Crafting Technologies for Agriculture and Health

2019 November 17

William Wu <w@qed.ai>

Director of **QED** | https://qed.ai

- **Job: “Technologist”**

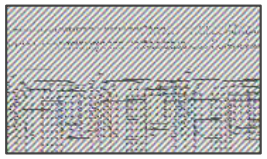
William Wu

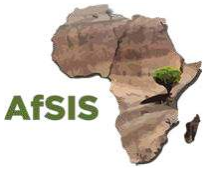
Ph.D. EE, M.S. Math (Stanford)
B.S. EECS (Berkeley)
Ex-NASA Jet Propulsion Lab

(first computer)

- **Past:**

- **Present:**





- **Why:**

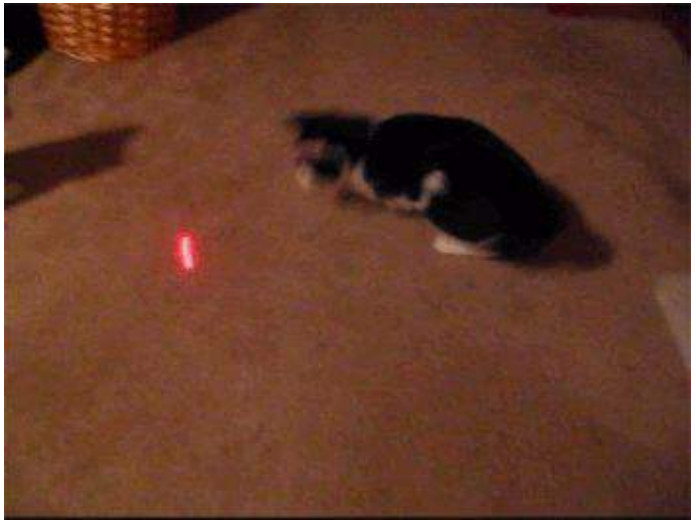
(SDGs)

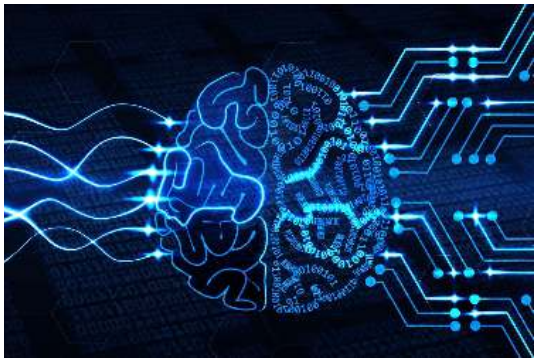
- **What: <u>Scale operations and lower costs with TECHNOLOGY.</u>**

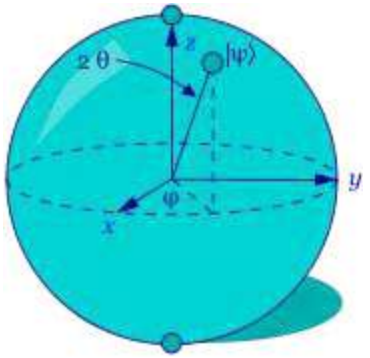
- **Goal #1**

Provide global perspective on using tech to address problems in ag and health.

- **Goal #2: Tech we need vs. Tech we don't**



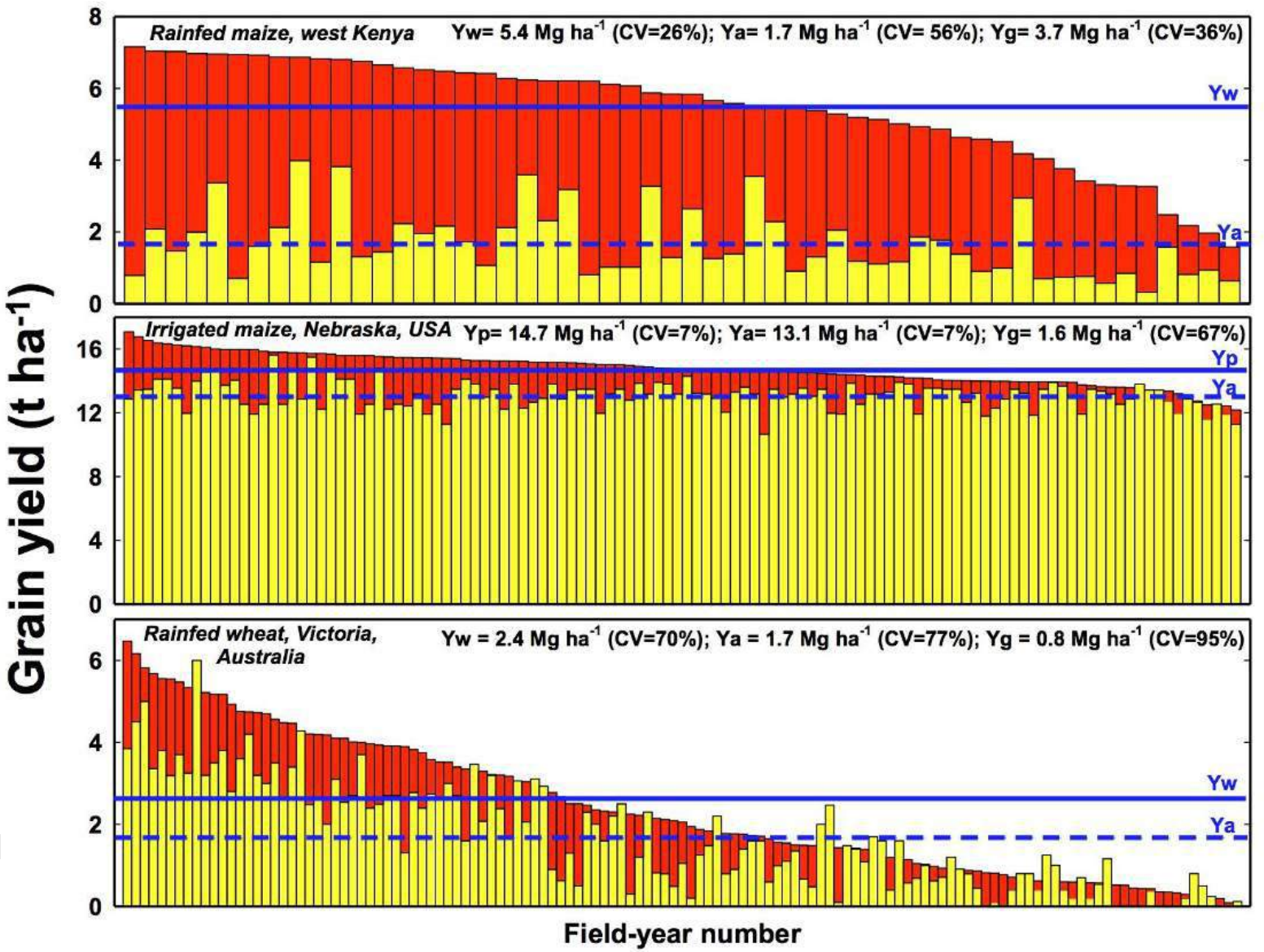




- **Goal #3: How to work together?**

Agriculture

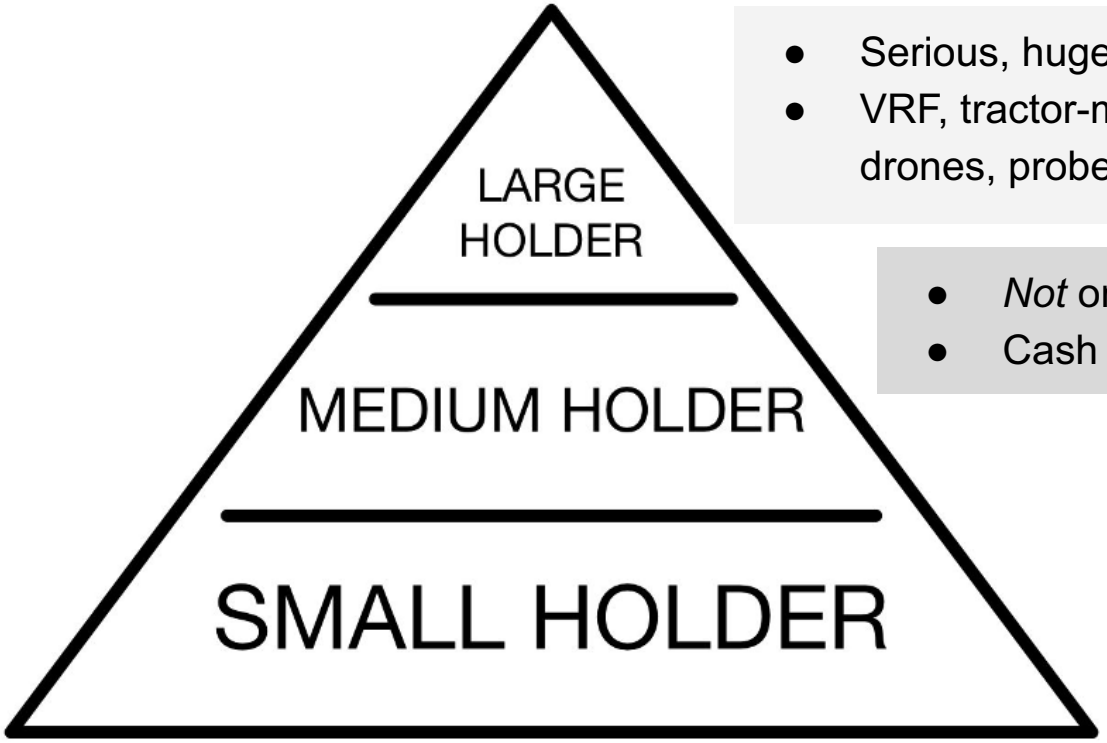
The Gap



yield gap

yield potential

(Ittersum 2013)



- Serious, huge farms with $$$$
- VRF, tractor-mounted spectrometers, drones, probes, soil labs, ...

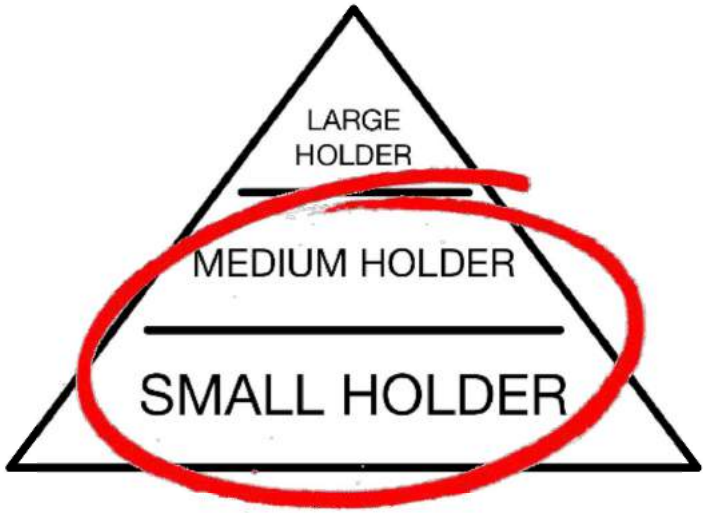
- *Not* originally farmers.
- Cash crops. Have some $$

- plot size < 2 ha
- **One-third of population (~2.5B)**
- 60-80% female
- Maize, wheat, rice, cassava ...
- 84% of farms *
- 24% of agricultural area **
- **30-34% of world food supply ****
- **80% of 3rd world food supply**
- income: $1-2 / day

- ~1B hectares of African arable land is **uncultivated**
  - e.g. TZ: 44M ha arable, only 33% cultivated
- SSA: 20% of arable land, 2% of fertilizers at 17 kg/ha

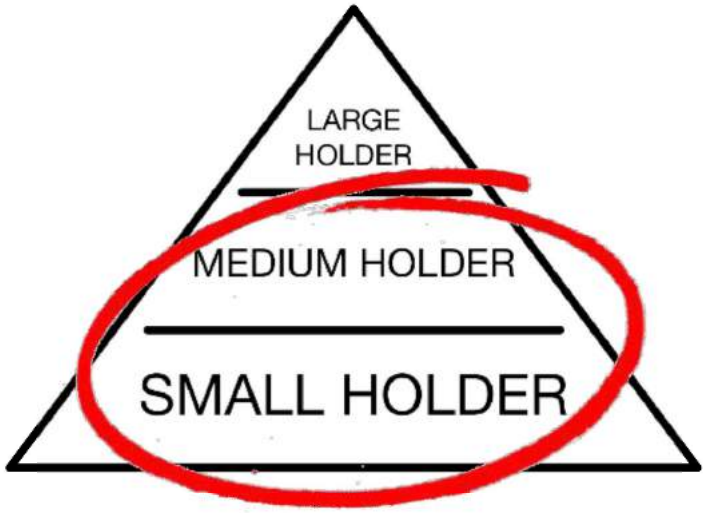
*: Lowder 2016, “The number, size, and distribution of farms, smallholder farms, and family farms worldwide” China: 98%, India: 80%, Ethiopia: 90%, Mexico: 50%, Brazil: 20% -- FAO, “The economic lives of smallholder farmers”

**: Riccardi 2018, “How much of the world's food do smallholders produce?” (often 70% is claimed somehow)



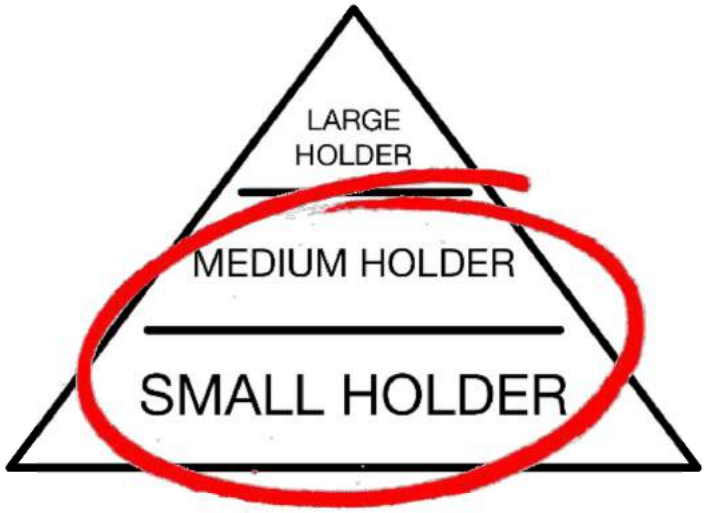
Huge untapped markets!
BUT ... do you dare enter?

- *"He will win who knows when to fight and when not to fight."*
- *"The general who wins the battle makes many **calculations** in his temple before the battle is fought. The general who loses makes but few calculations beforehand."*
- *"To hell with circumstances. I create opportunities!"*



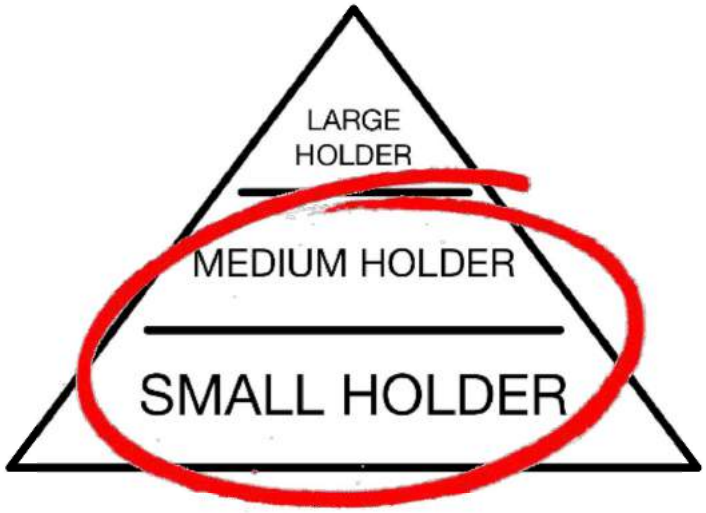
CALCULATIONS

- Where are these farmers?
  - Croplands
  - Houses
- What's their farm like?
  - Size
  - Crop types
  - Finances



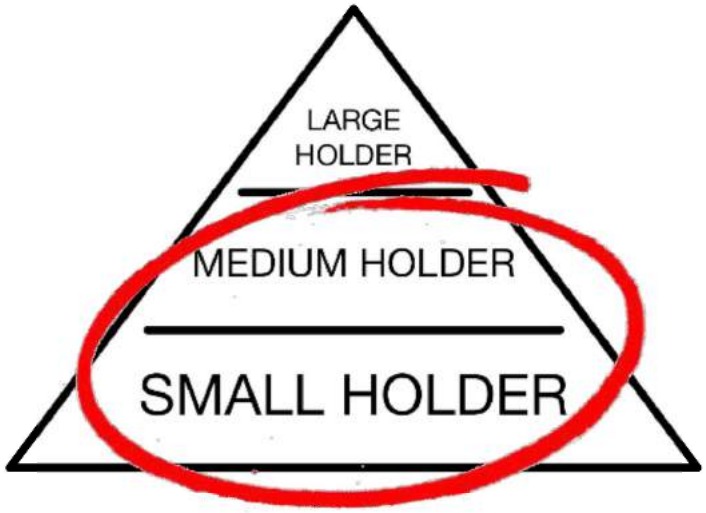
CALCULATIONS

- What fertilizer do they need?
  - Soil health
    i. Macro
    ii. Micro
    iii. Biologicals
    iv. Acidity *
  - Optimal blends
  - Availability
    i. suppliers + agro-dealers
    ii. govt. policy



CALCULATIONS

- How to facilitate sales?
  - Aggregators + distribution
  - Outgrower schemes
- How to advise and monitor?
  - Crop health surveillance
  - Sensors
  - Support hotlines
  - Extension agents



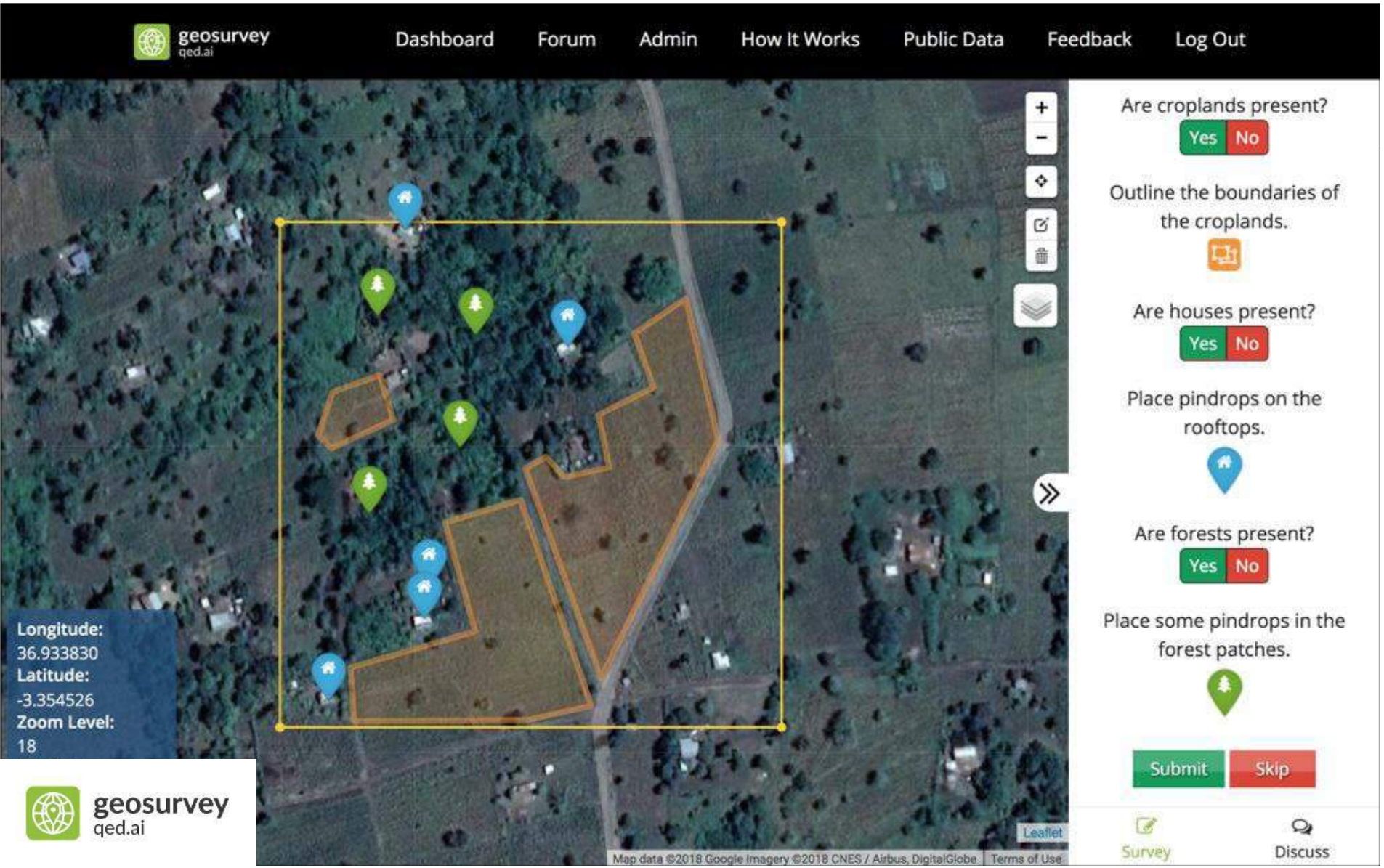
CALCULATIONS

- How to provide good seeds?
  - Genotyping
  - Phenotyping
  - Adulteration detection

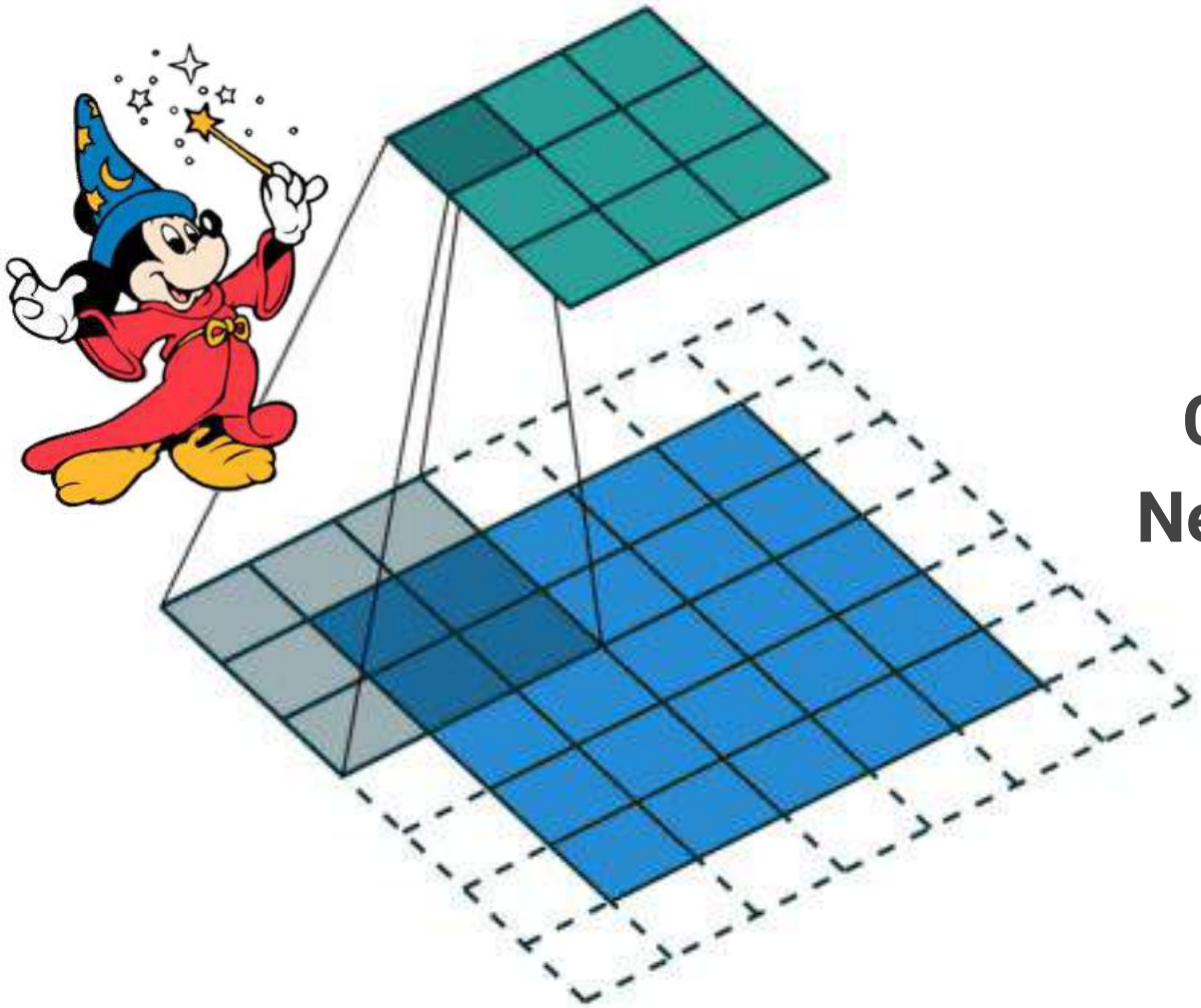
Where are the farmers and crops?

geosurvey
qed.ai

Scalably annotate any imagery (for AI).
https://geosurvey.qed.ai

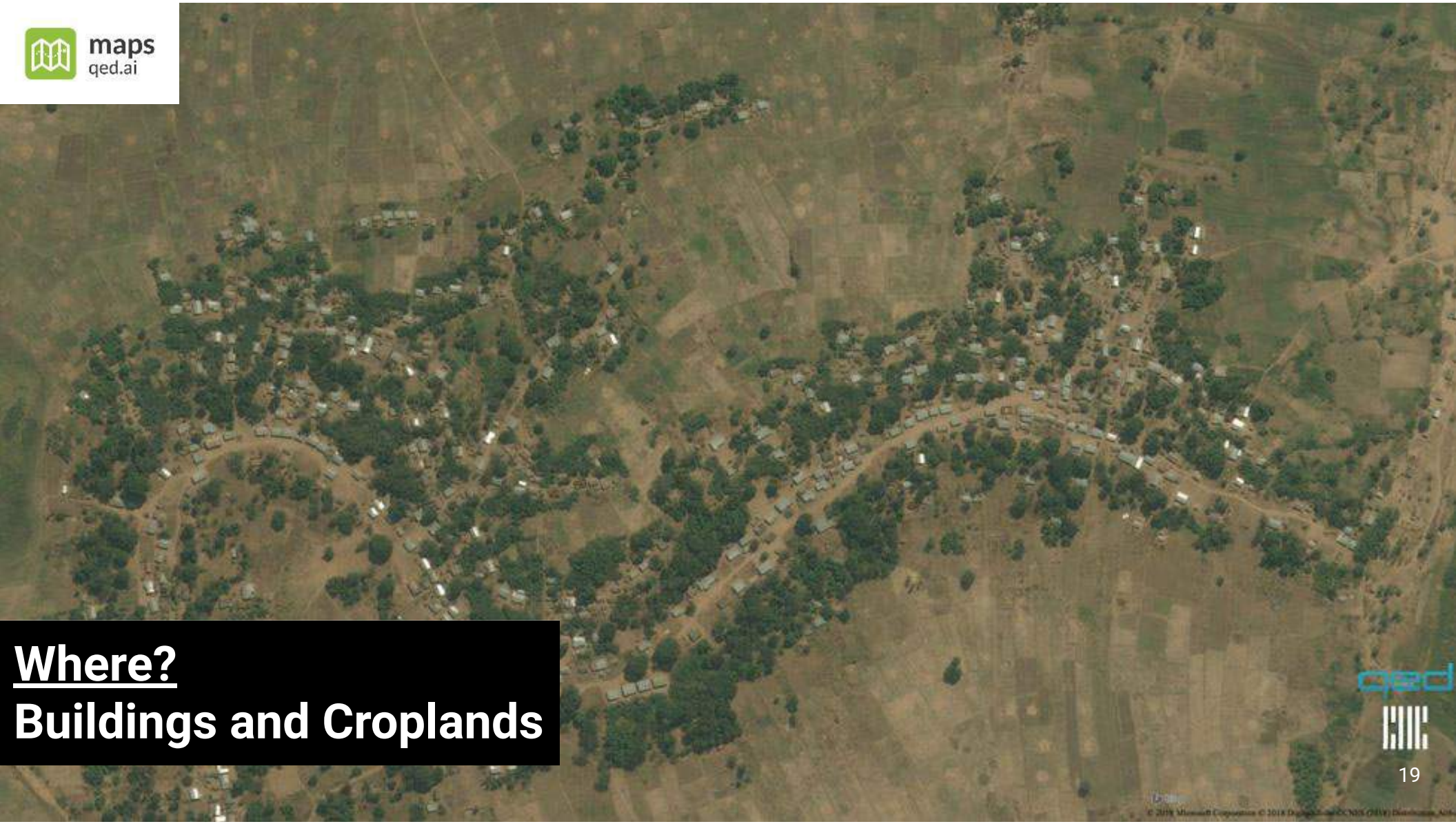


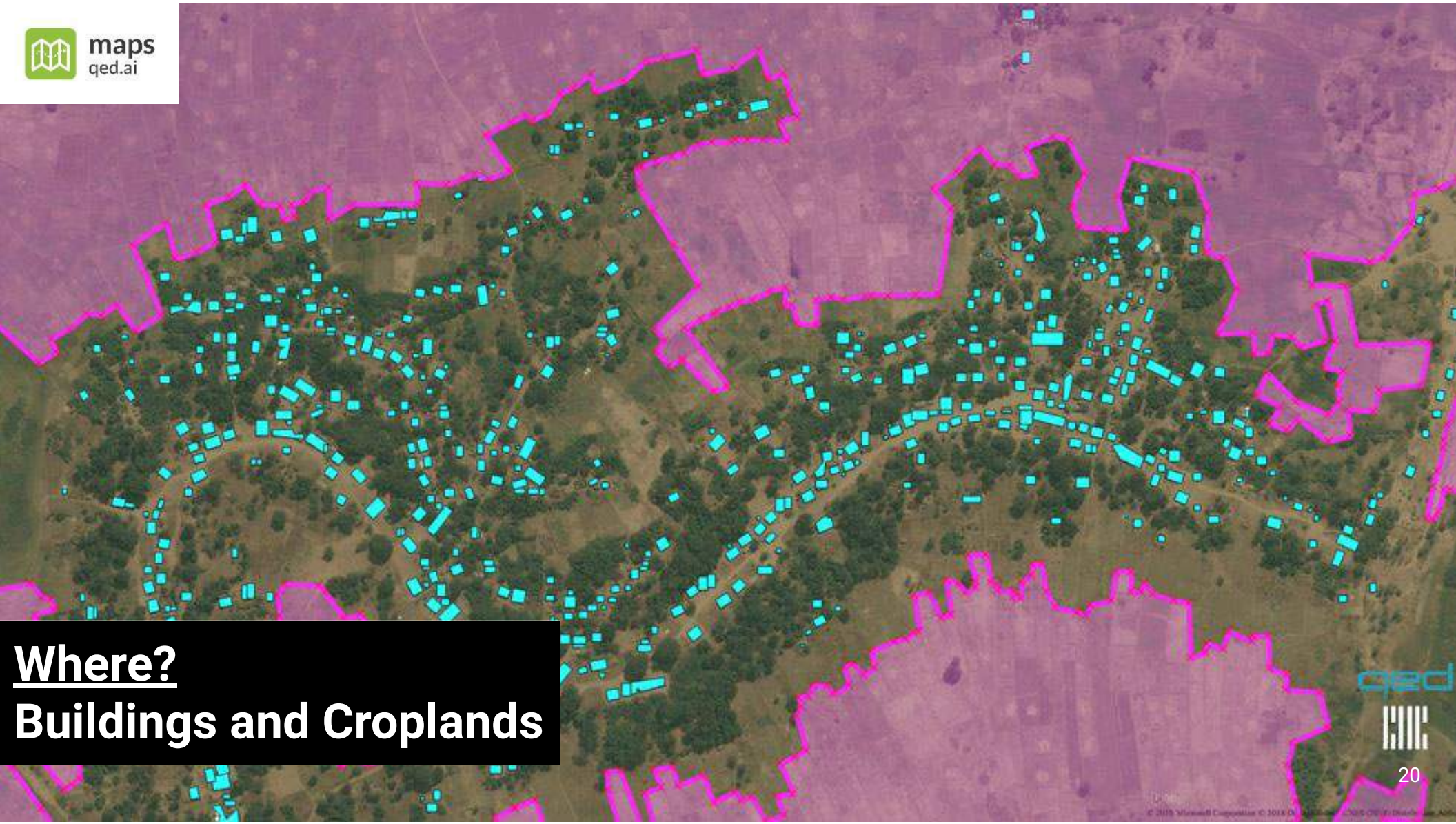
geosurvey
qed.ai



Convolutional Neural Networks

Deep Learning


maps
qed.ai
Where?
Buildings and Croplands



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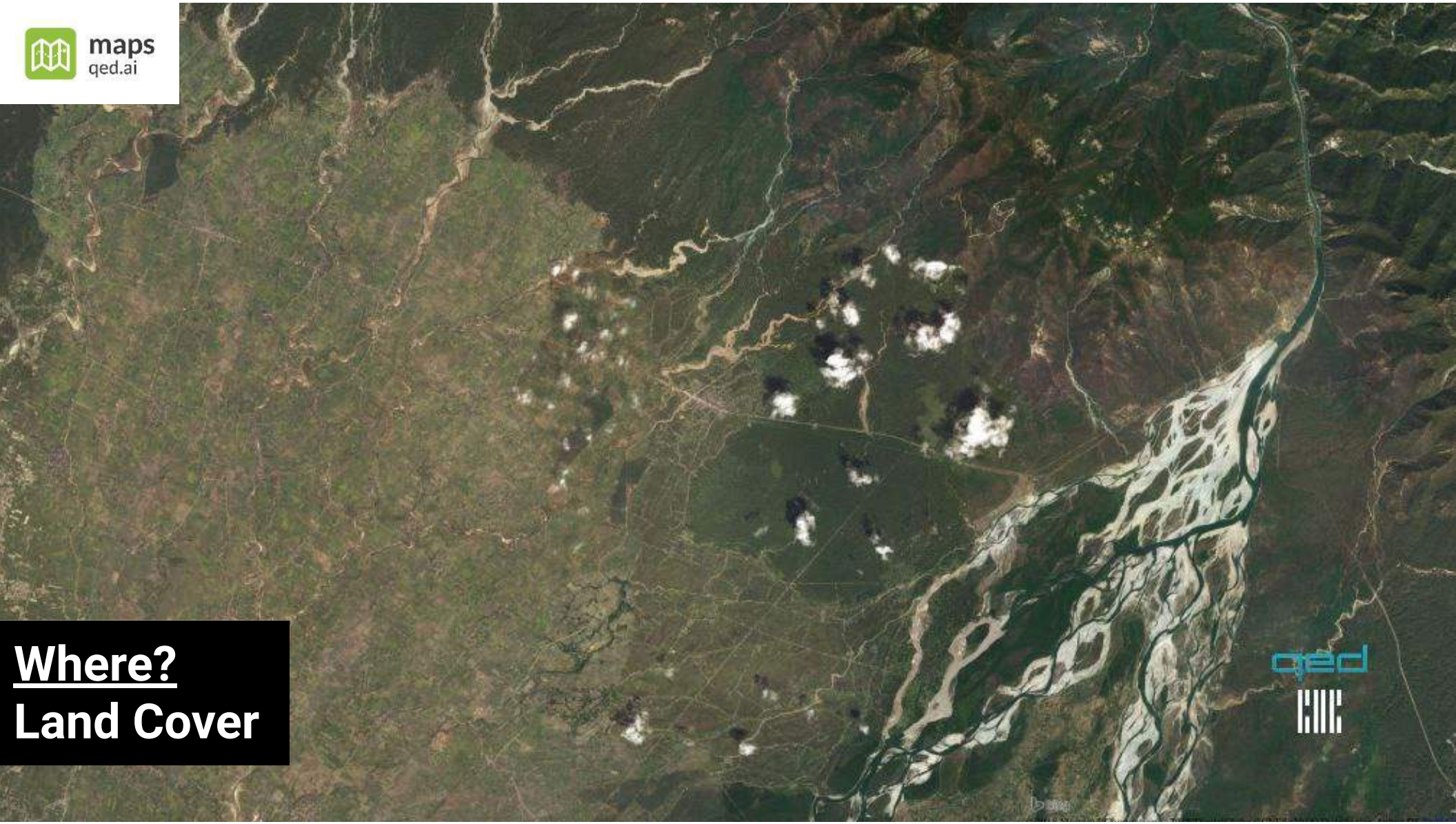
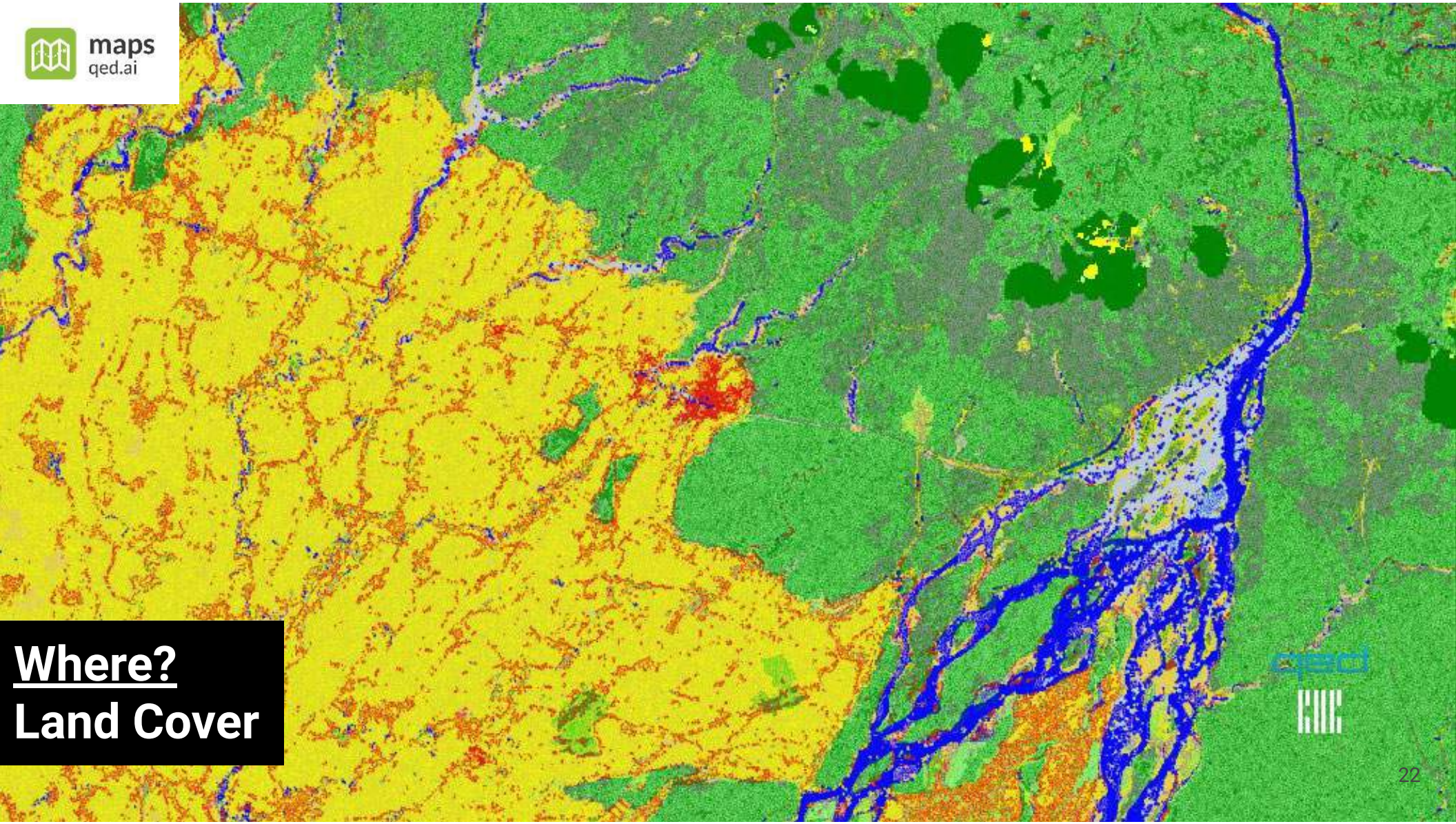
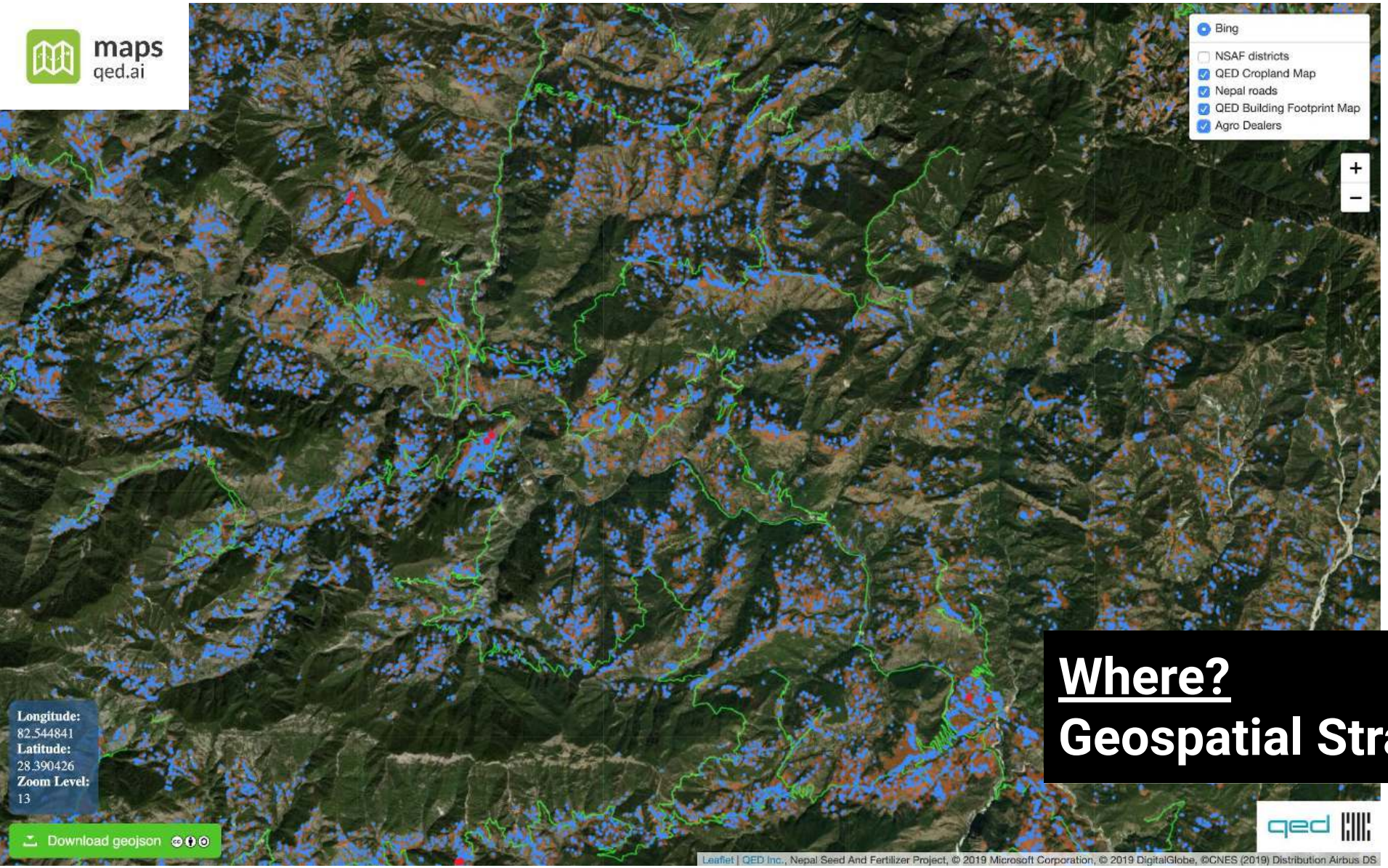
Buildings and Croplands


maps
qed.ai
Where?
Land Cover

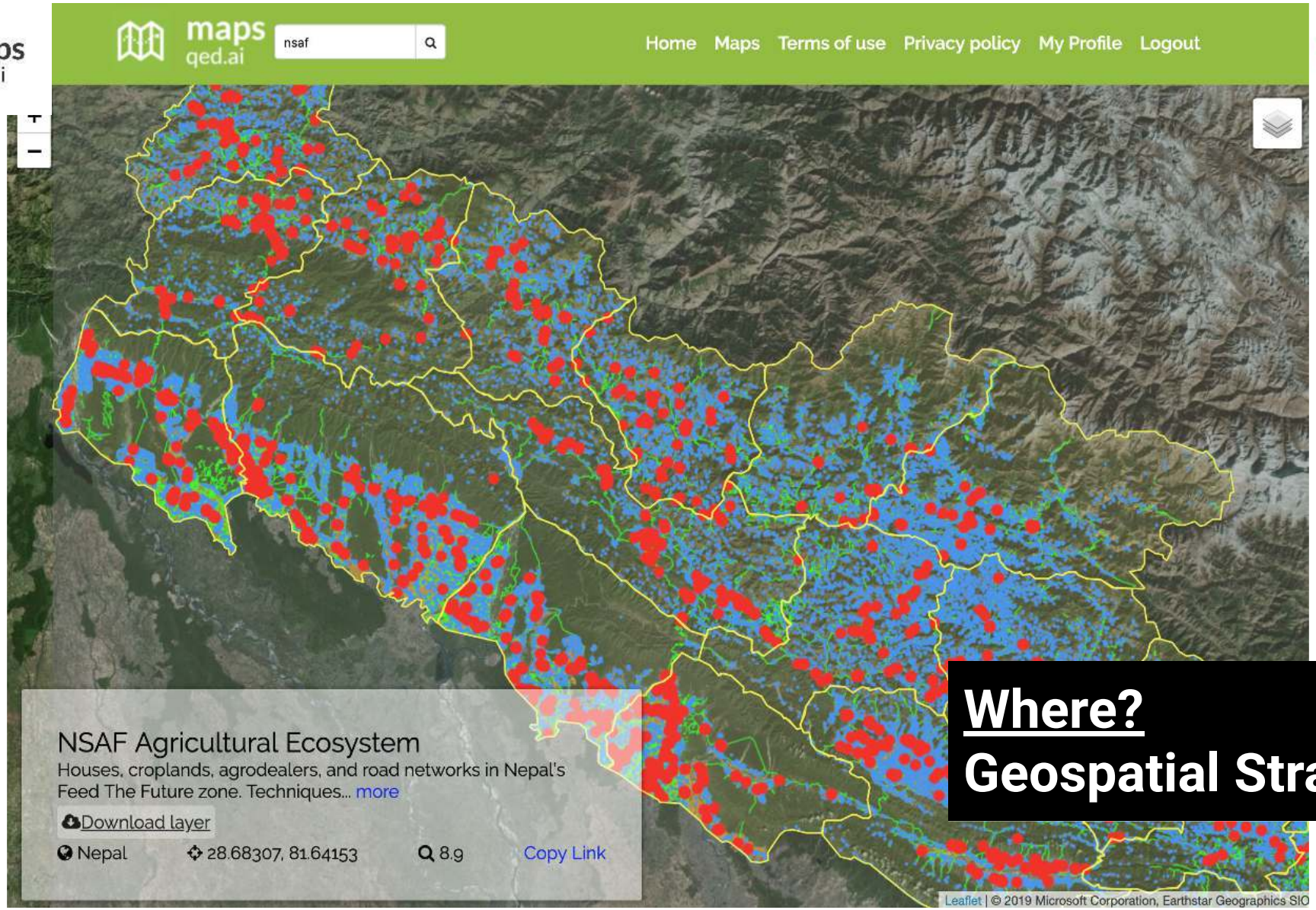
maps
qed.ai



Where?
Land Cover

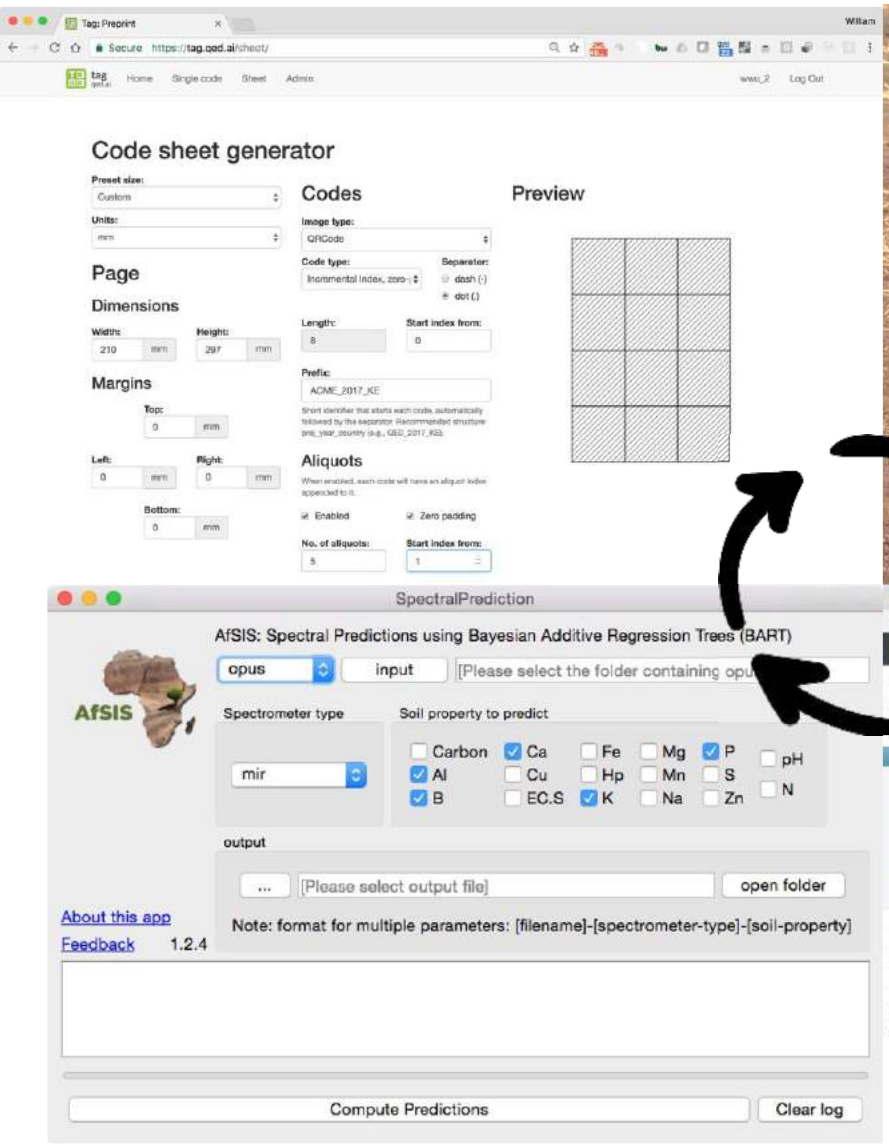


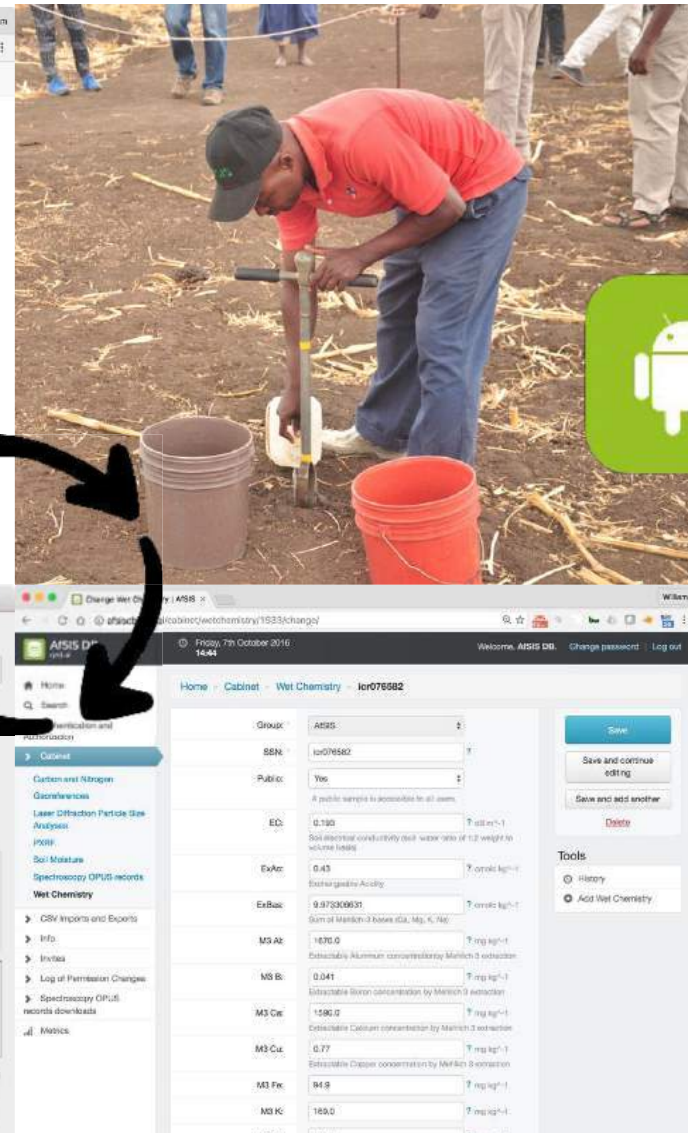
Where?
Geospatial Strategy



Where?
Geospatial Strategy

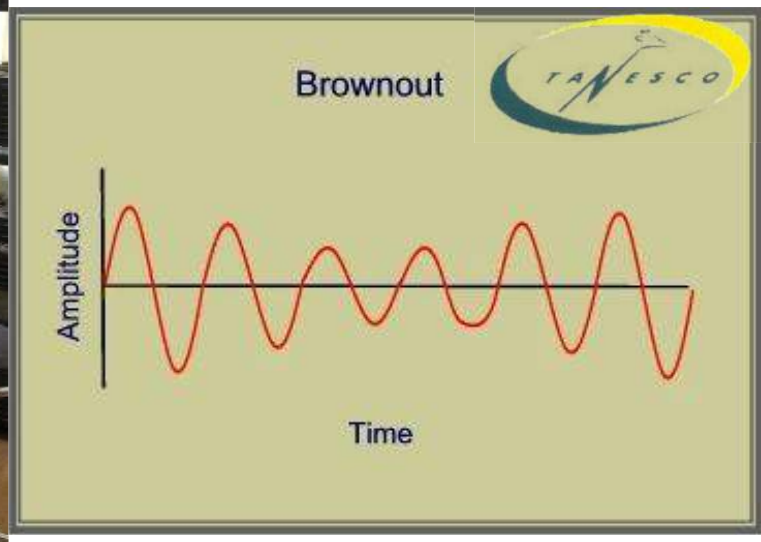
What’s their soil like?



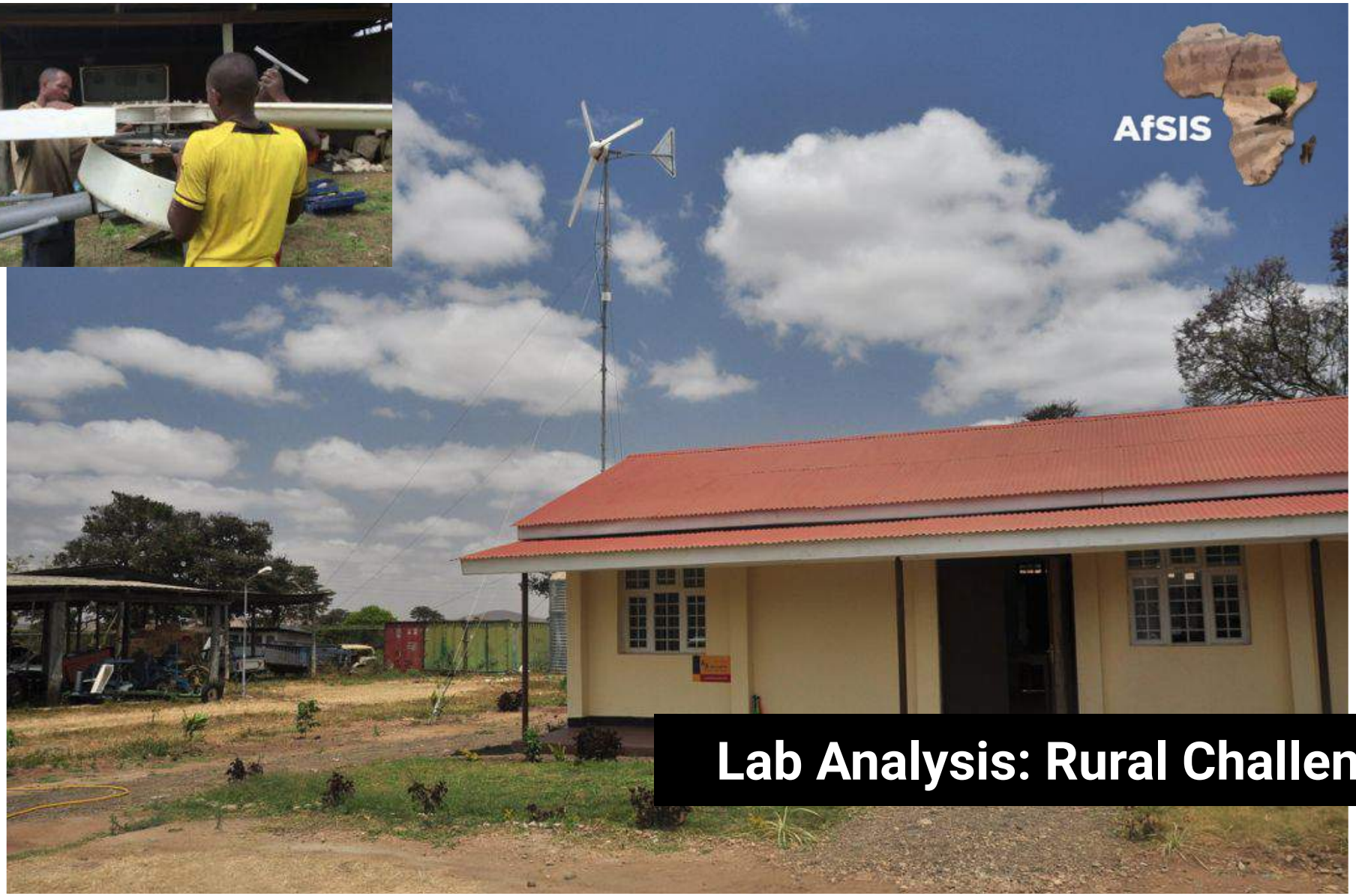


Field-to-Lab

- Barcoding
- Sampling
- Surveys
- LIMS
- Analysis



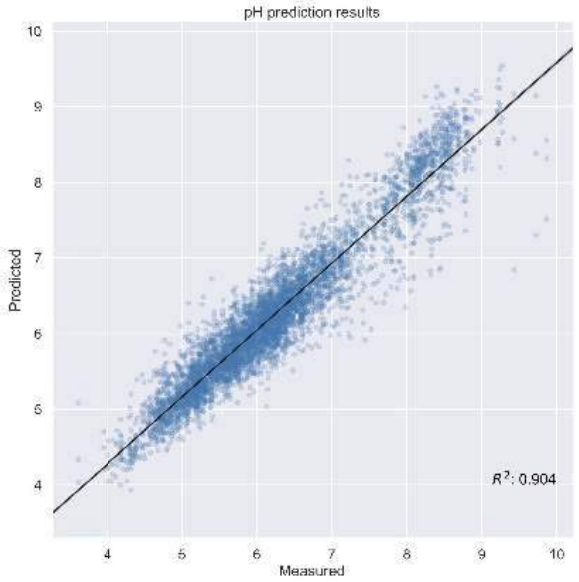
Challenges of Labs in Rural Areas

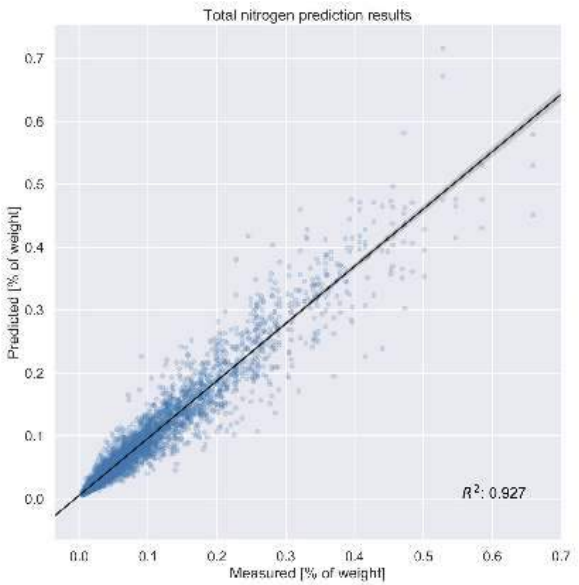


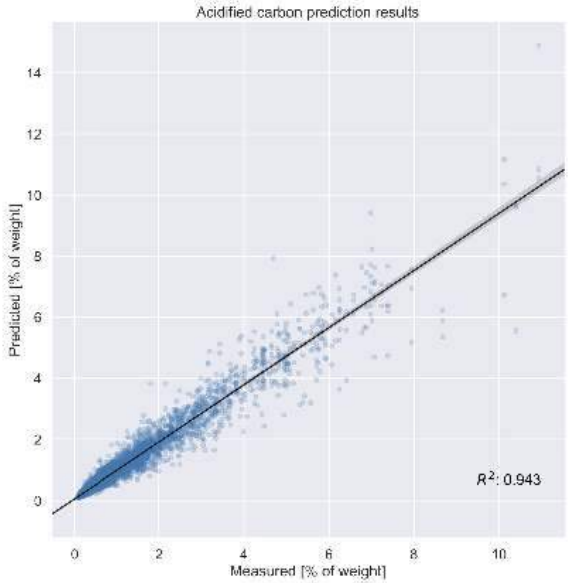
Lab Analysis: Rural Challenges

R^2 Values: MIR vs. Wet Chem

Acidified.Carbon: 0.9088957 *
m3.Al: 0.89998
pH: 0.898851
m3.Ca: 0.867247 *
Total.Nitrogen: 0.8357734 *
m3.Mg: 0.7831268 *
m3.Hp: 0.716419
m3.B: 0.712866 *
m3.Cu: 0.6225734
m3.S: 0.6402575 *
m3.Mn: 0.5416367 *
m3.Na: 0.5564027
m3.Fe: 0.4624206
m3.K: 0.4587326 *
m3.EC.S: 0.3556439
m3.Zn: 0.294272 *
m3.P: 0.2575507 *







$$$$
500K

$$$
50K

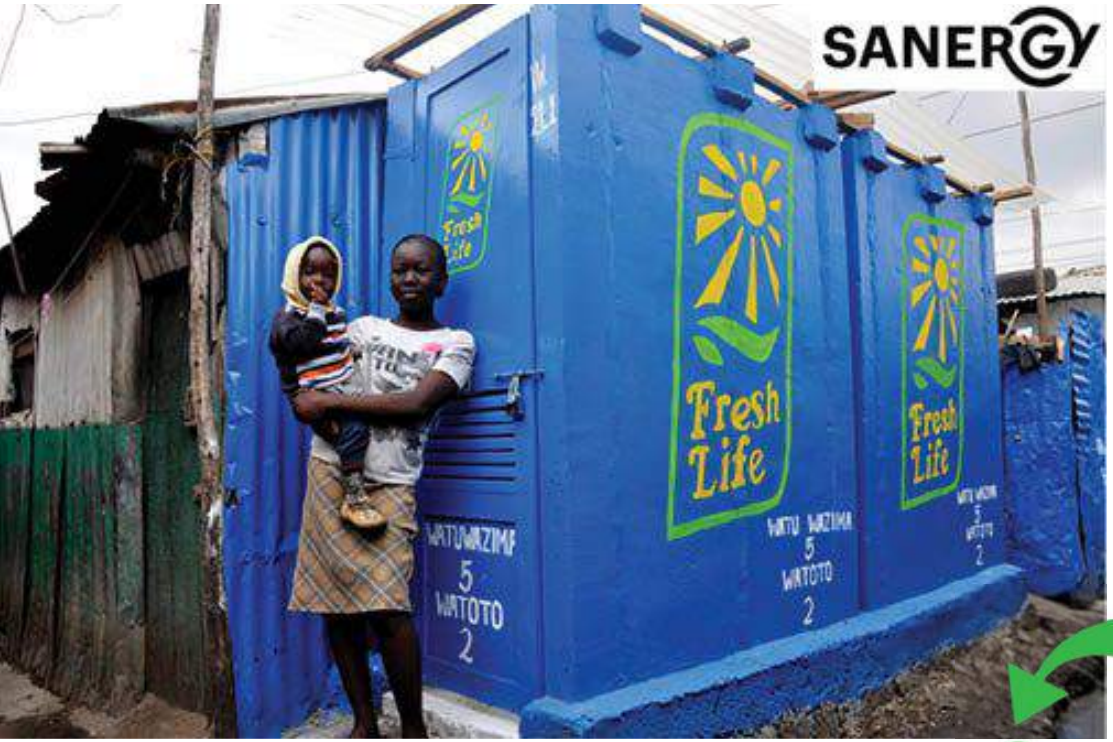
Field-to-Lab

$
.5K?

Lab-to-Field

$
.5K?

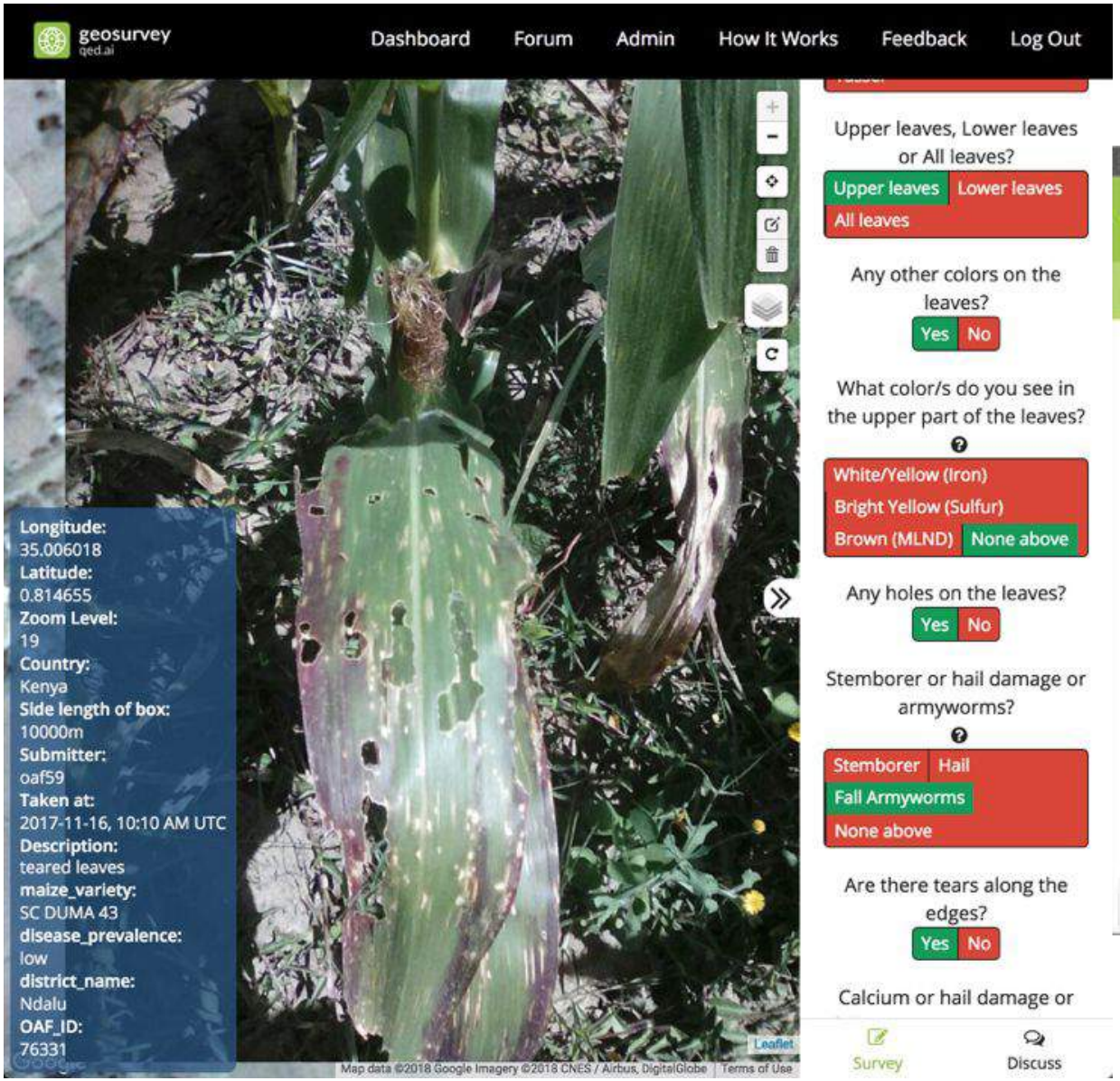
ScanSpectrum
qed.ai



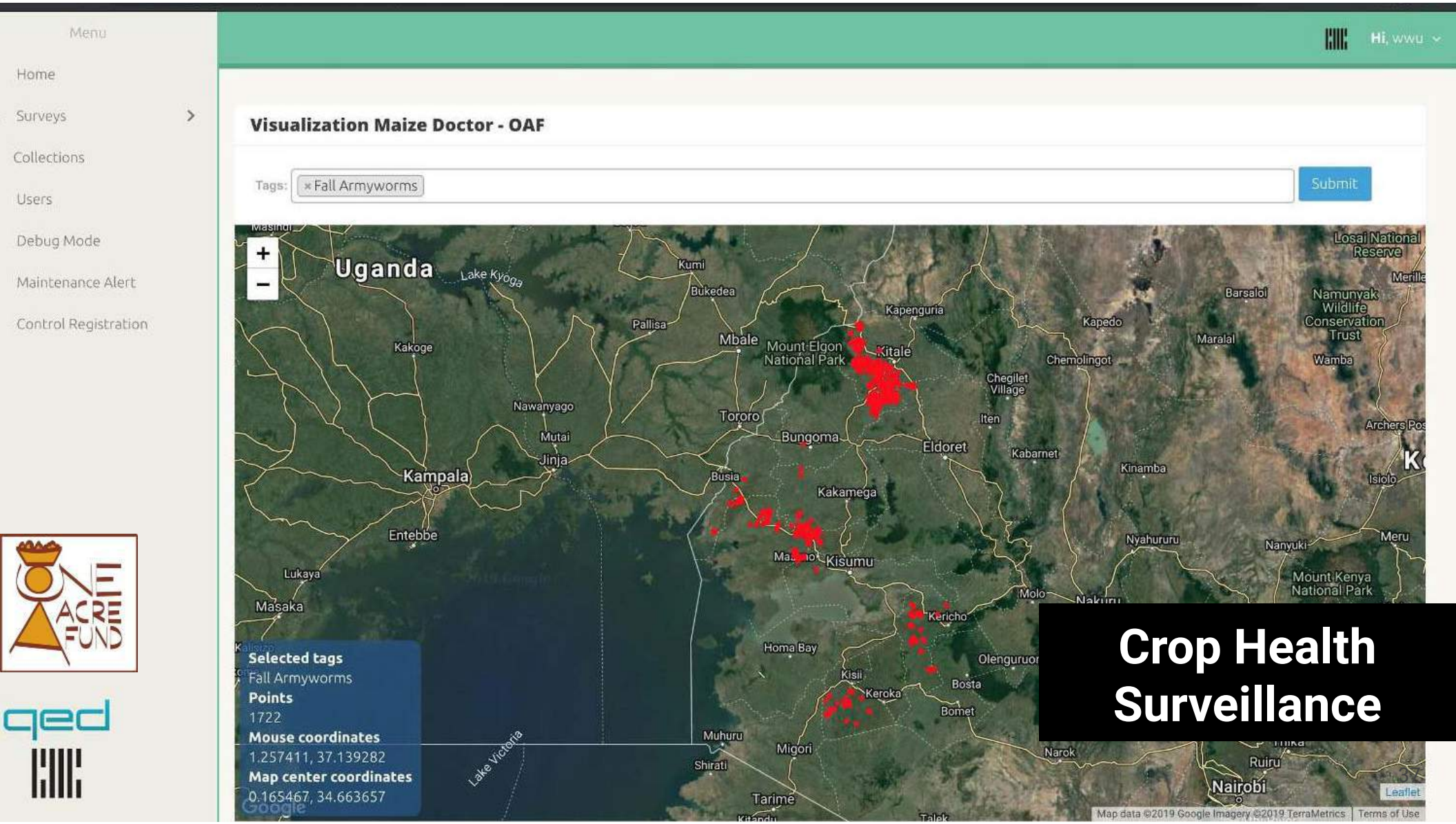
SANERGY

How to advise and monitor?

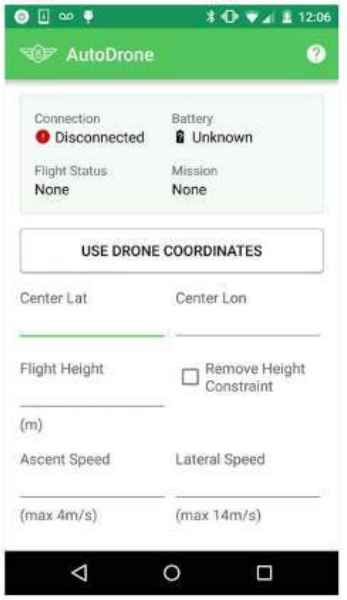
Visual Analysis

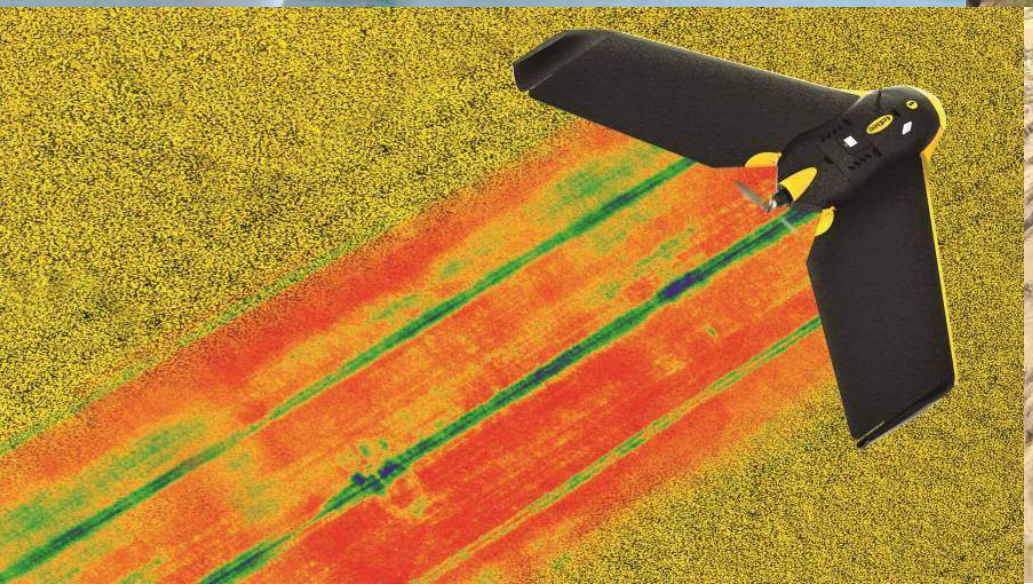


Visual Analysis


Menu
Home
Surveys
Collections
Users
Debug Mode
Maintenance Alert
Control Registration
Hi, wwu
Visualization Maize Doctor - OAF
Tags:
Fall Armyworms
Submit
Uganda
Lake Kyoga
Kampala
Entebbe
Jinja
Mutai
Nawanyago
Kakoge
Lukaya
Masaka
Kumi
Bukedea
Pallisa
Mbale
Mount Elgon National Park
Kapenguria
Kitale
Kapedo
Chemolingot
Maralal
Barsaloi
Losai National Reserve
Namunyak Wildlife Conservation Trust
Wamba
Chegilet Village
Iten
Tororo
Bungoma
Busia
Eldoret
Kabarnet
Kinamba
Isiolo
Archers Post
Kakamega
Kisumu
Nyahururu
Nanyuki
Meru
Mount Kenya National Park
Molo
Nakuru
Kericho
Homa Bay
Olenguruoi
Kisii
Keroka
Bosta
Bomet
Muhuru
Migori
Shirati
Lake Victoria
Narok
Ruiru
Nairobi
Tarime
Selected tags
Fall Armyworms
Points
1722
Mouse coordinates
1.257411, 37.139282
Map center coordinates
0.165467, 34.663657
Google
Leaflet
Map data ©2019 Google Imagery ©2019 TerraMetrics
Terms of Use
Crop Health Surveillance

pab


12:06
AutoDrone
Connection
Disconnected
Battery
Unknown
Flight Status
None
Mission
None
USE DRONE COORDINATES
Center Lat
Center Lon
Flight Height
Remove Height Constraint
(m)
Ascent Speed
Lateral Speed
(max 4m/s)
(max 14m/s)



Landscapes

Mini Weather Station

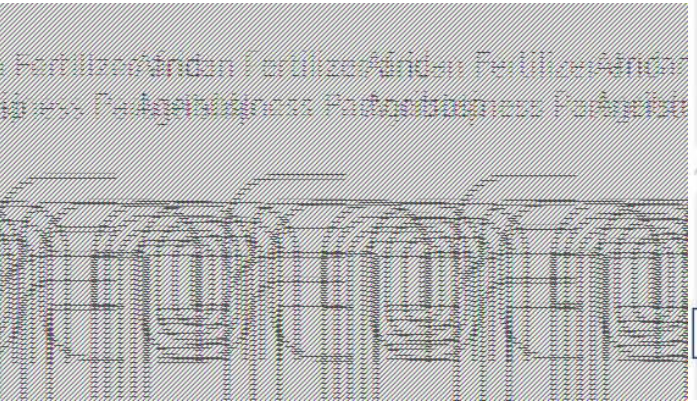
Arable Mark 2

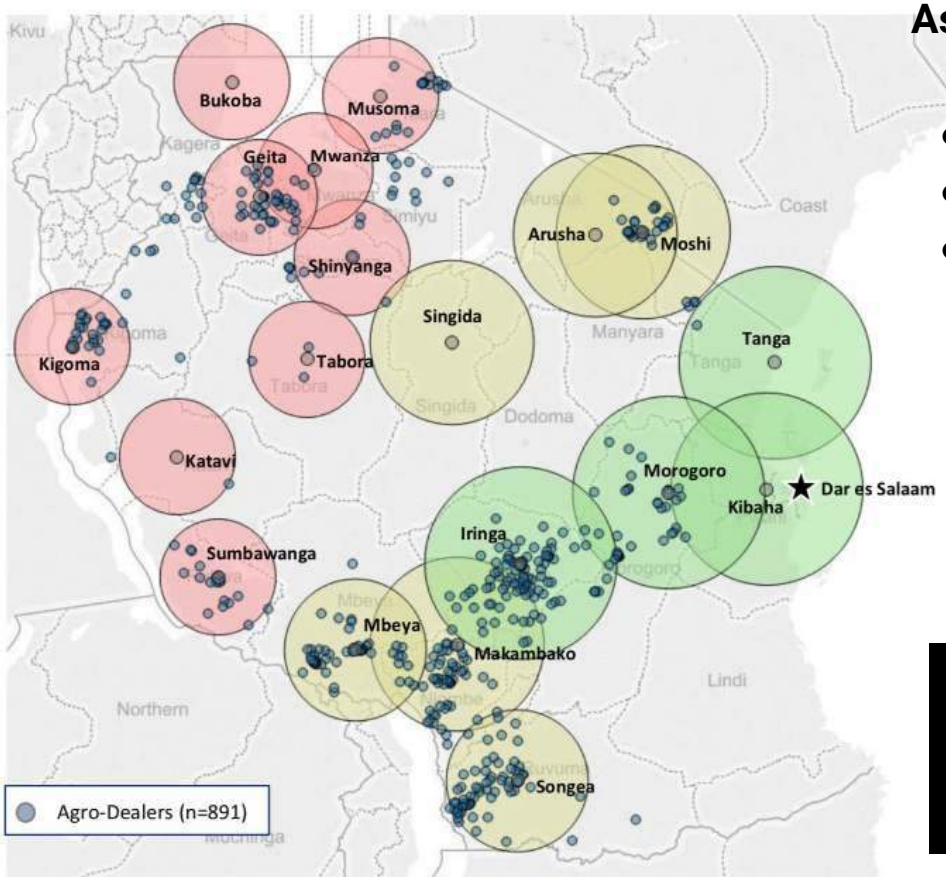
- Thermal and acoustic sensors replace laborious rain gauges and sap flow methods
- Rainfall: 0.2mm/hr accuracy
- Hourly water stress, daily leaf water potential
- Radiation, temp, wind, soil moisture, etc.

How to facilitate sales?

Wholesale Agro-dealers ("Hubs")

- Aggregate demand
- Few points of sale
- Local agronomist
- Storage capacity
- Lower default risk





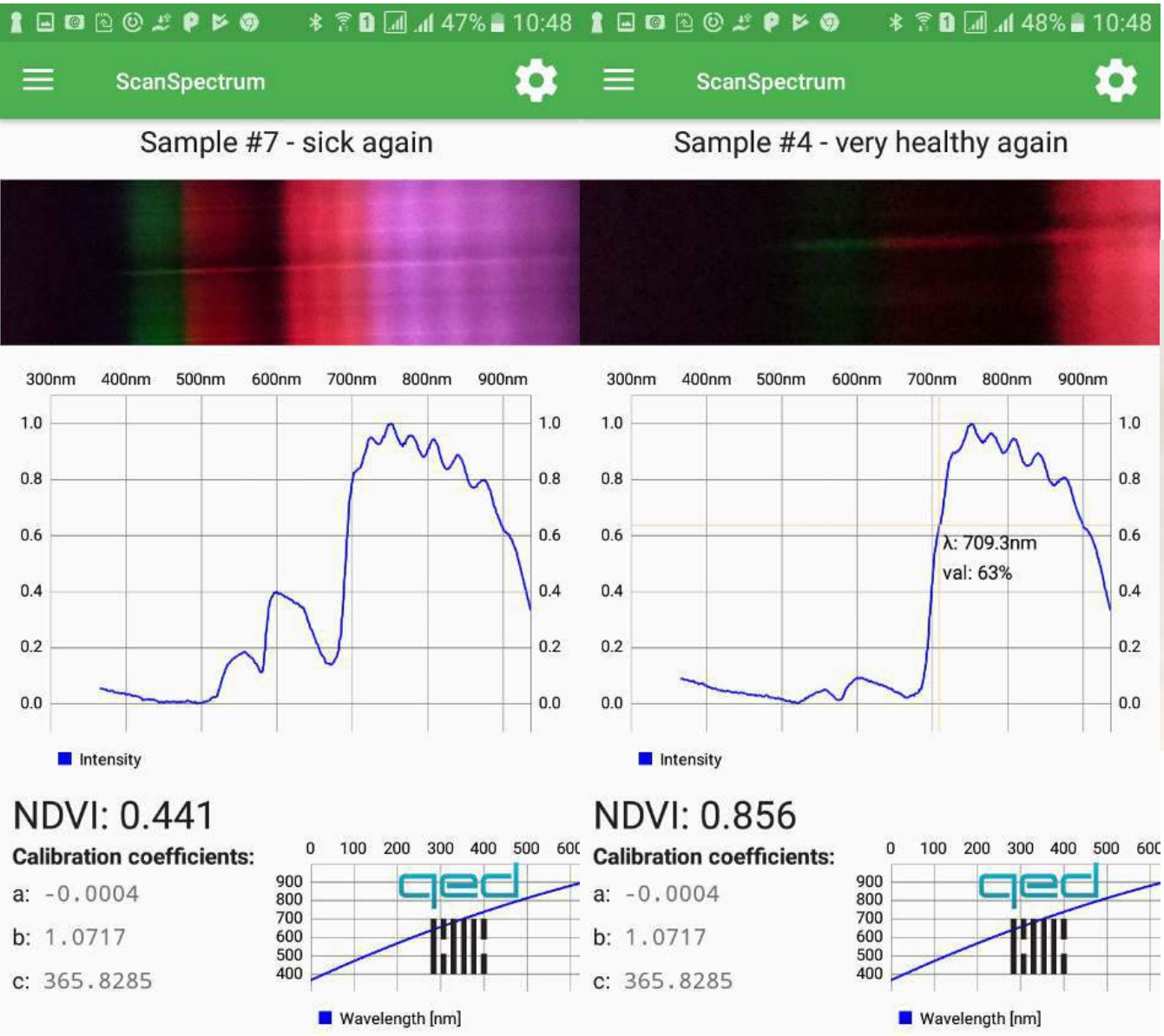
Assistance

- Credit guarantees
- Matching grants
- Policy (AMOFERT)

Value Chains And Policy

How to provide good seeds?

Breeding

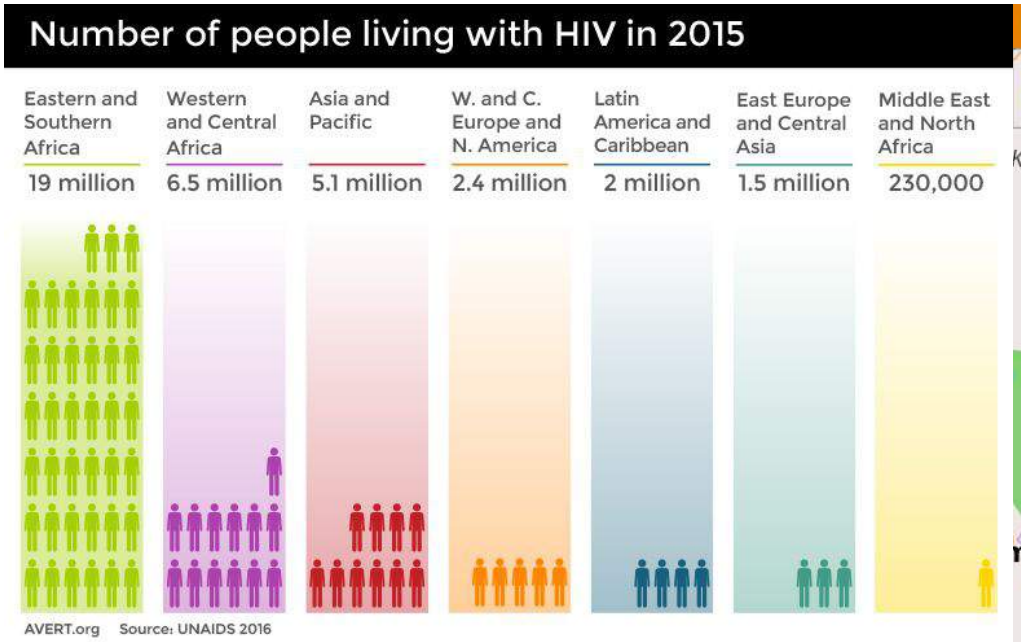

47% 10:48
ScanSpectrum
Sample #7 - sick again
300nm 400nm 500nm 600nm 700nm 800nm 900nm
1.0
0.8
0.6
0.4
0.2
0.0
Intensity
NDVI: 0.441
Calibration coefficients:
a: -0.0004
b: 1.0717
c: 365.8285
0 100 200 300 400 500 600
900
800
700
600
500
400
Wavelength [nm]
48% 10:48
ScanSpectrum
Sample #4 - very healthy again
λ: 709.3nm
val: 63%
NDVI: 0.856
Calibration coefficients:
a: -0.0004
b: 1.0717
c: 365.8285

Breeding

WorldVeg

Inspirations from Health

Direct Delivery



Drug Delivery

Active Surveillance

PROBLEM

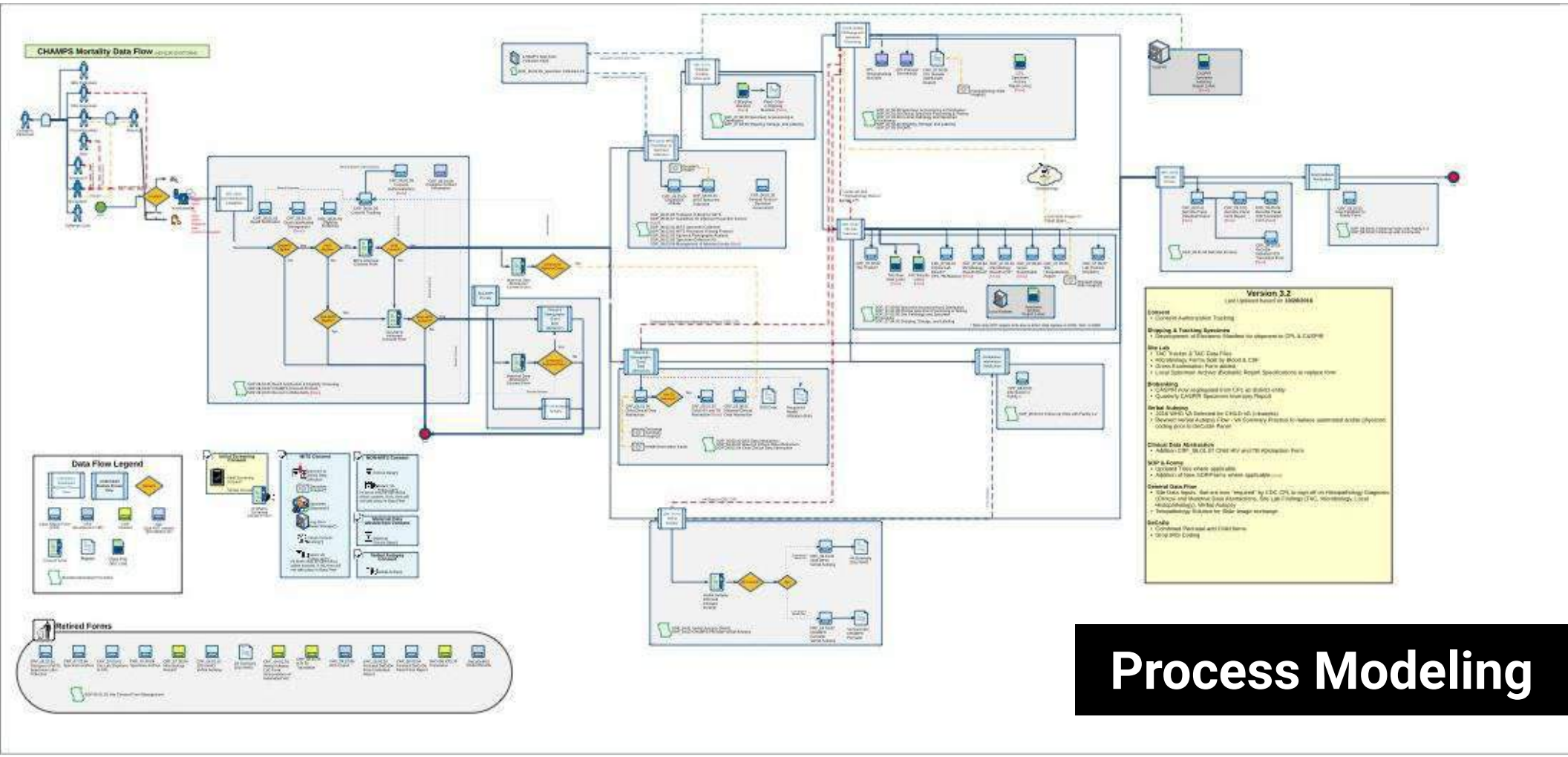
- <5 deaths/yr = 5.6 M, mostly in SSA
- Why?

APPROACH

- At high-mortality sites:
  - Get consent from parents in 24 hrs
- Collect ***everything***:
  - HIV, TB, Malaria ...
  - PCR, CSF, Pathology ...
  - MITS and verbal autopsy ...
  - Demographics ...
- Objective: **Determine Cause of Death**
- Duration: **20 years**

epidemic	Kisumu	US (%)
<5	**10**	0.6
TB	0.6	0.003
HIV	20-25	0.3

CHAMPS



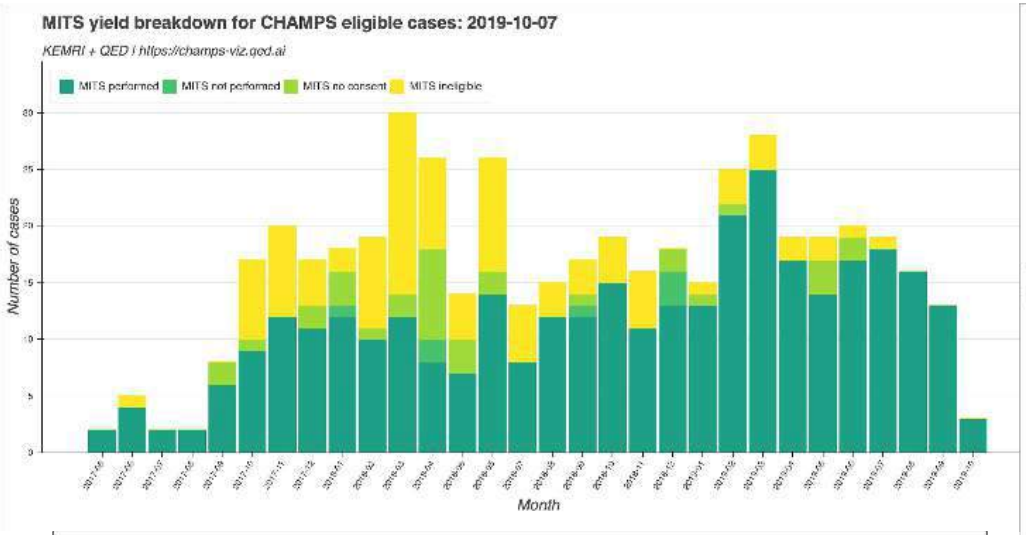
Process Modeling

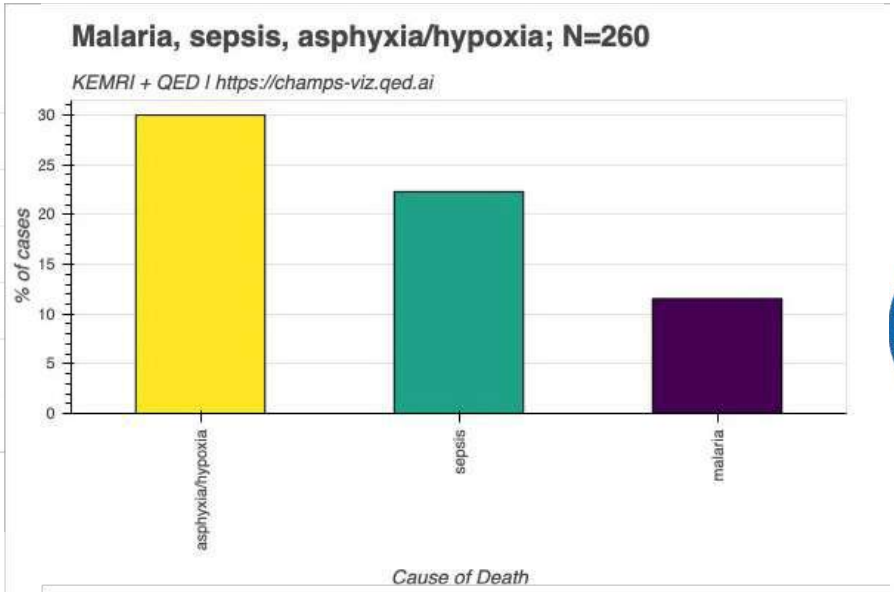
Translate business processes into software ...

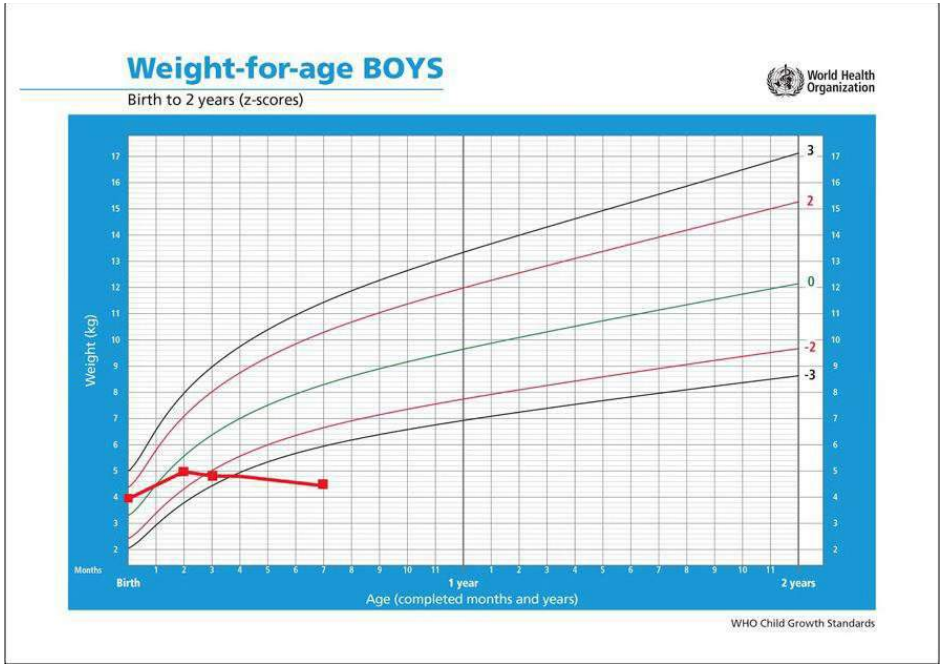
CHAMPS

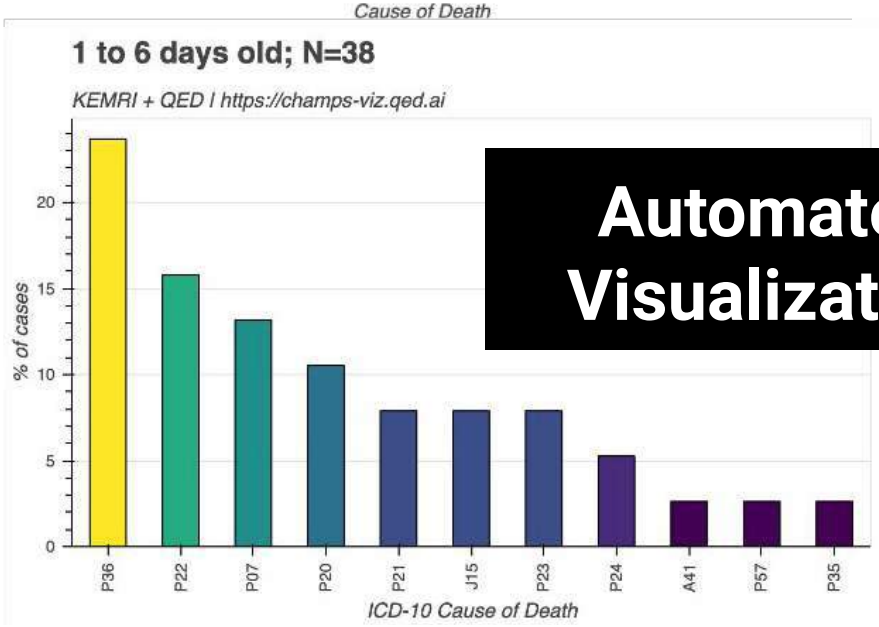
progress qed.ai
Hello, mortality!
Profile
Logout
Back
Manage Project
Reload table
Sample ID
DP1.1.A Initial Death Notification
DP1.1.B Eligibility Screening and Consent Tracking
DP1.2.A Consent Authorization
DP1.2.B Post-Consent Questions
DP3.1.A Disposition of Body Form
DP3.1.B Mits Specimen Collection Form
DP3.1.C Gross Examination
DP3.1.D PMA Procedure Form
DP3.1.E Malaria Lab Results - PCR
DP3.1.E Malaria Lab Results - Rapid
DP3.1.F HIV Lab Results
DP3.1.G TB Lab Results - Cultures
DP3.1.G TB Lab Results - Rapid
DP3.1.H Clinical Lab Results
DP3.1.I Bld Microbiology Results
DP3.1.J CSF Microbiology Results
DP3.1.K Tac Tracker
DP3.1.L Site Pathology Report
DP3.1.M PMA Pathology Report
DP3.2.A: Child Case Info
Status
Deadline
KEAA00138
06 May 2018 11:13 AM
KEAA00140
-30w
06 May 2018 10:05 AM
KEAA00142
-30w
06 May 2018 12:55 PM
KEAA00144
11 May 2018 09:52 AM
KEAA00145
Deadline: 21 Jan 2018, 12:01 PM
10 May 2018 12:37 PM
KEAA00147
12 May 2018 12:01 PM
KEAA00149
-33w
-33w
-32w
-33w
-32w
-32w
-29w
-27w
13 May 2018 01:21 PM
KEAA00151
KEAA00152
-29w
13 May 2018 01:51 PM
17 May 2018 02:43 PM
-28w
24 May 2018 07:07 AM
maprocedureform/instance#/94370
progress
qed.ai

Case Mgmt.





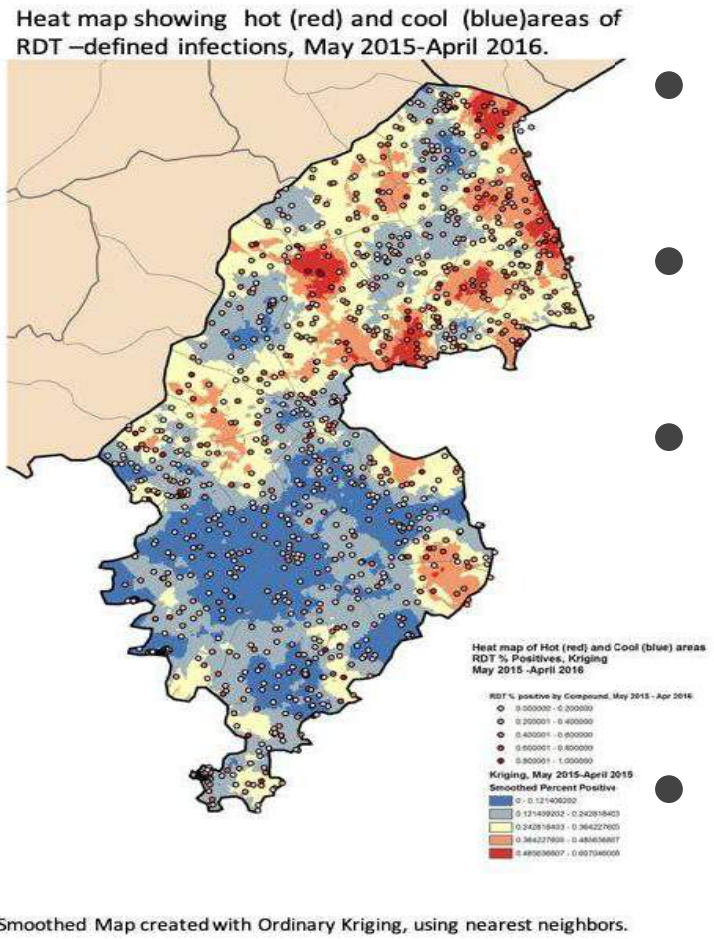




Automated Visualization

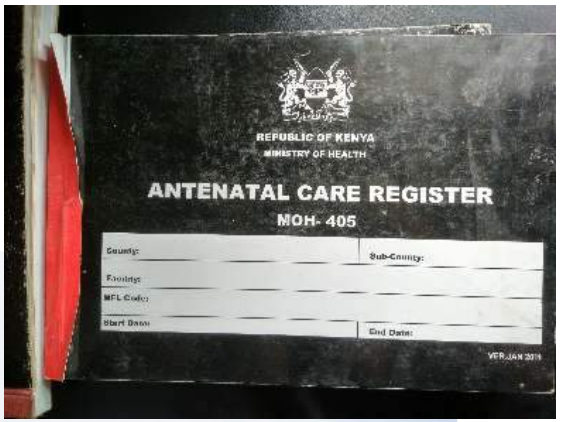
Passive Surveillance

A Path to Sustainable Surveillance



- **ACTIVE**
  Costly parallel network, door-to-door surveys.
- **PASSIVE**
  Strengthen *existing* network (e.g., govt, biz, …)
- **Existing network:**
  >90% pregnant women → antenatal care (ANC)
  Random cross-section.
  Integrate finger-prick into checkup.
- **Last step:**
  Just collect ANC registers! Oh wait ...

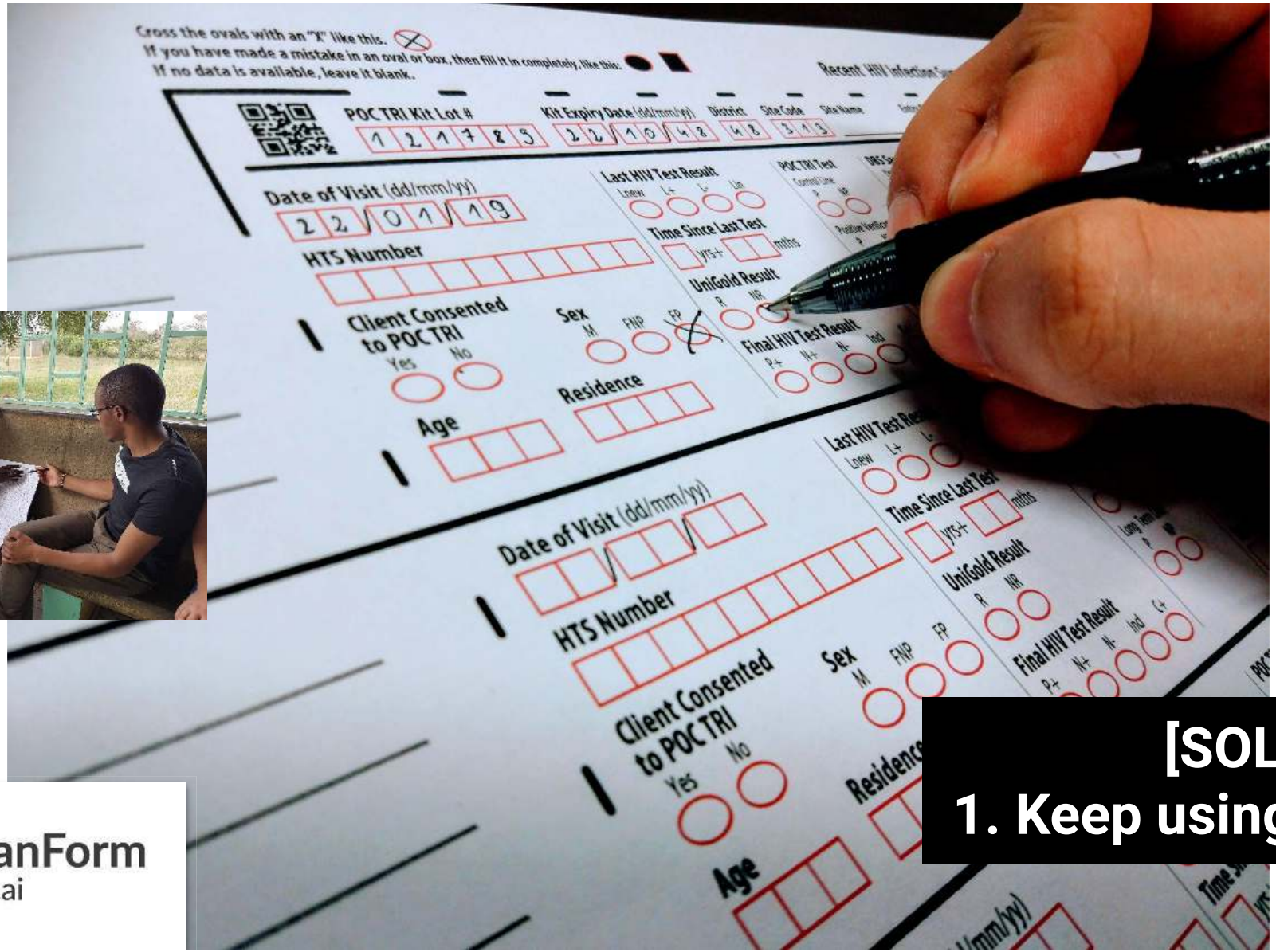
REALITY CHECK



No electricity!
No internet!
No computers!
No scanners!
No book removal!
...
(No running water!)
(No funding!)

*** not reflective of *all* situations, just *many***

ScanForm
qed.ai



[SOLUTION]
1. Keep using paper.

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[SOLUTION]
2. Take picture!

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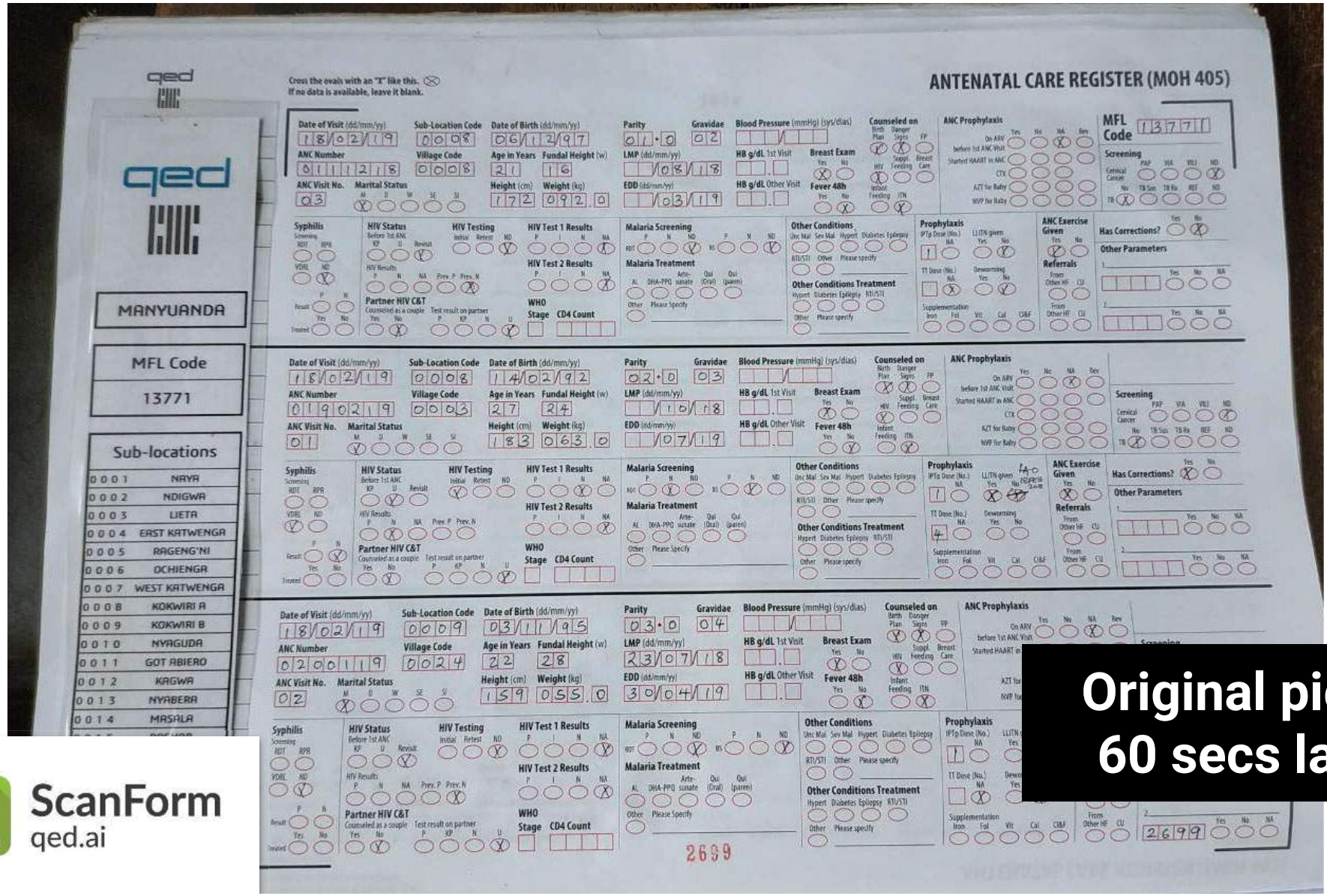

Original picture.
60 secs later ...

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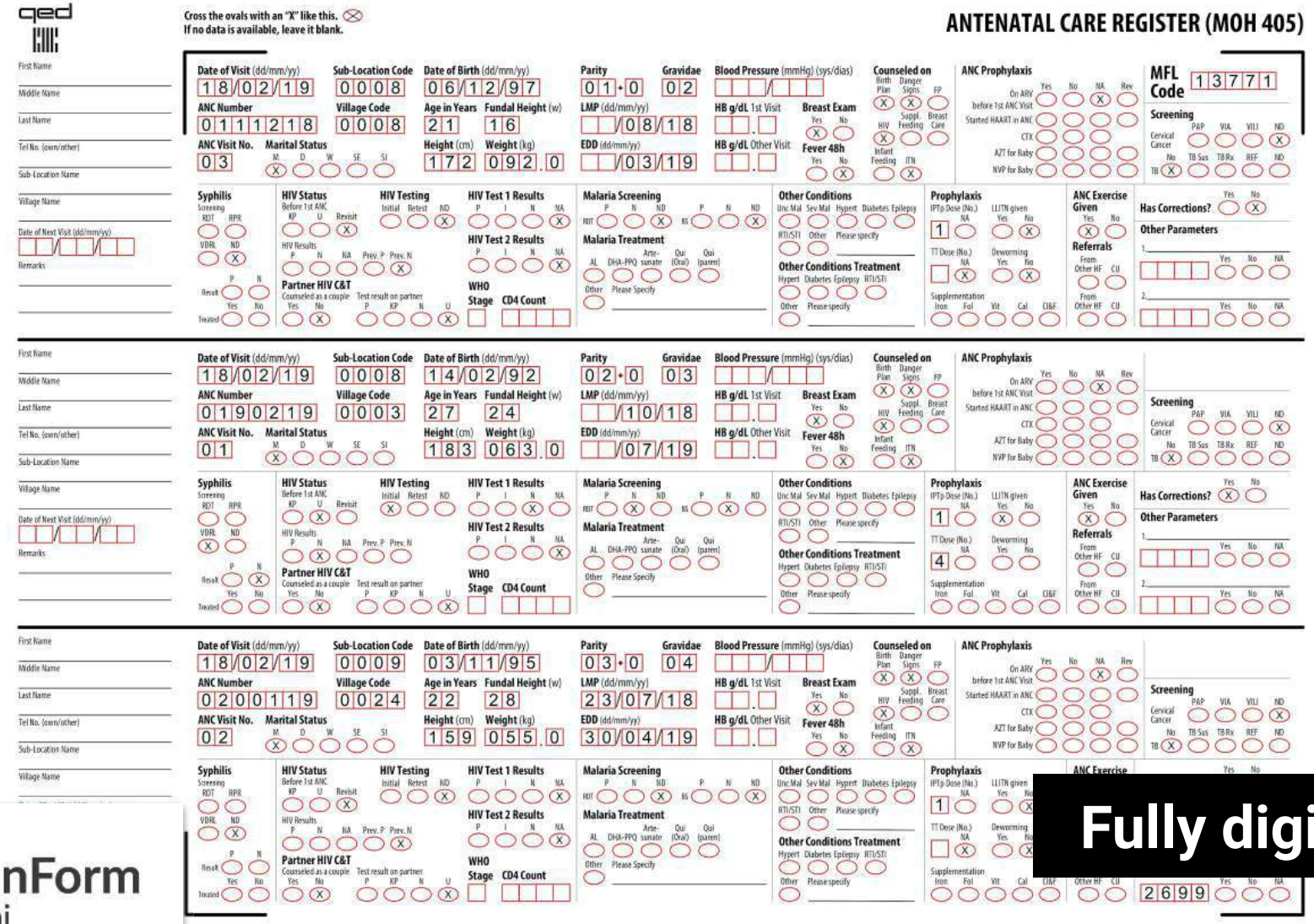

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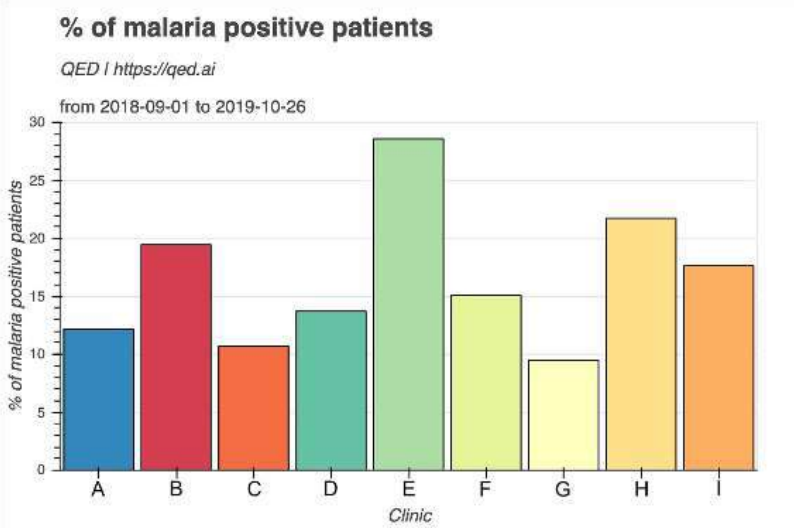
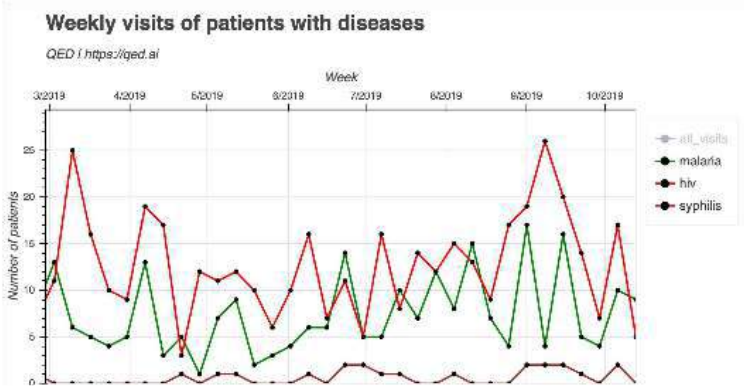
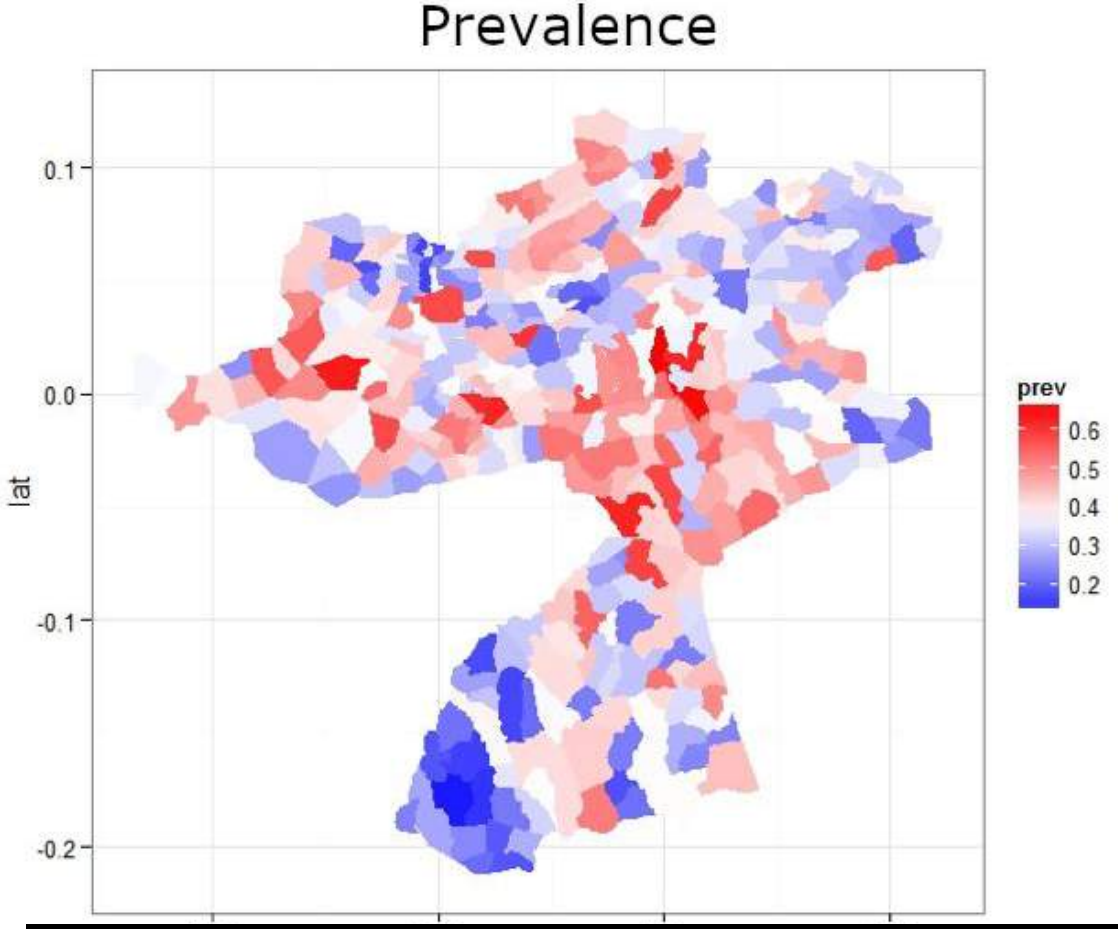
Fully digital data!







ScanForm
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Automated analytics.
Sustainable passive surveillance.

Closing

Tech Strategy: Closing Remarks

- Customize tech for realities on the ground. Ignore the West.
- Motivate technologists with problems worth fighting for.
- Achieving “Sustainable Development Goals” also requires learning to sustain ourselves!
  Industrial partnership is key to the future of humanity.

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Business: https://business.qed.ai