

GIS Field Data Collection for Agricultural Monitoring Applications



Get Answers: Questions will be answered at the end.
You can submit them at anytime through the Q&A module.



On-Demand: The recording will be posted shortly after the webinar.
You'll receive an email with the link to view or download.



Start time: The webinar will start at 10:00 am PDT



Contact us: For anything else, please email us: LPeters@esri.com



GIS Field Data Collection for Agricultural Monitoring Applications

Geospatial approach for Agriculture
and Food Security in Africa
Webinar series

Today's Presenters



Christina Jade Justice

Food Security and Early Warning Lead
NASA



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Solution Engineer, MSL
Esri National Government Team



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Technical Lead
NASA



Lorien Innes

Global Business Development Africa
Esri

Agenda

Introduction	NASA Harvest	NASA Harvest	Demonstration & Discussion
GIS Field Data Collection for Agricultural Monitoring Application	Overview The Problem Challenges	Field Data Considerations Advantage of Streaming Polygons	Resources Questions

ArcGIS

A Comprehensive Geospatial Platform

Services Based

Open



Distributed

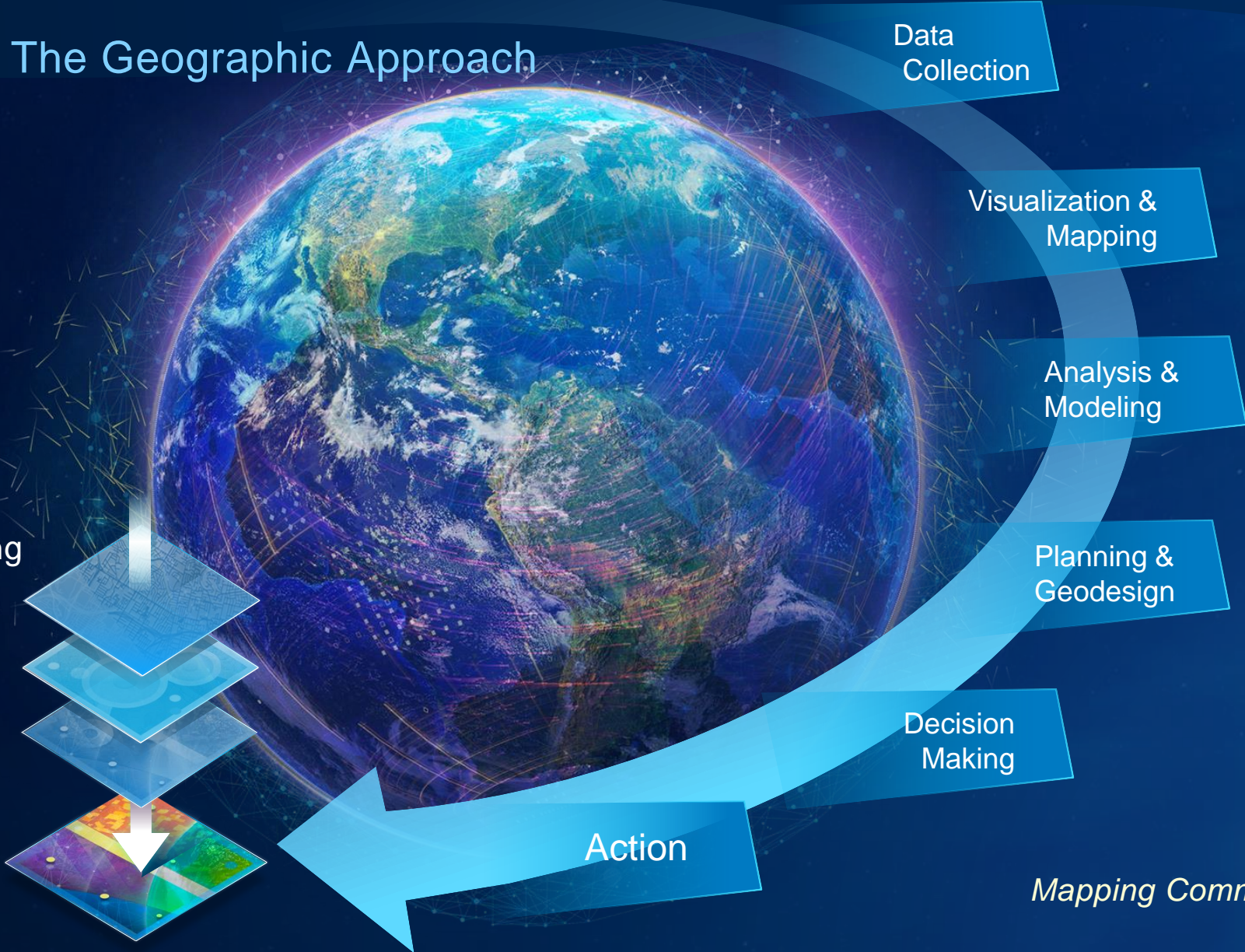
Extendable

SaaS & Software

Supporting Individuals, Teams and Organizations

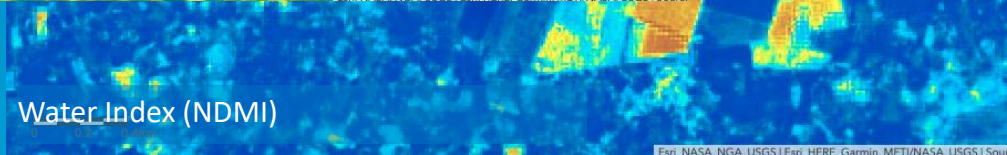
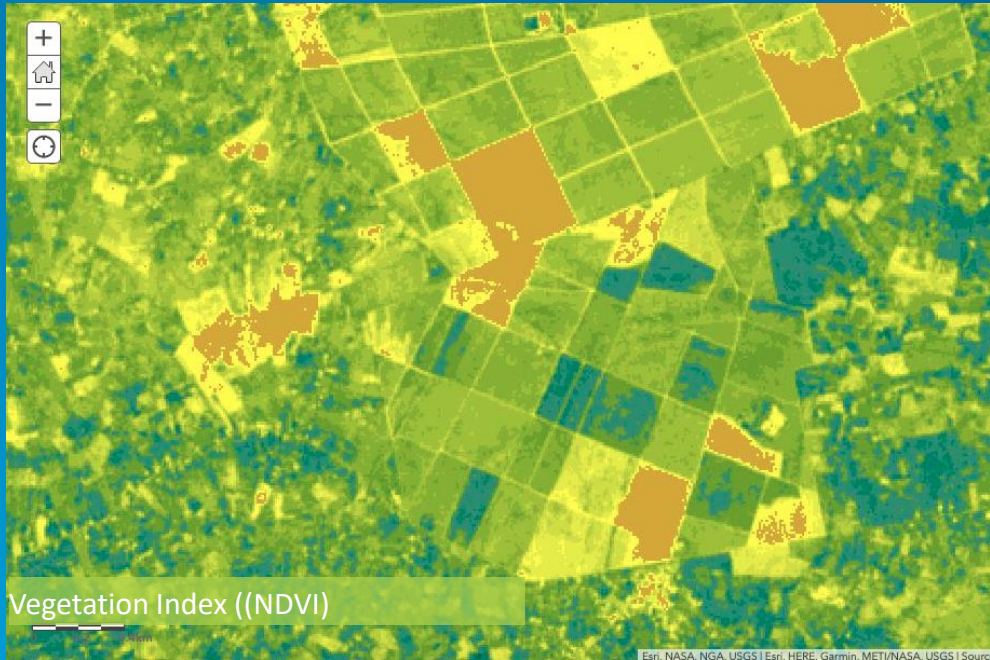
GIS Enables The Geographic Approach

A Process for
Creating Understanding
& Facilitating
Collaboration



Mapping Common Ground

Sentinel-2 Dynamic Renderers



Choose Rendering ✕

Natural Color ▾ ?

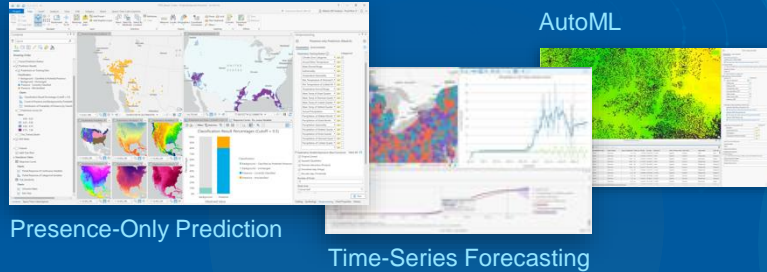
Natural Color

- Agriculture
- Color Infrared
- Short-wave Infrared
- Geology
- Bathymetric
- Vegetation Index
- Normalized Burn Ratio
- Built-Up Index
- NDVI Raw
- NDVI - VRE only Raw
- NDVI - with VRE Raw
- NDMI Colorized
- NDWI Raw
- NDWI - with VRE Raw
- Custom SAVI
- Custom Water Index
- Custom Burn Index
- Urban Index
- Custom Bands
- Custom Index
- Basemap Only

AI, Machine Learning & Deep Learning

Embedding GeoAI Across the ArcGIS System

Ready-to-Use
Tools & Models



New & Improved

- Pretrained Models (15+)
- Motion Imagery Tools
- Tools for Spatial Machine Learning
- Spatiotemporal Forecasting
- GeoAI Toolbox (Pro)

Vector &
Tabular

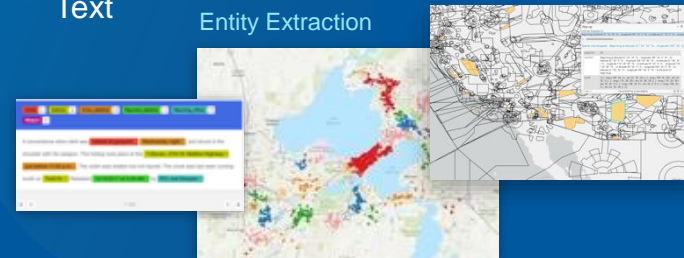
GeoAI



Imagery &
Remote Sensing



Text



Open Science
Libraries



... Automating, Processing & Accelerating
Intelligent Decision-Making

Poll Question

Please Tick the Boxes that Apply to Your Organization





Field data collection for agricultural monitoring applications

Christina Justice

NASA Harvest


Food Security & Early Warning Co-Lead

Blake Munshell

NASA Harvest

Technical Lead





Food security remains one of the most pressing issues we face in this century

Innovation in developing robust and scalable measures to monitor the world's crops in a timely, transparent manner is a key component in helping to address this global challenge

EO for Agricultural Monitoring

With recent major advances in Earth observing (EO) satellites, cloud compute, GPS technologies, and machine learning/artificial intelligence, we currently have the data and tools needed to monitor and track nearly every field across the globe on a near daily basis.

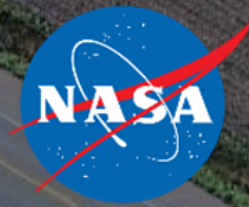
- Where crops are being grown (cropland & crop type mapping)
- How they are growing (agricultural monitoring, yield estimation, disaster impact assessment, precision agriculture)





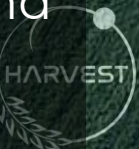
NASA's Food Security & Agriculture Program

NASA HARVEST

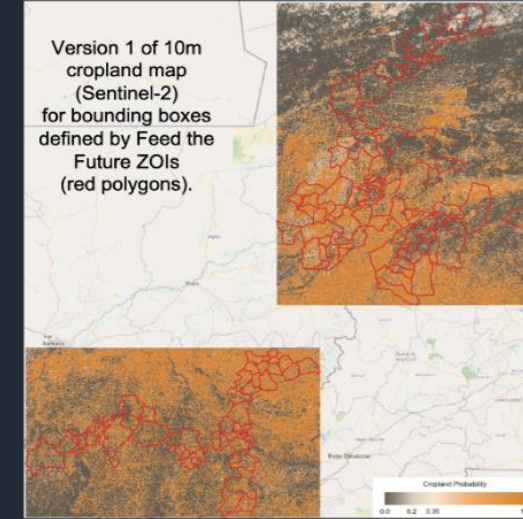
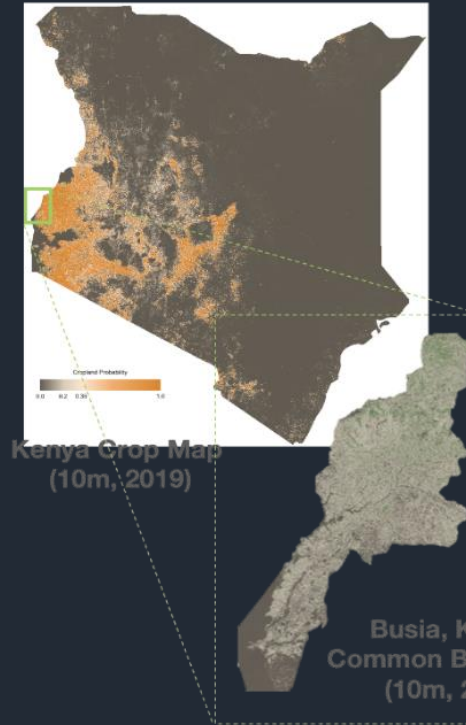
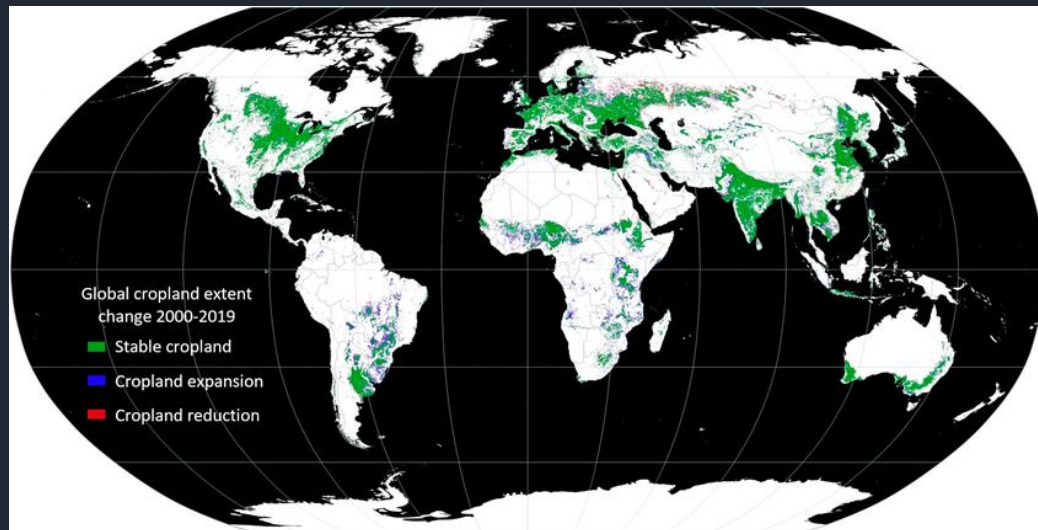
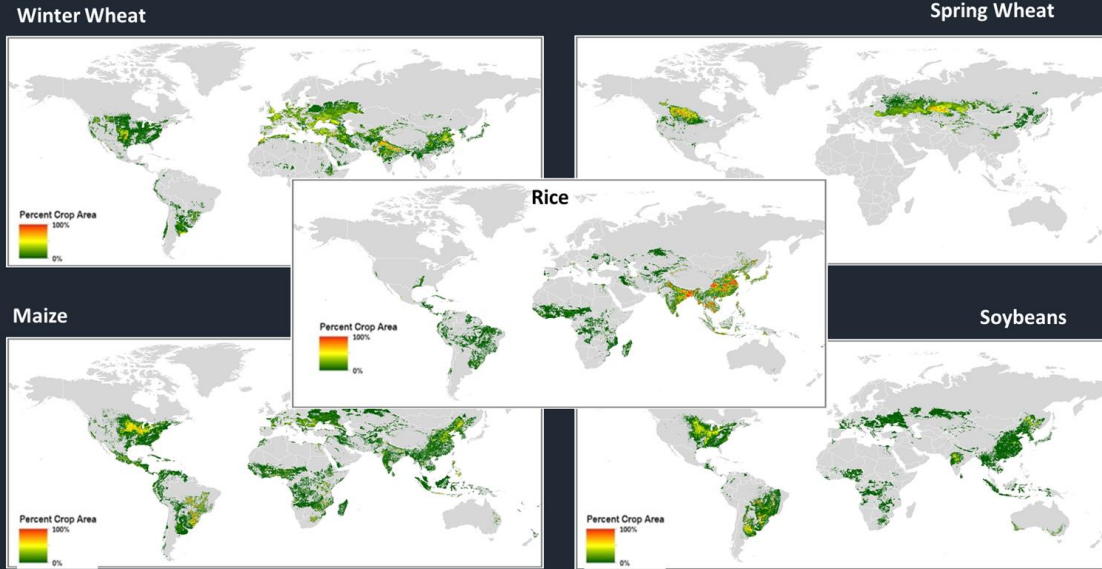


A multi-sectoral Consortium enabling and advancing awareness, use, and adoption of satellite Earth observations by public & private organizations to benefit food security and agriculture in the US and worldwide

- Diverse Consortium of >50 members from public, private, NGO, intergovernmental, & humanitarian sectors
- Driven by stakeholder and end-user needs
- Focused on operational R&D and transition
- Demonstrating socioeconomic benefits of EO for agriculture and food security
- NASA's contribution to GEOGLAM
- Led by the University of Maryland
- Established Nov. 2017
- <https://nasaharvest.org>



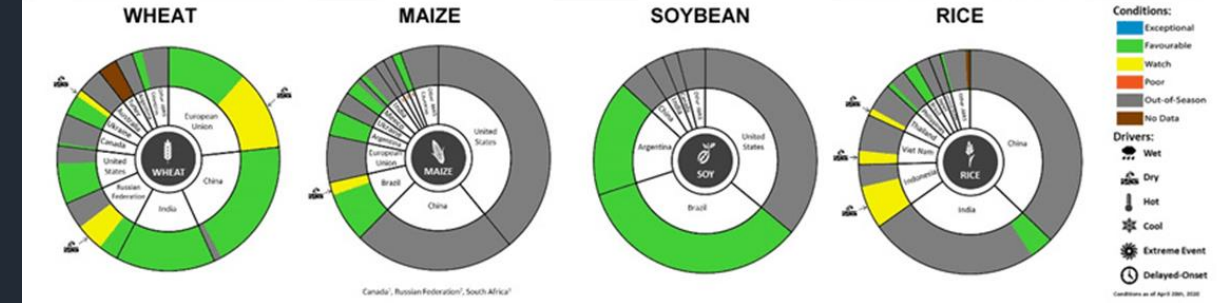
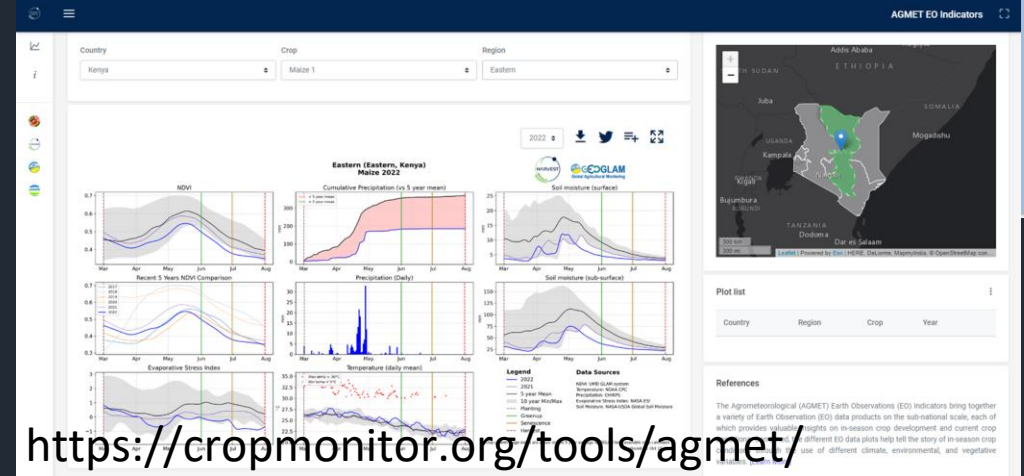
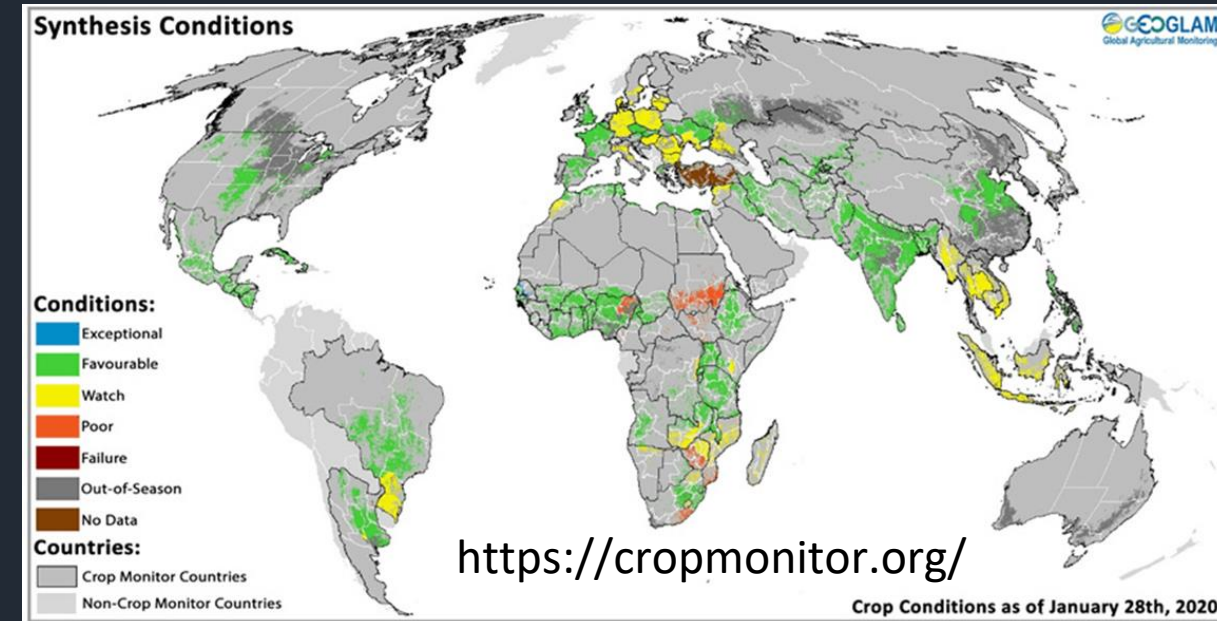
Cropland & Crop Type Mapping: Global to National Scale



innovating to address the sparse & heterogeneous data challenge

EO Based Tools & Products: Crop Condition Monitoring

Putting satellite data into the hands of end-users to bolster: agrifood system resilience, food security, conservation farming, agricultural productivity, and market stability.

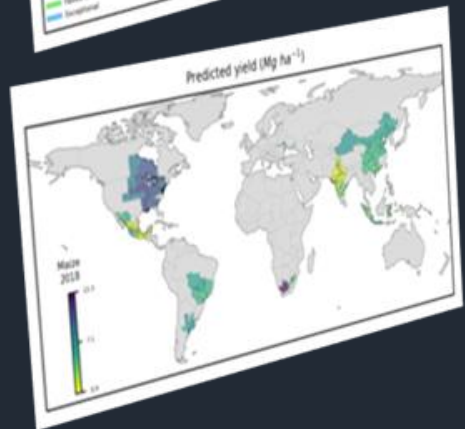
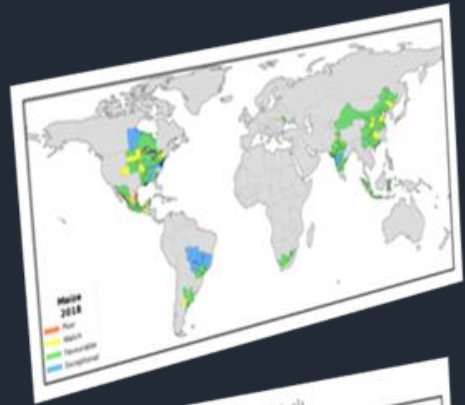




YIELD FORECASTING & ESTIMATION: FIELD TO GLOBAL SCALES

Global Scale

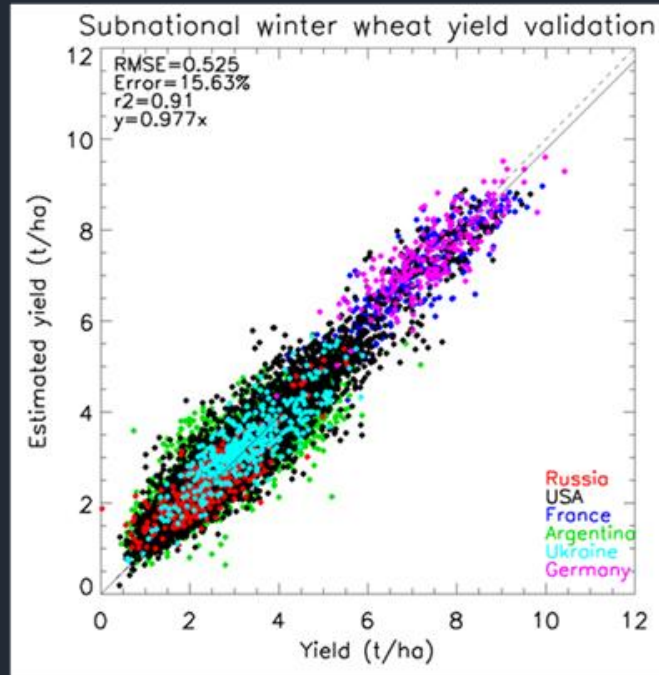
Forecasts within 3-5% error, 2 months prior to harvest



Sahajpal et al. 2020

Sub-National Scale

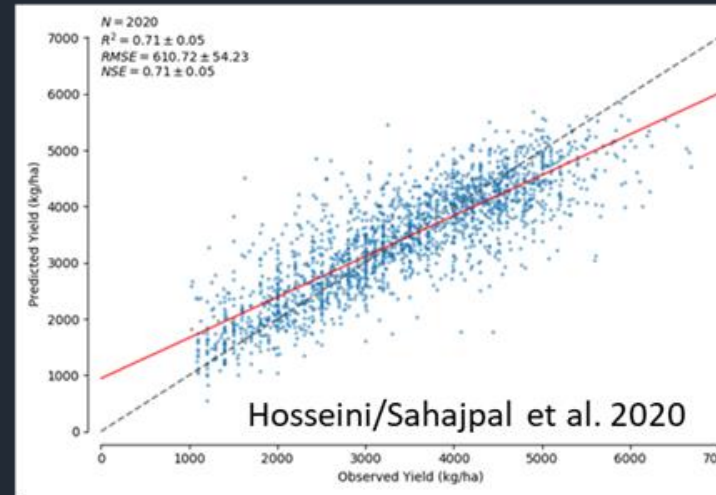
8-14% error 1.5-2 months prior to harvest



Franch et al, 2015, 2017

Field Scale

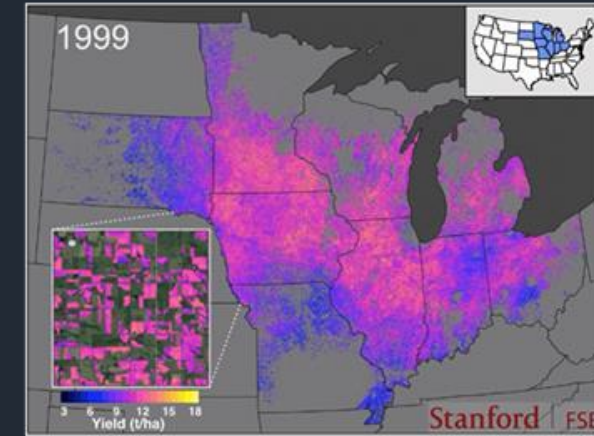
Argentina



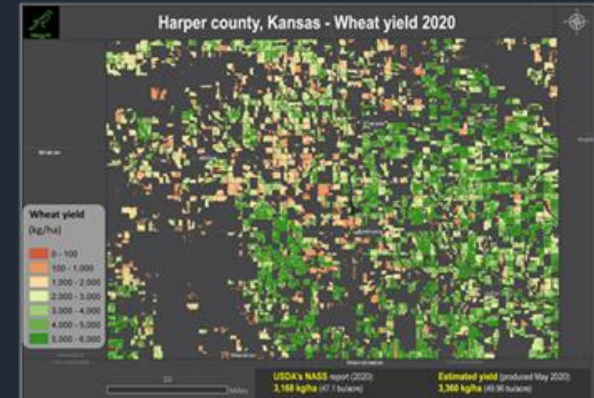
Hosseini/Sahajpal et al. 2020

Field Scale

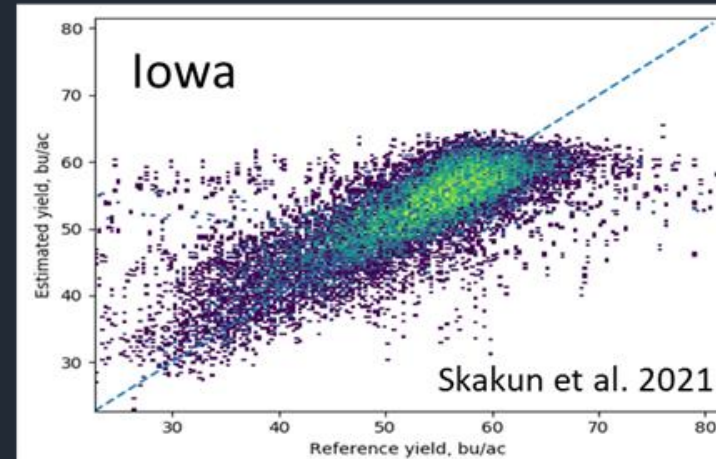
US Cornbelt



Kansas



Iowa



Skakun et al. 2021

Ground Truth Data for Training & Validation

Ground-truth data collected from the field enable us to train models to learn correlations and extrapolate over large areas and validate our EO based tools and products

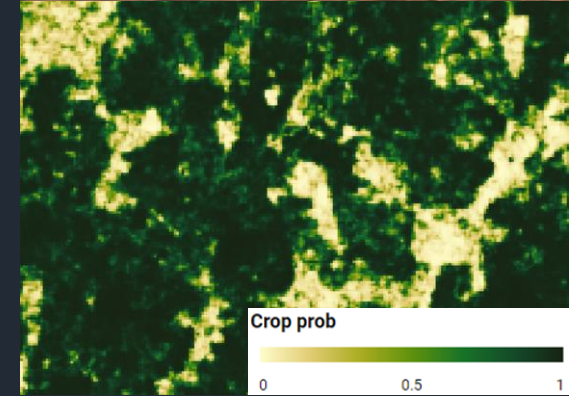
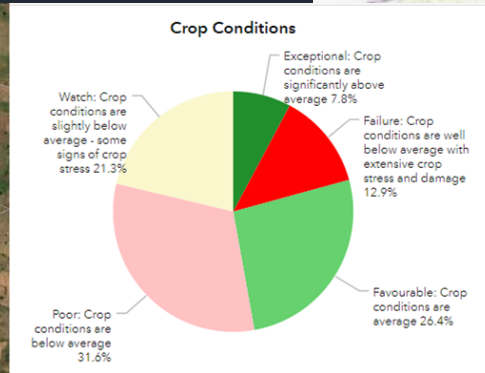
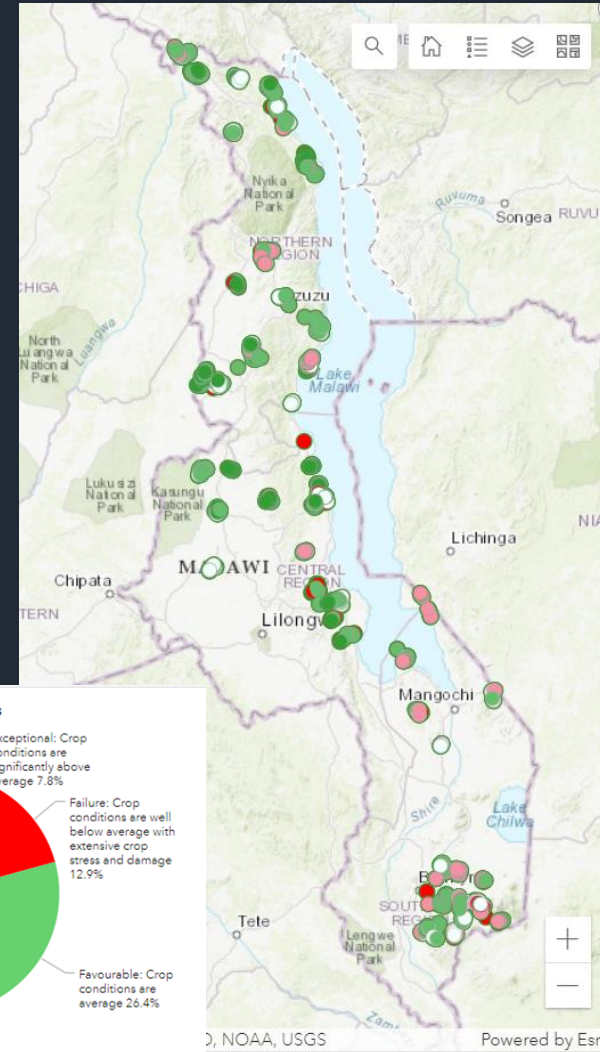


To build trust by the end user, EO products & models need to be validated and their accuracy assessed

How is NASA Harvest Using Survey123?



- Cropland/ Croptype Mapping
- Crop Condition Monitoring & Farm Management
- Yield Model Training and Validation
- Disaster Impact Monitoring



Top: 3m Planetscope
Middle: 10 m Sentinel-2
Bottom: 10 m Cropland Mask based on Sentinel for Kasungu, Malawi

Malawi 2022 agricultural assessment - crop condition

NASA Harvest & UN FAO partner to improve validation datasets for croptype mapping & yield estimation



Collecting critical yield and croptype validation dataset in Malawi to improve national scale cropland and croptype maps and remote sensing based yield forecasting estimates for use by National Ministries

- Geolocated crop type: Used to train ML models to map cropland and croptype
- Geolocated crop condition assessment & farm management: Used to validate agricultural assessments from EO and inform government actions
- Geolocated sample crop cuts: Used to train and validate EO & ML based yield forecast models



Malawi Data Collection: Crop Type

FAO Malawi Country Office partnered with NASA Harvest to collect ground truth data labels of croptype & crop condition during two campaigns in 2021 and 2022

Geolocated croptype used to train machine learning models to identify cropland and crop type from satellite imagery

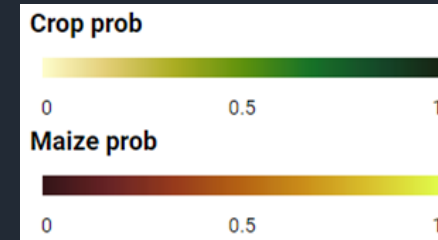
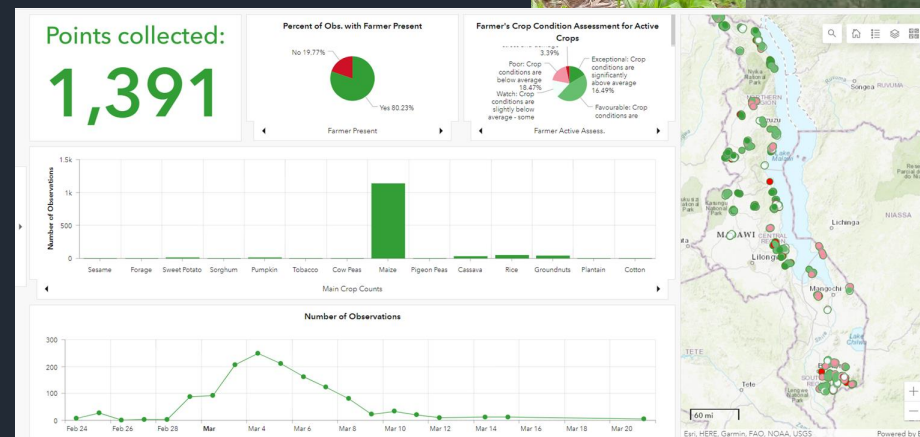
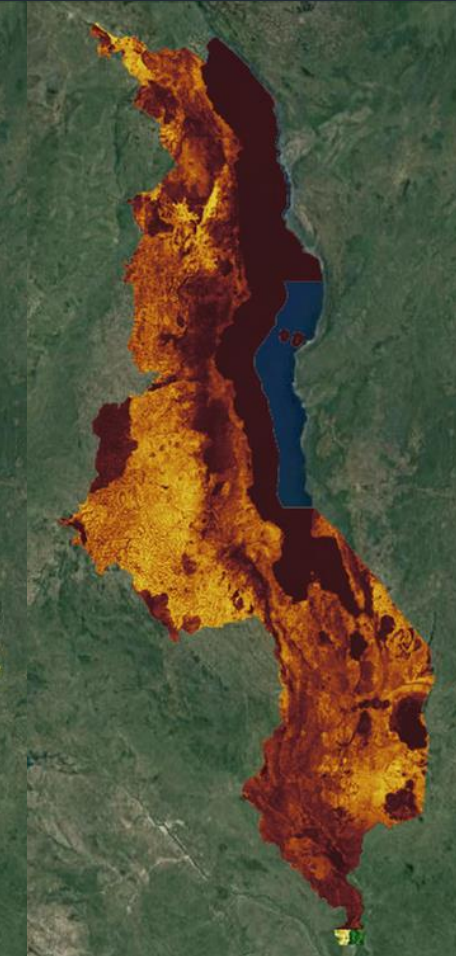
Developed high-resolution ($\leq 10\text{m}$) in-season and postseason cropland map and maize crop type in Malawi

Critical data collection components for crop type mapping:

- Location (inside the field)
- Croptype
- Single/ Multiple Cropping

Cropland Mask

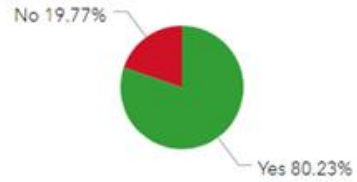
Maize Crop Type Mask



Malawi Data Collection: Crop Condition Assessment

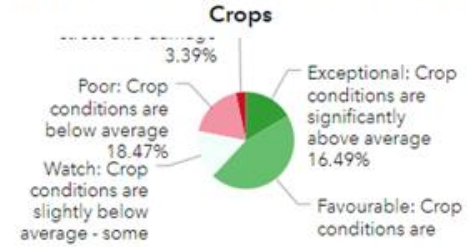
Points collected:
1,391

Percent of Obs. with Farmer Present

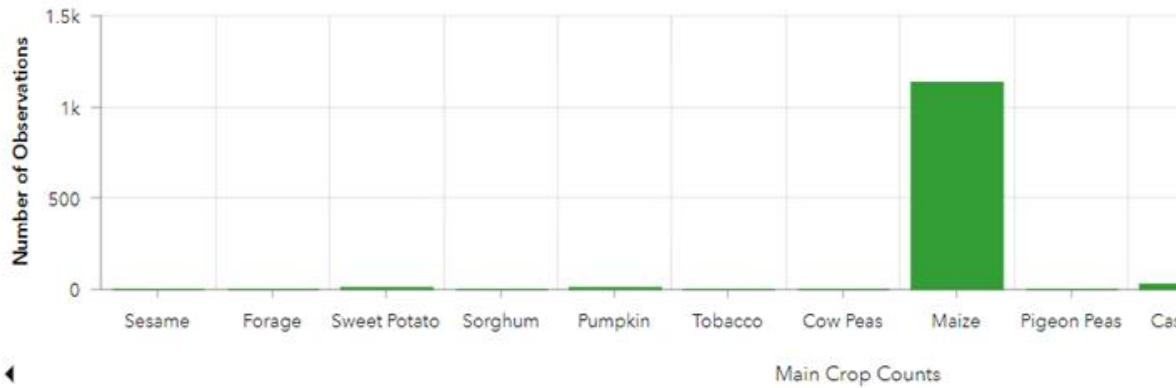


Farmer Present

Farmer's Crop Condition Assessment for Active

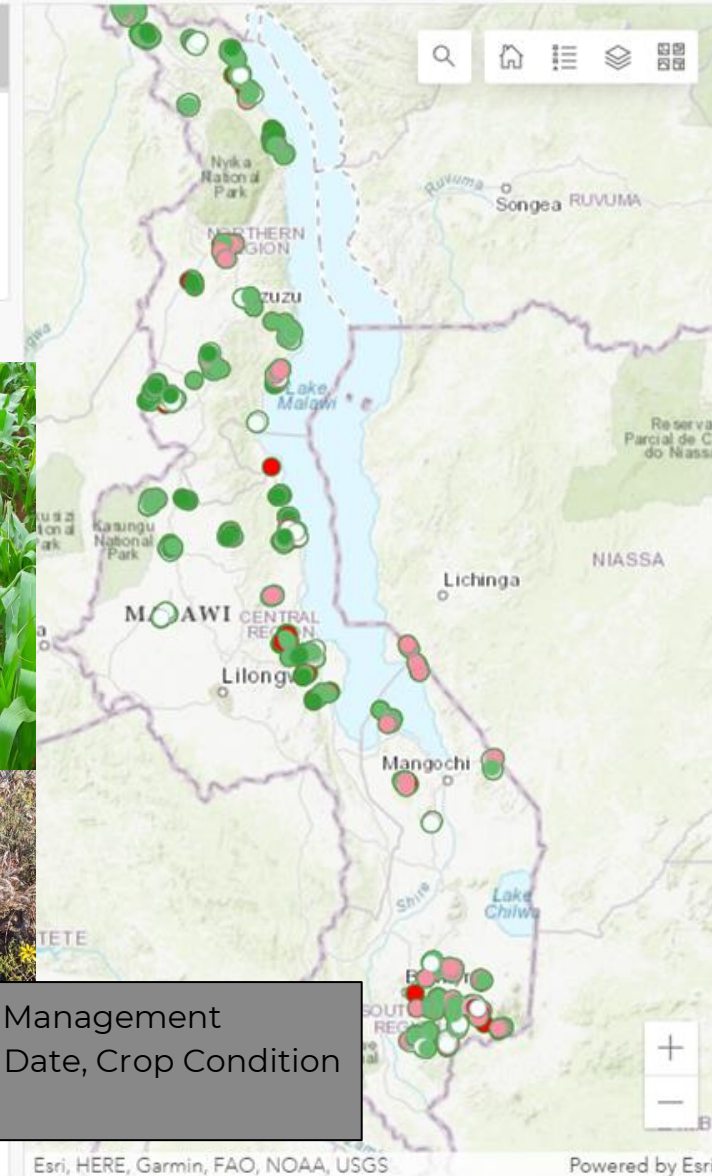


Farmer Active Assess.



Main Crop Counts

Number of Observations

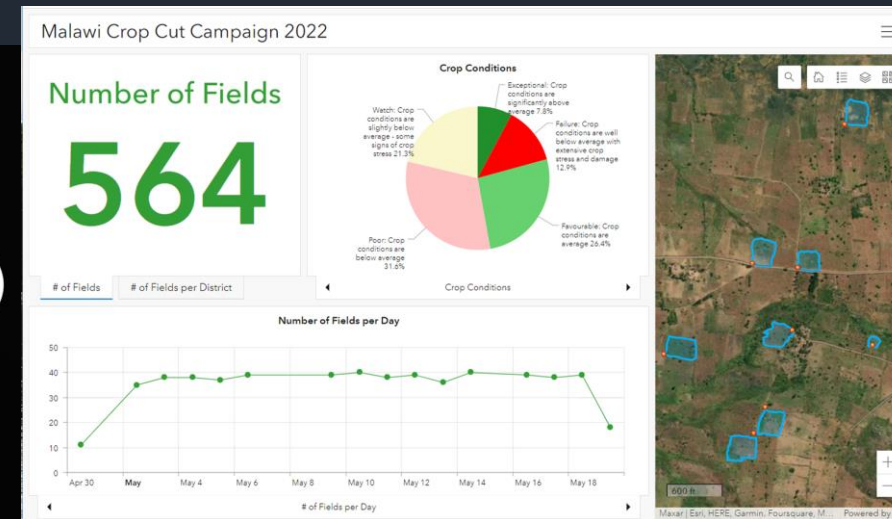
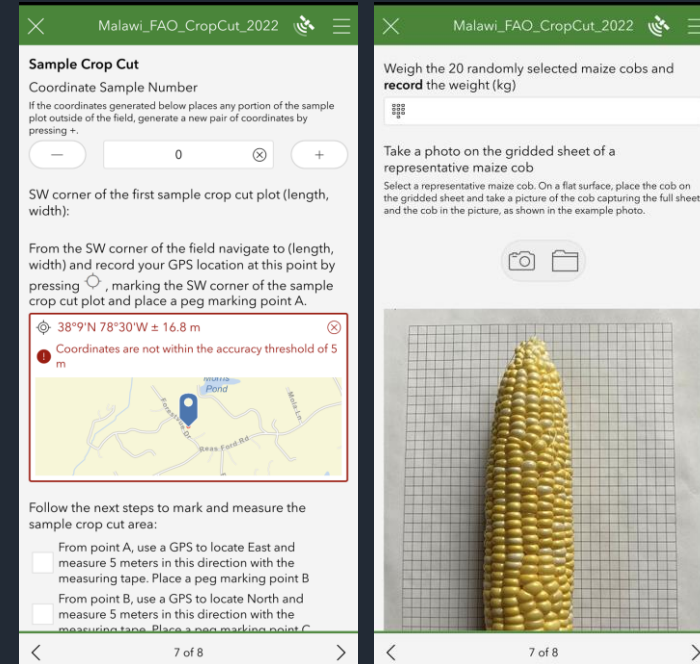


Rapid crop assessment: Location, Field Perimeter & Area, Planting date, Crop Type & Mixed cropping, Replanting, Management Practices, Inputs, Source of Inputs, Input Accessibility, Seed type, Irrigation, Crop Stress/damage & Cause, Harvest Date, Crop Condition

Feb 24 Feb 26 Feb 28 Mar Mar 4 Mar 6 Mar 8 Mar 10 Mar 12 Mar 14 Mar 16 Mar 18 Mar 20

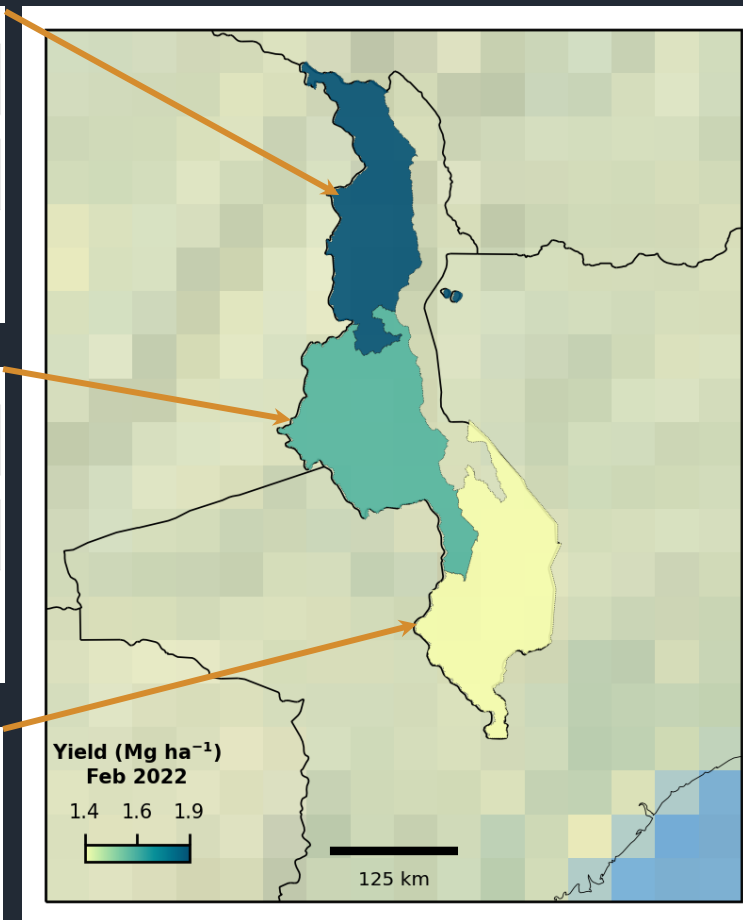
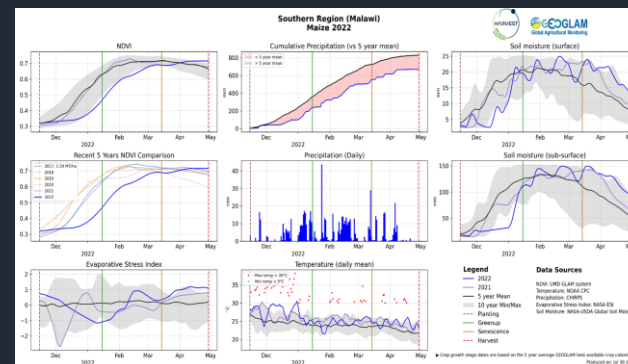
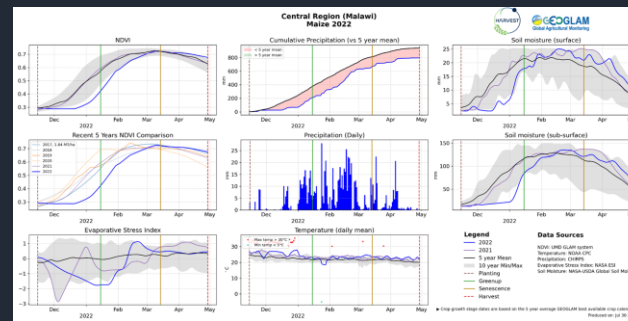
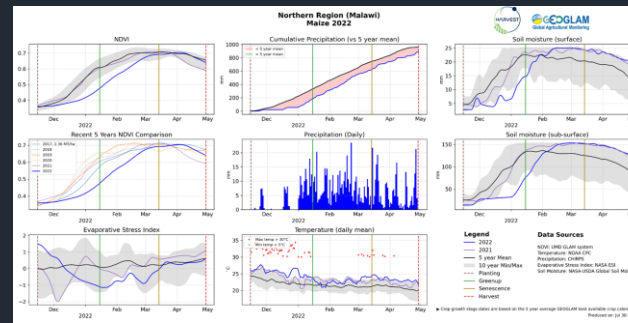
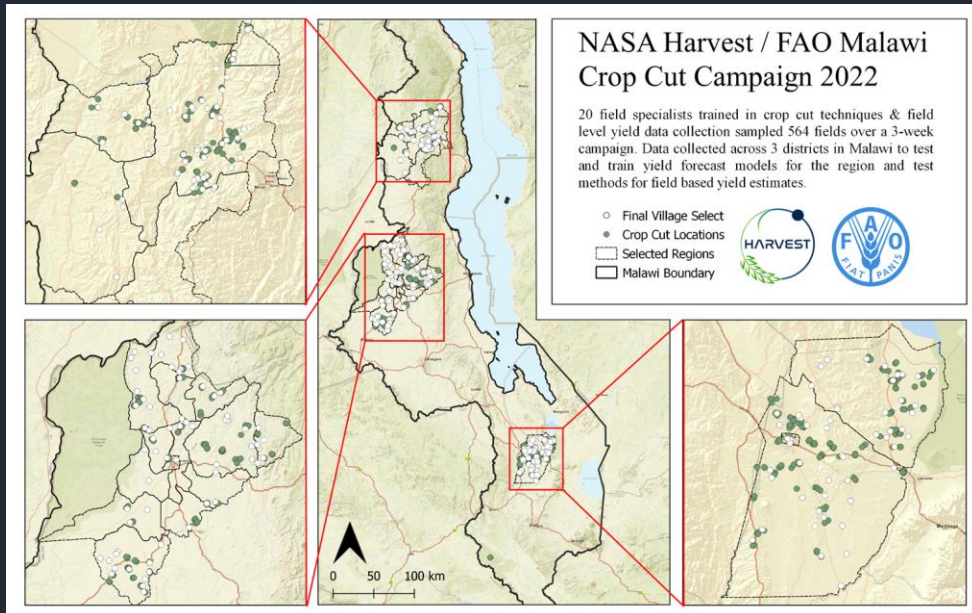
Malawi Data Collection: yield training & validation data

- Sample Crop Cuts (Gold Standard for yield measurements)
 - EO informed village selection - high variability sample to support model training
- Field based yield proxy measurements: test accuracy and application of these measurements in place of crop cutting methods
 - Photos for ML applications
- Rapid crop assessment from Farmer Interview
 - Investigating the relationship between Crop Management & Condition with crop yields taken from sample Crop Cuts.
 - Planting date, Mixed cropping, Replanting, Management Practices, Inputs, Source of Inputs, Seed type, Irrigation, Crop Stress/damage, Harvest Date, Crop Condition



Incorporating Ground Data into Yield Forecast Estimation

- Using yield measurements from sample crop cuts to train remote sensing & ML based yield forecast models



(top) GEOCIF February 2022 maize yield estimate results for Malawi, 4 months prior to harvest. (left) Agmet Indicator Graphics for Malawi 2022 cropping season source: NASA Harvest

Field Data Considerations & Survey123



Crop type data is only useful with accurate location data

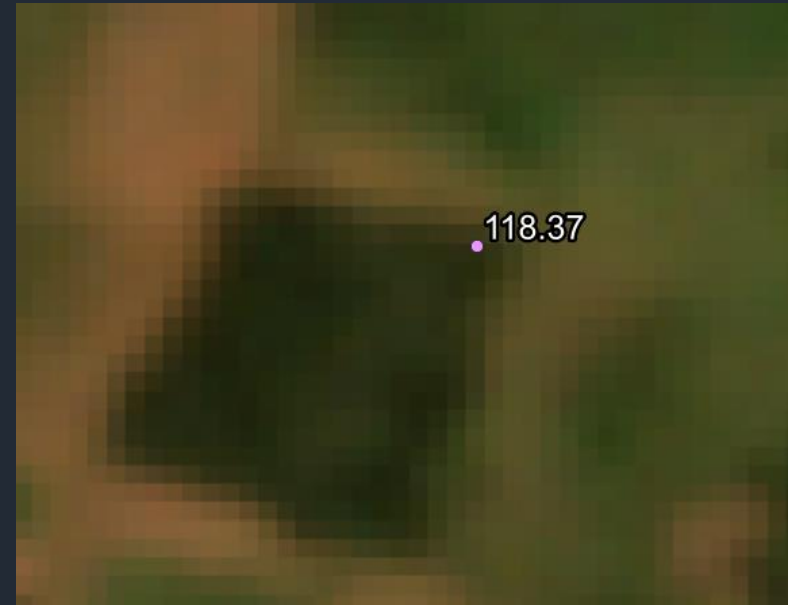
While point locations can give us a rough estimate of where a field is, accurate field boundaries give us much more information

- Points are one-dimensional = points could be inside a field or on the boundary (which have very different profiles)
- Polygons are two-dimensional = more confidence in accurate field location

Streaming location to collect the field boundary (compared to the previous method of allowing the user to draw locations) guarantees that the field observations are what is being recorded in the app



- From a campaign in Malawi in March of 2022
- High spatial resolution data (Google Satellite, left) gives us a good idea of where field boundaries lie, but lack temporal resolution (especially over Africa)
- High temporal resolution data (Planet Labs, right) gives us an accurate image of crops greening and recent developments, but we have less confidence of location of the field boundary



While point location is helpful, field boundaries are the only way we can guarantee ground truth.













2:03



2:03



Record the field boundary by clicking the map icon below and then following the instructions to walk and record t...

Record the field boundary by clicking the map icon below and then following the instructions to walk and record t...

2:04

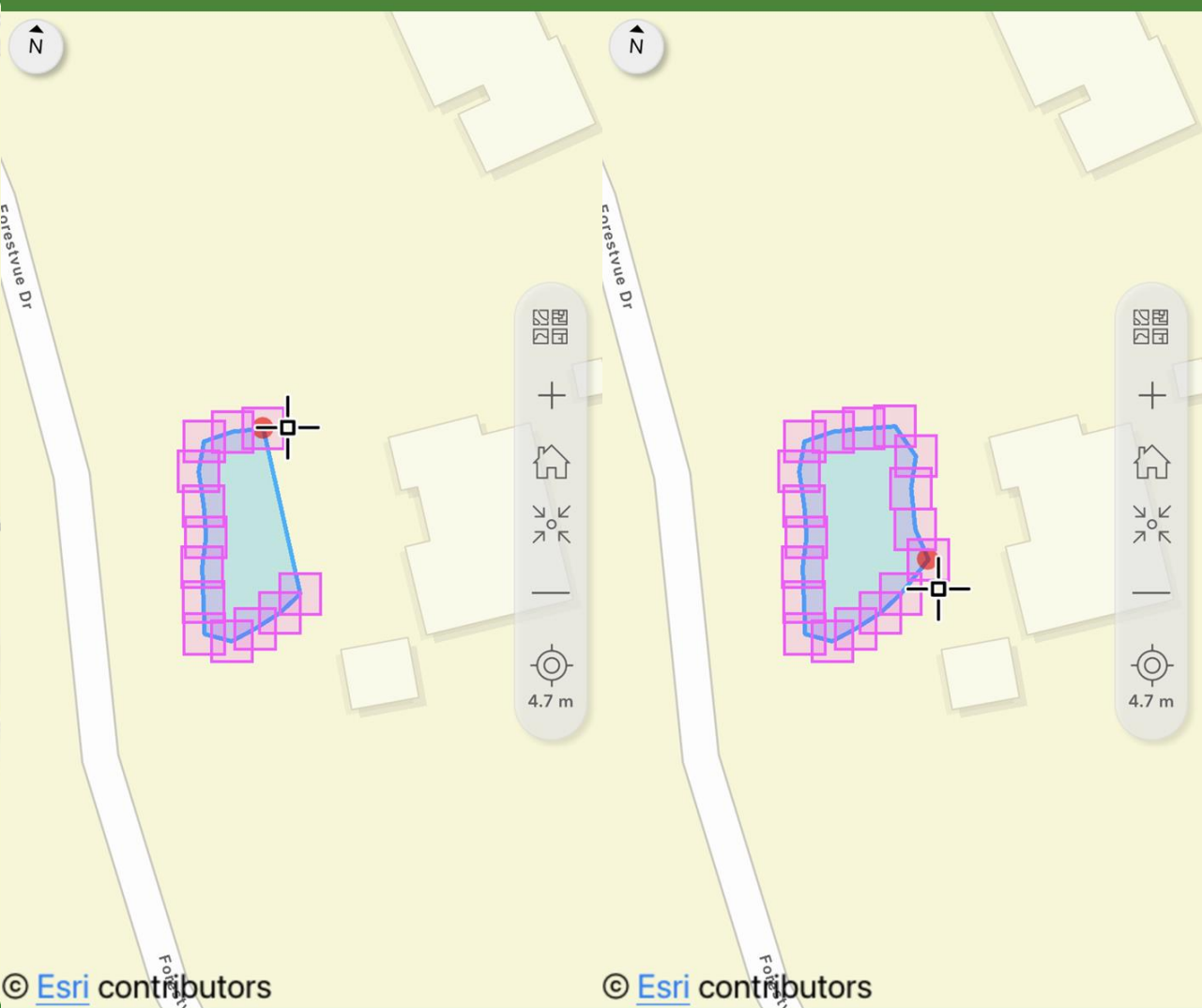
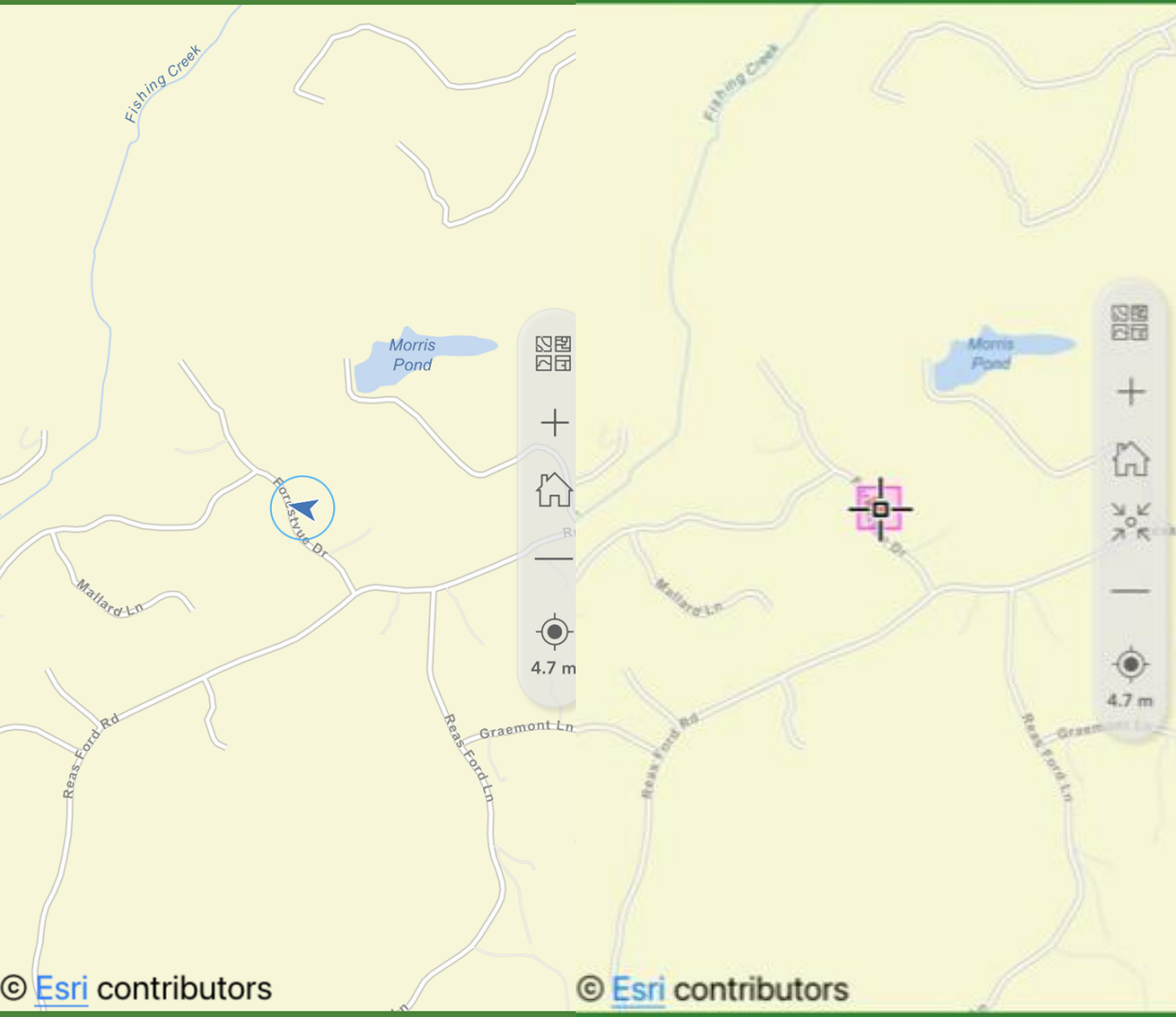


2:05



Record the field boundary by clicking the map icon below and then following the instructions to walk and record t...

Record the field boundary by clicking the map icon below and then following the instructions to walk and record t...



Area: 0.05 acres, Perimeter: 204 ft

Area: 0.07 acres, Perimeter: 222 ft





What you see...



User-friendly Forms

Simpler form creation and intuitive application design allows for simple surveys that capture more detailed information

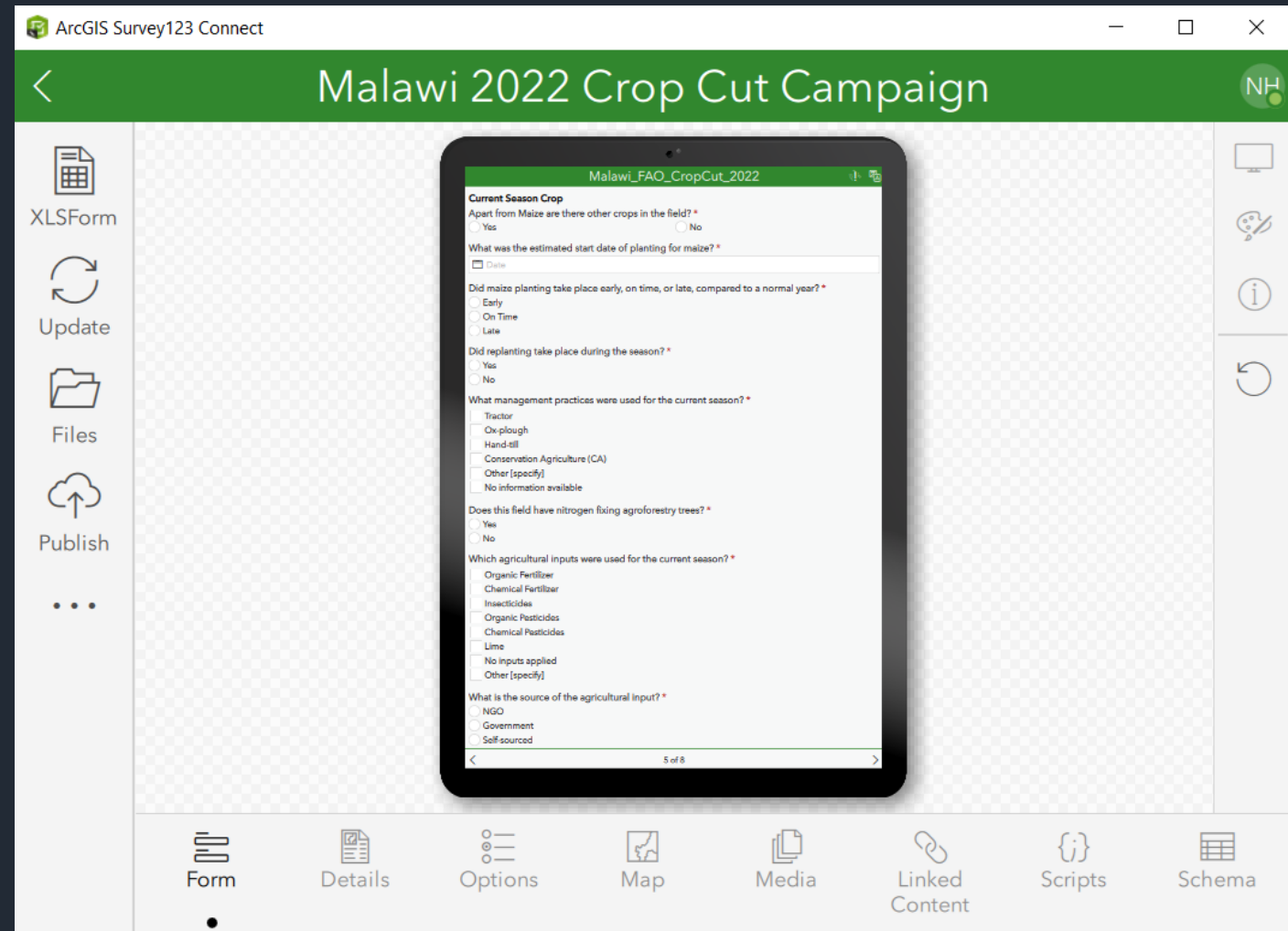
A collage of three screenshots from a mobile data collection application. The application is titled "Malawi_FAO_FieldDataCollection_2022". The screenshots show various survey questions and input fields:

- Top Screenshot:** "Crop Conditions" section. Questions include: "What was the estimated start date of planting for the MAIN crop (maize)?", "Did planting take place early, on time, or late, compared to a normal year?", "Did replanting take place during the season?", "What kind of replanting took place?", "Estimate the date of the replanting", "Estimate the percentage (%) of the field that was replanted", "What management practices were used for the current crop?", and "What Conservation Agriculture management practices were used for the current crop?".
- Middle Screenshot:** "Developmental stage of the MAIN crop (maize)", "Which agricultural inputs were used for the current crop?", "Is the field irrigated?", "Are there any visible signs of crop stress/damage?", "What is the cause of the stress/damage to the crop?", and "What was the MAIN type of the seed used in this field?".
- Bottom Screenshot:** "How much of the field was impacted by crop damage?", "Please estimate the percentage of crop loss", and "Take a close up photo of the damage".

The application interface is clean and user-friendly, with clear labels and intuitive input methods like radio buttons, checkboxes, and sliders.

Survey 123 User Features

- Survey123 Connect
 - User-friendly form development
- Survey123 Online
 - Streamlined data management
- ArcGIS Dashboard
 - Allows real-time monitoring of submitted data and user-friendly data analysis features



In app survey development and testing prior to publication



Survey123 & ArcGIS Online Integration

- Allows flexibility in data and personnel management
 - User Accounts
 - User Troubleshooting

The screenshot displays the ArcGIS Online interface for the 'Malawi 2022 Crop Cut Campaign'. The top navigation bar includes the title, a link to 'Open in Map Viewer Classic', and user information for 'NASA Harvest'.

A pop-up window titled 'MWI CC Pts 190522archive: NASAHarvestCollector_UofMD' is open, showing a metadata table with the following fields and values:

farmer	Steve Mbewo
farmer_cc	favorable
farmer_pn	999876650
field_num	1
fldbndnote	
fldimpact	moderate
full_harv	yes
GlobalID	a614fac3-03e3-491c-9508-946a824184cc
img_dir	
impactper	
irrigated	
irrigated2	no
kerncircu1	13
kerncircu2	12
kernwt1	2.2
kernwt2	1.8

Below the map, a data table for 'MWI CC Pts 190522archive' is visible, showing 564 records with 1 selected. The table columns include cobcount1, weigh20_1, numkernal1, kerncircu1, avggrsize1, kernwt1, mc1, and ytp1.

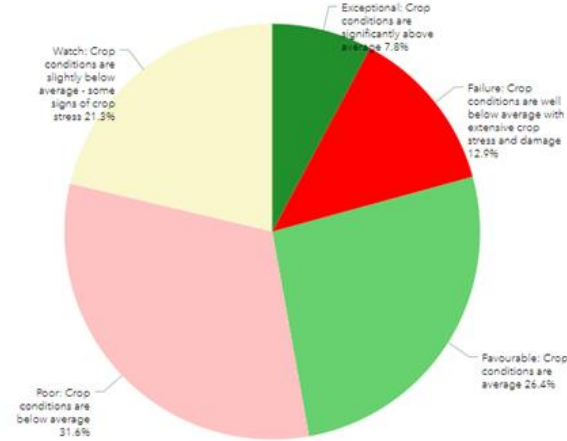
	cobcount1	weigh20_1	numkernal1	kerncircu1	avggrsize1	kernwt1	mc1	ytp1
65	65	1.5	31	14	0.35	1.15	20	4.6
98	98	4.05	39	10	0.35	3.15	20	3.7
72	72	2.9	32	12	0.35	2.05	20	5.6
86	86	3.7	40	12	0.35	2.8	21	4.2
108	108	4.35	34	14	0.35	3.05	21	7.8
100	100	5.4	38	16	0.35	4.1	19	8.5
75	75	4.65	44	14	0.28	3.7	21	4.7

Malawi Crop Cut Campaign 2022

Number of Fields

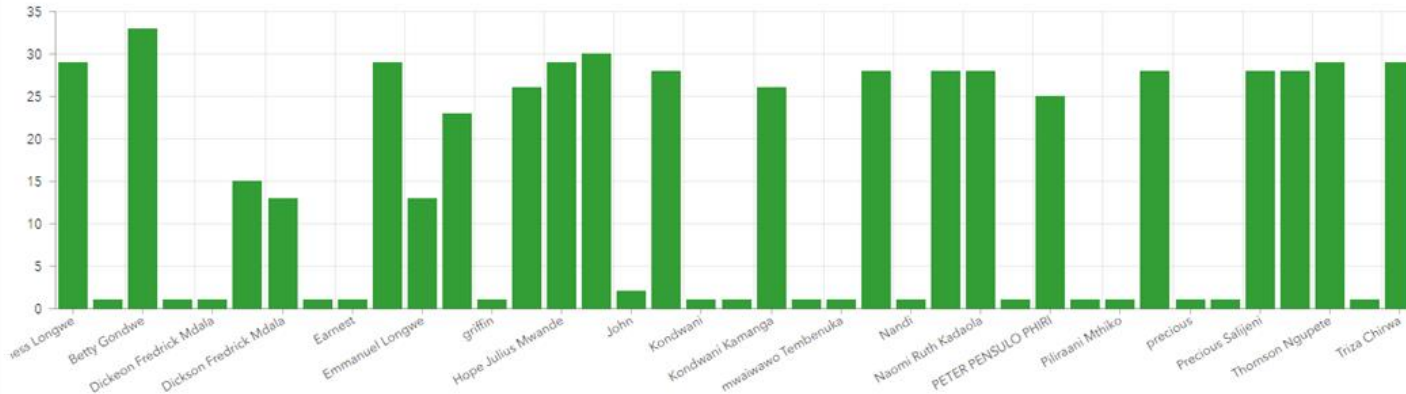
564

Crop Conditions

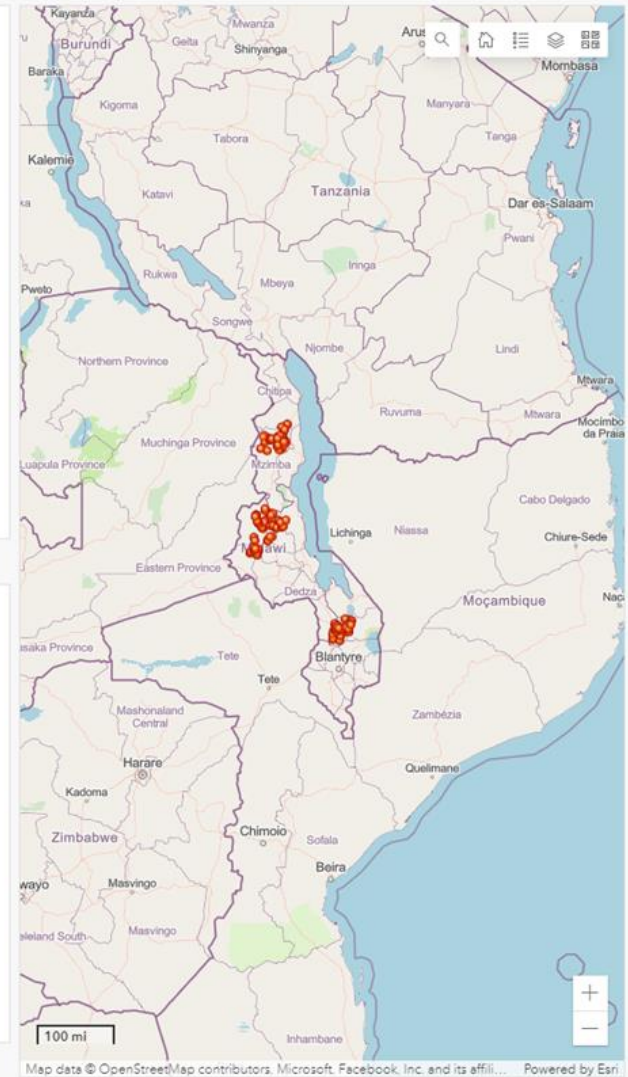


- # of Fields
- # of Fields per District
- Crop Conditions
- Crop Damage
- Replanting
- Type of Replanting

Submissions per Enumerator



- Number of Observations
- # of Fields per Day
- Field Photos
- Seed Type
- Management
- Other Crops
- Input Types
- Cause of Damage



Malawi Crop Cut Campaign 2022

Number of Fields

564

of Fields

of Fields per District

Crop Conditions

Crop Damage

Replanting

Type of Replanting

Did replanting occur?



Number of Fields per Day



Number of Observations

of Fields per Day

Field Photos

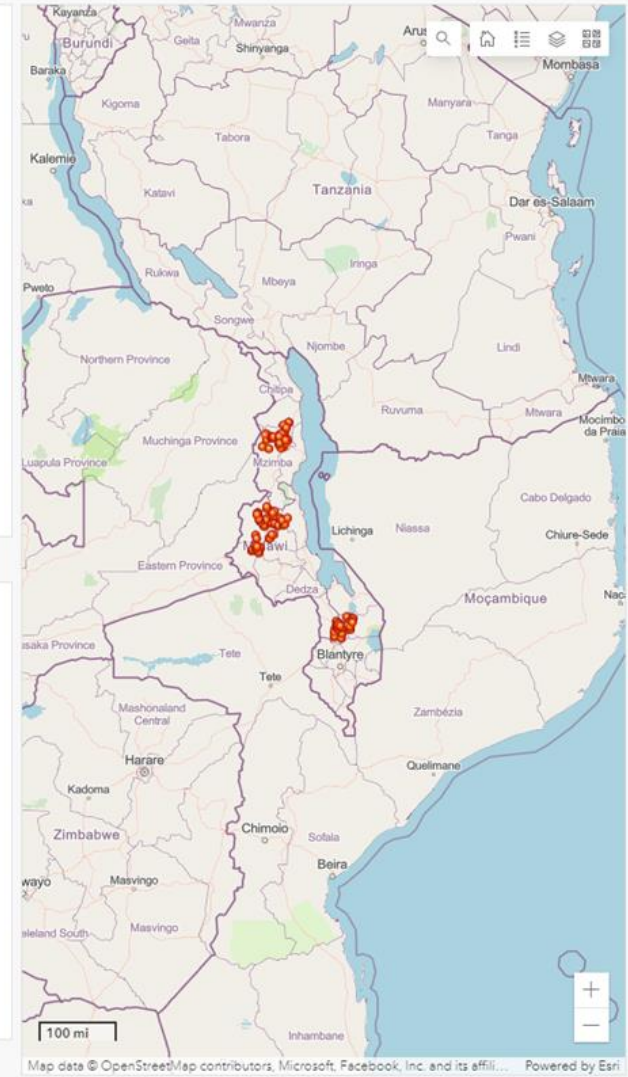
Seed Type

Management

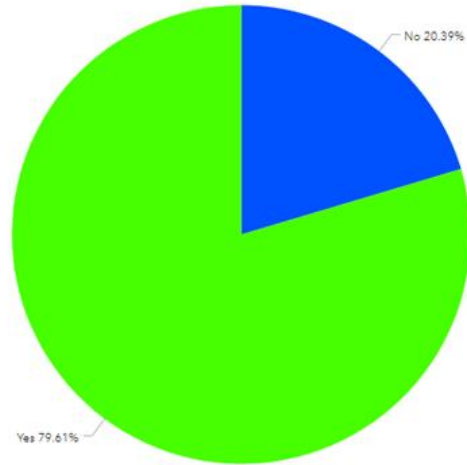
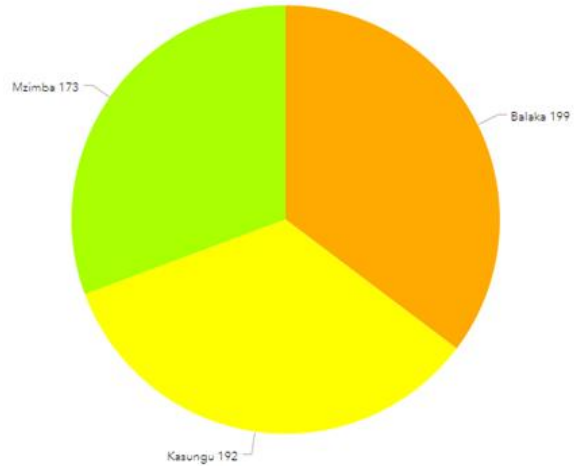
Other Crops

Input Types

Cause of Damage

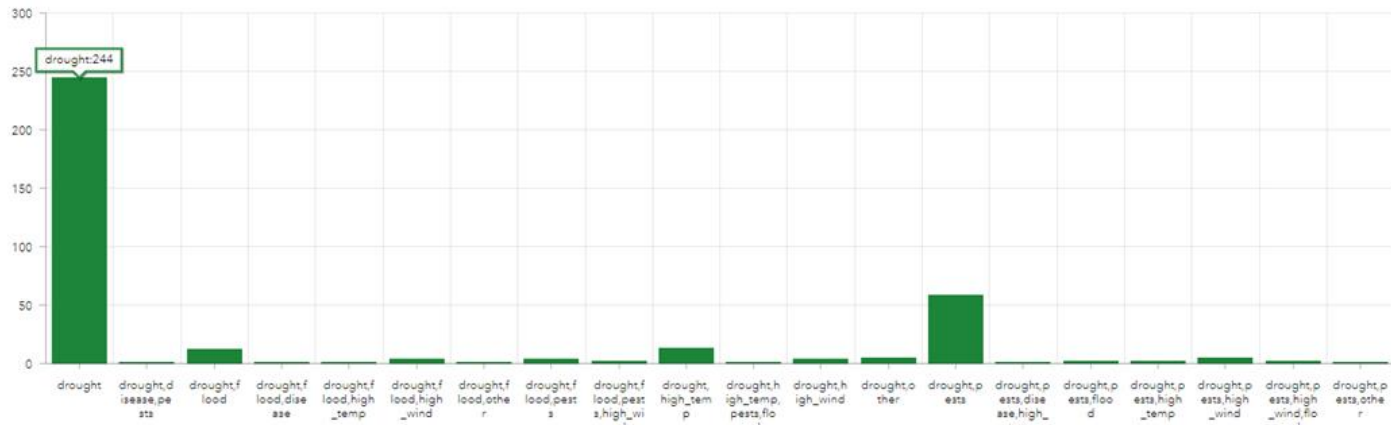


Malawi Crop Cut Campaign 2022

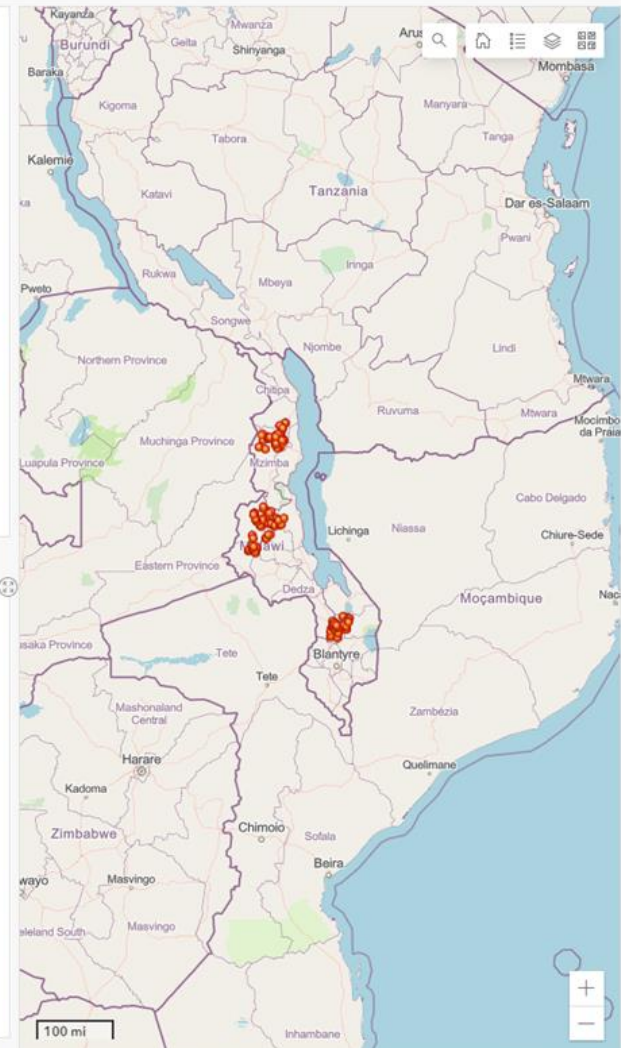


of Fields | # of Fields per District

Crop Conditions | **Crop Damage** | Replanting | Type of Replanting



Number of Observations | # of Fields per Day | Field Photos | Seed Type | Management | Other Crops | Input Types | **Cause of Damage**



Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affili... Powered by Esri



Key Takeaways

- Ground truth data is a critical component to agricultural monitoring
 - Location and correct field identification is key!
- Survey123 supports our needs
 - Building capacity - Partner organizations can take advantage of user-friendly tools to support and expand data collection needs
 - Efficient & Sustainable - Saves money, time and resources
 - Innovative & Agile - Continued cutting edge development through connecting Survey123 end users with development



NASA Harvest <3's Survey123



Websites:

www.nasaharvest.org

www.geoglam.org

www.cropmonitor.org

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Thank You!



Kate Hess

Demonstration



Poll Question

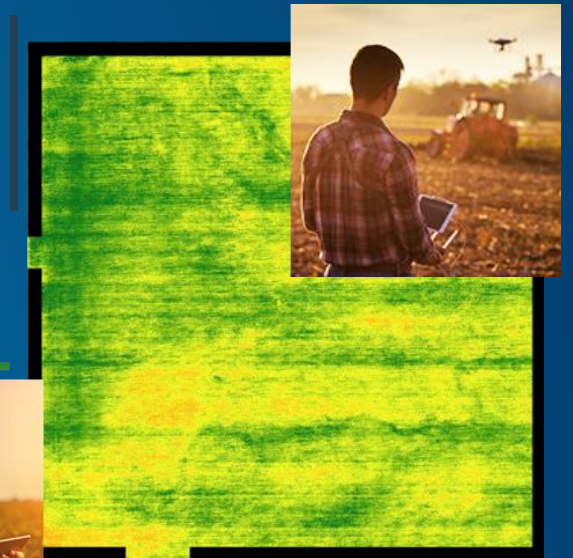
Please Tick the Boxes that Apply to Your Organization



Benefits to Agricultural monitoring

Enabling Us to Do More with Less

- Responsiveness - Speeding Timely Information to Decision Makers
- Expanding use of Technology, Data Analysis & Information Delivery
- Saving Time, Money, Labor and Environmental Impact
- Increasing Efficiency and Expanding Capacity
- Improving Accuracy and Engagement with User Community



GIS Field Data Collection for Agricultural Monitoring Application

Question & Answer

Please Enter Questions in the Questions Window



Resources

Esri Resources:

- <https://survey123.arcgis.com/>
- [Survey123 Resources](#)
- [Survey123 Community](#)
- [ArcGIS Blog: Nasa Harvest grows ground truth knowledge with ArcGIS](#)
- [Africa GeoPortal](#)
- <https://learn.arcgis.com/en/>

NASA Resources:

- www.nasaharvest.org
- www.geoglam.org
- www.cropmonitor.org

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**Thank You for Your Time and
Please Take a Minute to
Complete the Survey!**





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