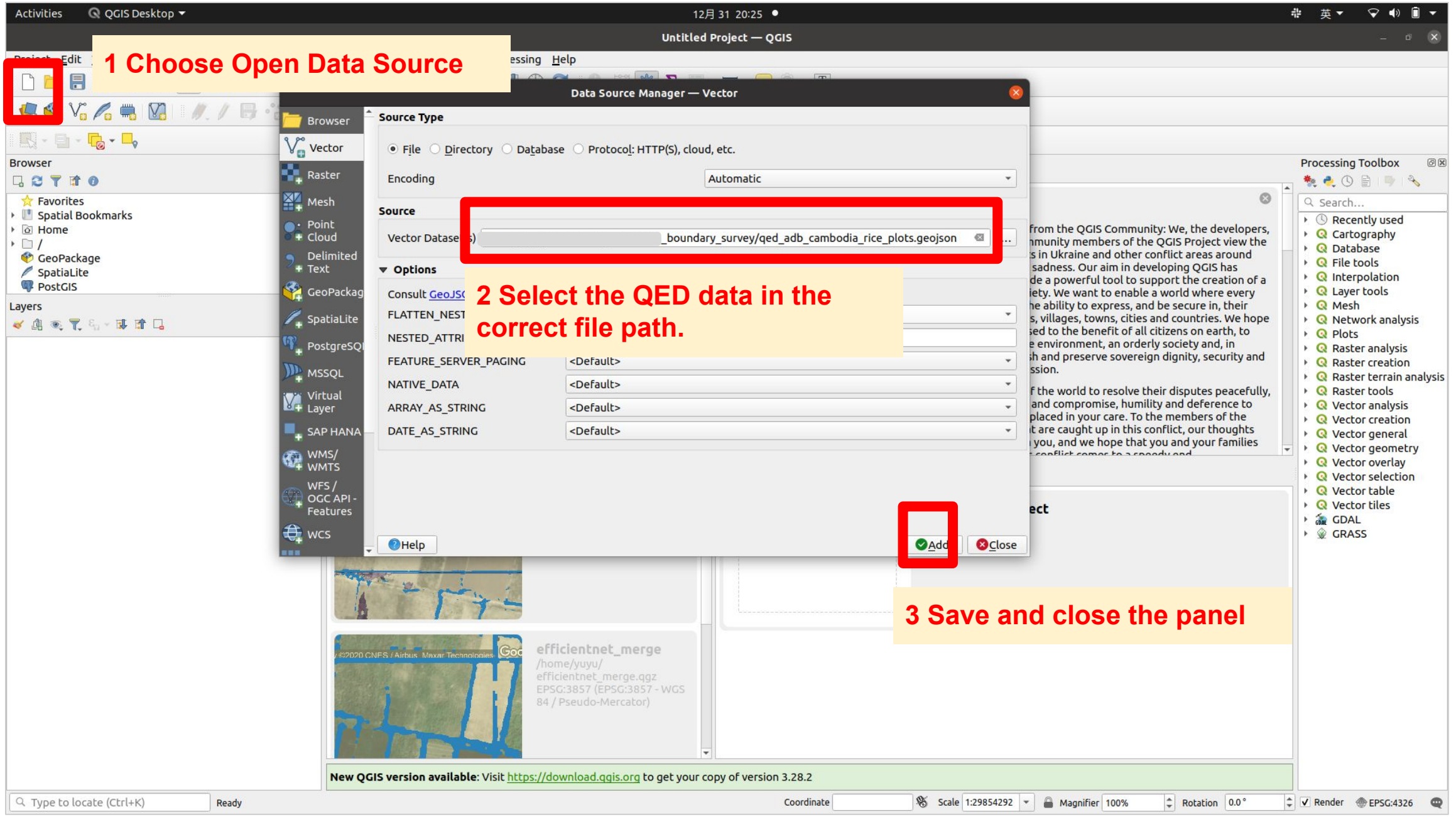
1 Choose Open Data Source
Data Source Manager — Vector
Source Type
File
Directory
Database
Protocol: HTTP(S), cloud, etc.
Encoding
Automatic
Source
Vector Dataset(s)
_boundary_survey/qed_adb_cambodia_rice_plots.geojson
Options
FLATTEN_NEST
NESTED_ATTRI
FEATURE_SERVER_PAGING
NATIVE_DATA
ARRAY_AS_STRING
DATE_AS_STRING
<Default>
2 Select the QED data in the correct file path.
Help
Add
Close
3 Save and close the panel
Browser
Vector
Raster
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Point Cloud
Delimited Text
GeoPackage
SpatiaLite
PostgreSQL
MSSQL
Virtual Layer
SAP HANA
WMS/ WMTS
WFS / OGC API - Features
WCS
Processing Toolbox
Recently used
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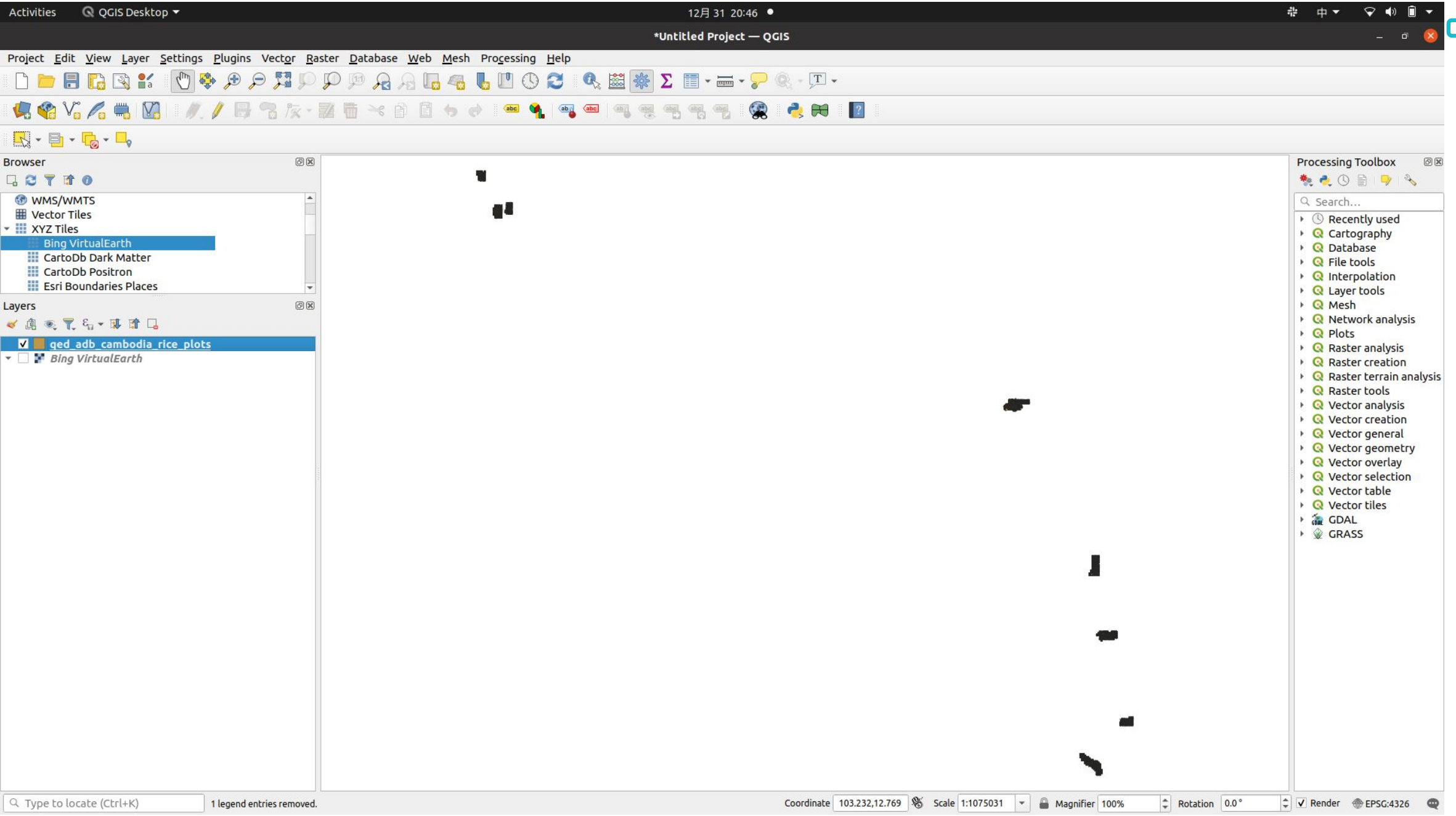
Raster analysis
Raster creation
Raster terrain analysis
Raster tools
Vector analysis
Vector creation
Vector general
Vector geometry
Vector overlay
Vector selection
Vector table
Vector tiles
GDAL
GRASS
efficientnet_merge
/home/yuyu/efficientnet_merge.qgz
EPSG:3857 (EPSG:3857 - WGS 84 / Pseudo-Mercator)
New QGIS version available: Visit https://download.qgis.org to get your copy of version 3.28.2


Activities
QGIS Desktop
12月 31 20:46
*Untitled Project — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Browser
WMS/WMTS
Vector Tiles
XYZ Tiles
Bing VirtualEarth
CartoDb Dark Matter
CartoDb Positron
Esri Boundaries Places
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Raster tools
Vector analysis
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Vector general
Vector geometry
Vector overlay
Vector selection
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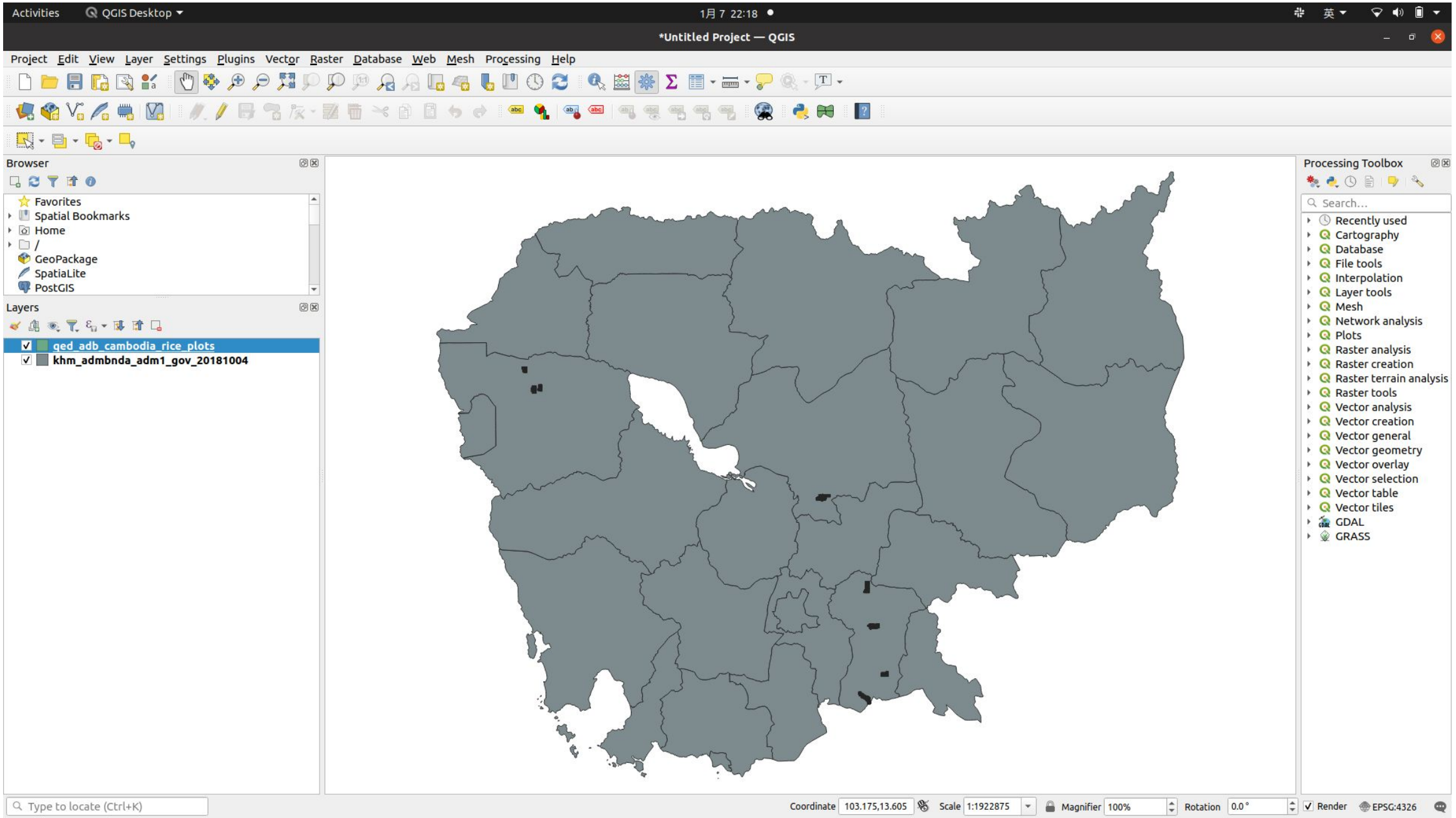
GDAL
GRASS
Type to locate (Ctrl+K)
1 legend entries removed.
Coordinate 103.232,12.769
Scale 1:1075031
Magnifier 100%
Rotation 0.0 °
Render
EPSG:4326


Activities
QGIS Desktop
1月 7 22:18
英
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khm_admbnda_adm1_gov_20181004
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Raster tools
Vector analysis
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Type to locate (Ctrl+K)
Coordinate 103.175,13.605
Scale 1:1922875
Magnifier 100%
Rotation 0.0 °
Render
EPSG:4326

Discussion, Questions and Answers

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email: maps@qed.ai