Active Monitoring and Responsive Management of Food Production Systems - Applying space Technologies in Crop Monitoring

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Group on Earth Observations Global Agriculture Initiative (GEOGLAM)
NASA SERVIR Applied Sciences Team Member and Agriculture and Food Security Thematic Lead

Side Event: Accelerating climate risk management in the LDCs, 26 May 2021

NASA Harvest

HARVEST
EARTH DATA
FOR INFORMED AGRICULTURAL DECISIONS

NASA's Food Security and Agriculture Program, led by UMD

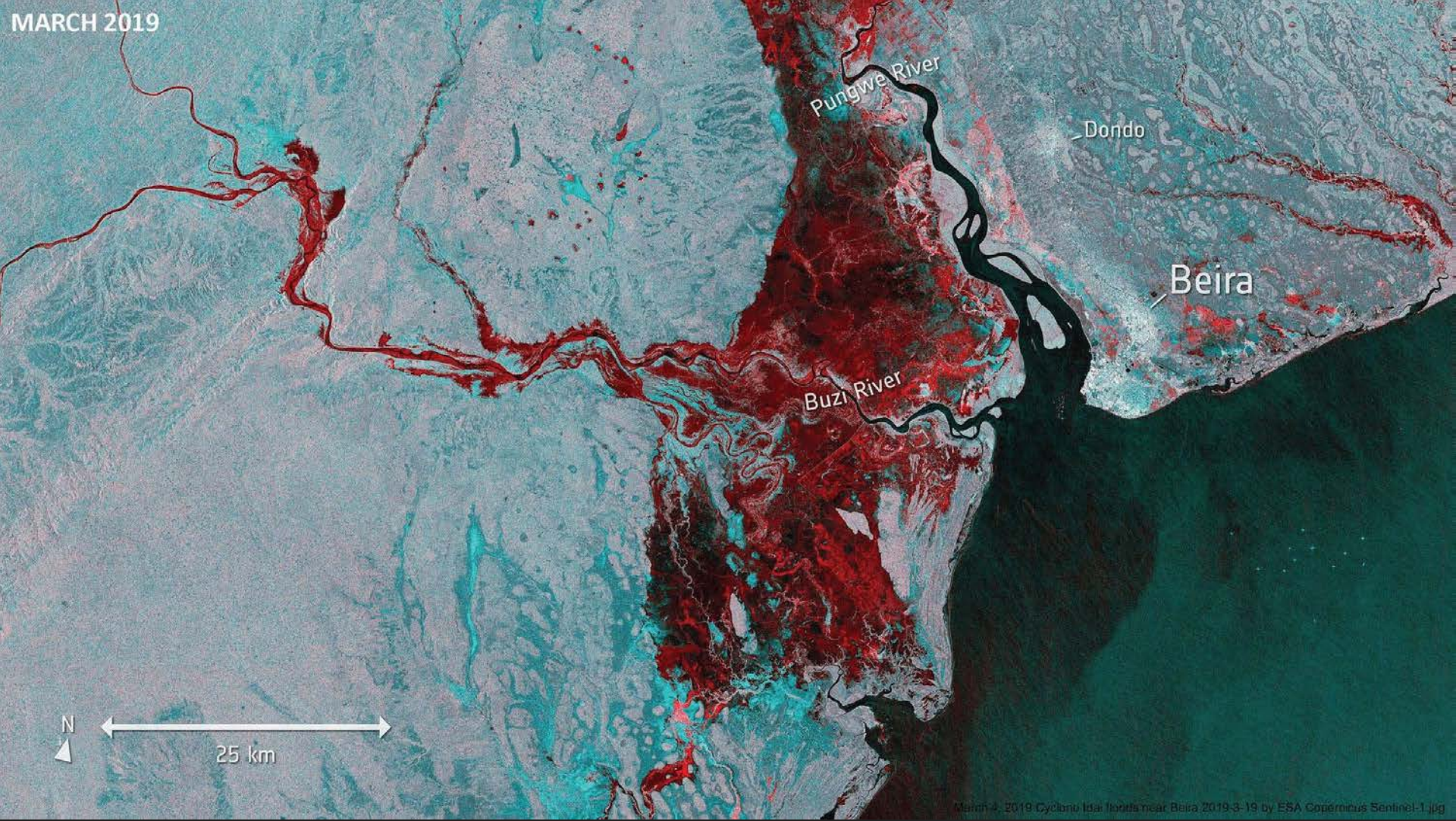
Goal: enable and advance the adoption of satellite **Earth observations** to benefit f**ood security**, **agriculture**, and human and environmental **resiliency**

NASA's Contribution to GEOGLAM Global Agricultural Monitoring

Space for Agriculture

Know what, where, how crops are is growing- forecast and early warning of impending failure and bumper harvests

- Increase production – EO improve the accuracy and relevance of decision support tools and
  - Increases access credit and other financial products
  - Food Balance Sheets
- Improve supply chain efficiency
  - Reduce losses, supply chain optimisation, traceability and market performance
- Environmental resources management
  - Farm practices, optimize inputs while reducing negative impacts,
- Resilience to climate change
  - Early warning systems, inform mitigation and adaptation


MARCH 2019
Pungwe River
Dondo
Beira
Buzi River
N
25 km
March 4, 2019 Cyclone Idai floods near Beira 2019-3-19 by ESA Copernicus Sentinel-1.jpg

File:Cyclone Idai west of Madaga...
commons.wikimedia.org

Cyclone Idai. | Flickr
flickr.com

Cyclone Idai, Mozambique, aftermath, 15 ...
flickr.com

Cyclone Idai, Mozambique, aftermath, 15 ...
flickr.com

Cyclone IDAI.jpg - Wikimedia Commons
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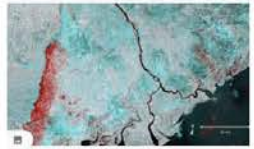
In Beira, Cyclone Idai caused damage to ...
flickr.com

Cyclone Idai, Mozambique, response, 18 ...
flickr.com



File:Flood near Zambezi Delta after ...
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Cyclone Idai, Mozambique, evacuees in ...
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Cyclone Idai, Mozambique, evacuees in...
flickr.com

Cyclone Idai, Mozambique, aftermath, 15 ...
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Malawi following Cyclone Idai.jpg ...
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Cyclone Idai, Mozambique, response, 18 ...
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File:Cyclone Idai floods near Beira ...
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Cyclone Idai, Mozambique, response, 18 ...
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EU response to cyclone Idai in ...
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Cyclone Idai, Mozambique, response, 18 ...
flickr.com

People take refuge on the roofs of ...
flickr.com

Tropical Cyclone Idai | iss059e000502 ...
flickr.com

Cyclone Idai, Mozambique, response, 18 ...
flickr.com

List of natural disasters by death toll ...
en.wikipedia.org

EU response to cyclone Idai in ...
flickr.com

Cyclone Idai, Mozambique, evacuees in ...
flickr.com

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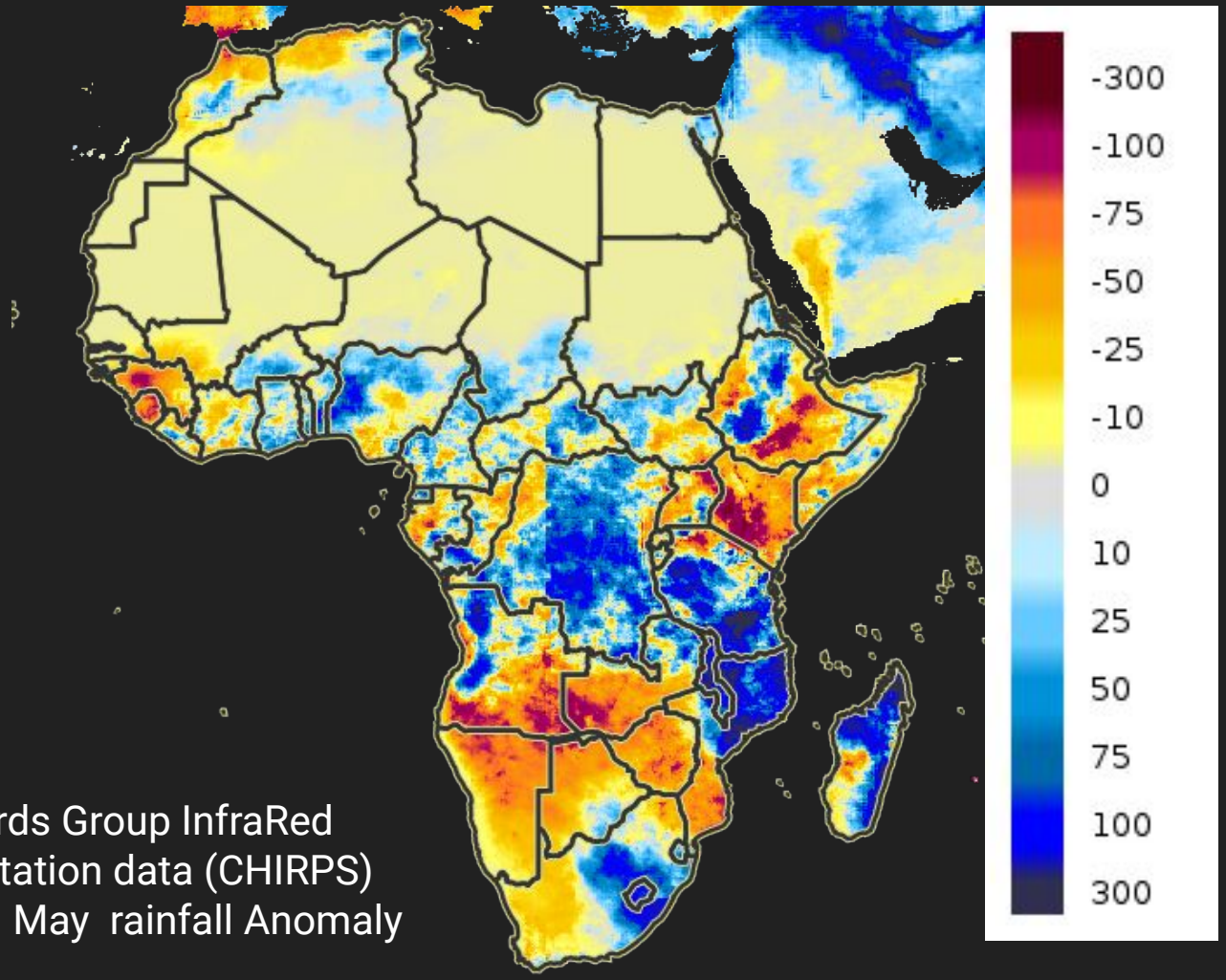
commons.wikimedia.org



2019 Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) Rainfall March April May rainfall Anomaly

Source: https://earlywarning.usgs.gov/fews/ewx/index.html?region=af

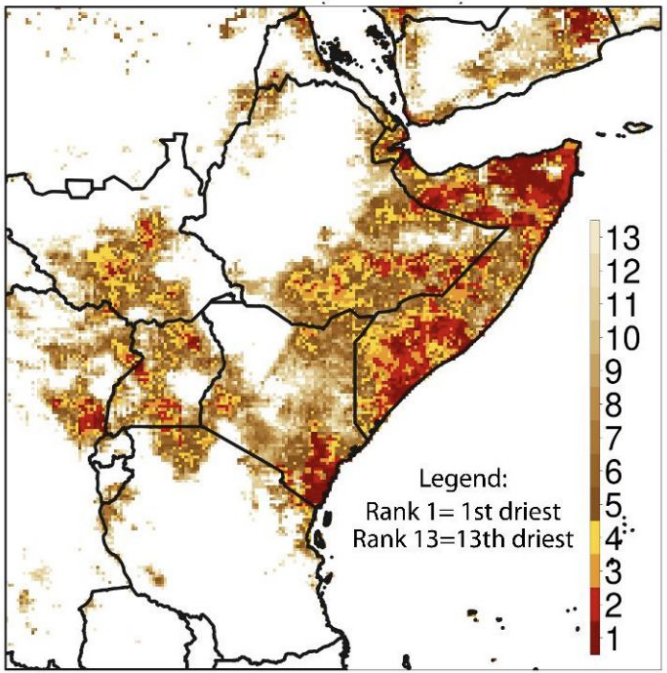
May 9th, 2019

Climate Hazards Center
UC SANTA BARBARA

GEOGLAM
Global Agricultural Monitoring

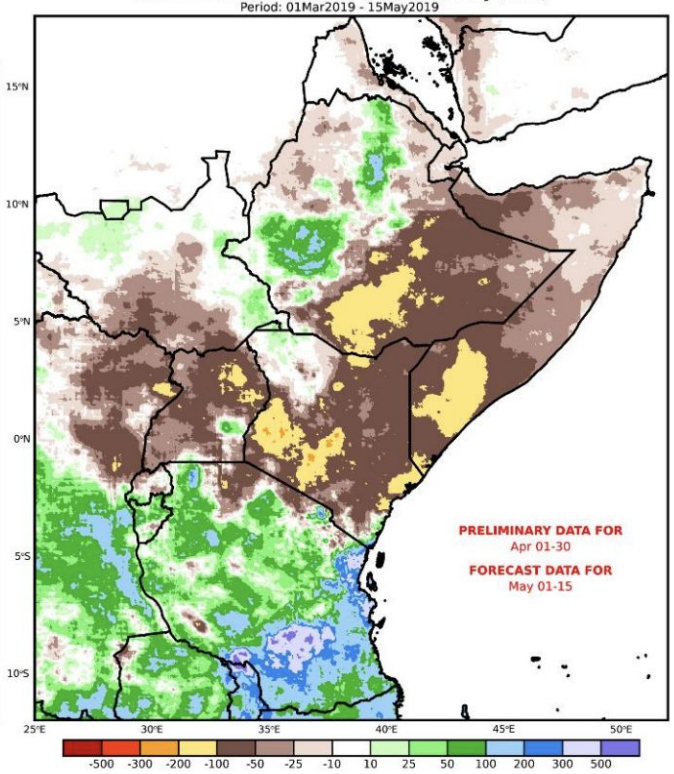
2019 March-April Rainfall: Rank among 1981-2019

Data: CHIRPS 2.0 final and preliminary



CHIRPS 15-Pentad Total Rainfall Anomaly (mm)

Period: 01Mar2019 - 15May2019



Highlights

- Planted area of the long rains maize crop in Kenya was significantly reduced compared to the previous year due to delayed onset of the March to May rains and widespread drought over the marginal agricultural areas of eastern, central, and coastal Kenya.
- Long rains maize production outlook is estimated at 20 percent below the 2018 bumper harvest and 10 percent below the average 2016 harvest.
- In agropastoral and marginal agricultural areas of central, southeastern and coastal Kenya, long rains maize harvest finished in August and production is estimated at about 50-60 percent below-average, with a near failure of the harvest reported in southeastern areas (Figure 1).
- By contrast, in key growing areas of Rift Valley and western provinces, where the long rains season (which normally extends from March to August) improved rains from May onwards, mostly offsetting rainfall deficits and resulting in a partial recovery of water-stressed and late-planted crops.
- Maize harvest over the West and Rift Valley will begin in late October to November and while yields are expected to be average due to improved rains from mid-May onwards (Figure 1), production prospects are below-average due to a delay in

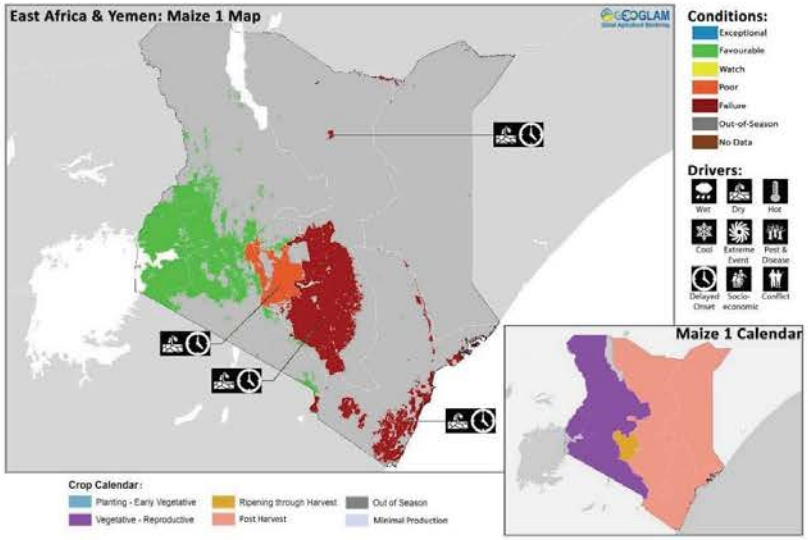
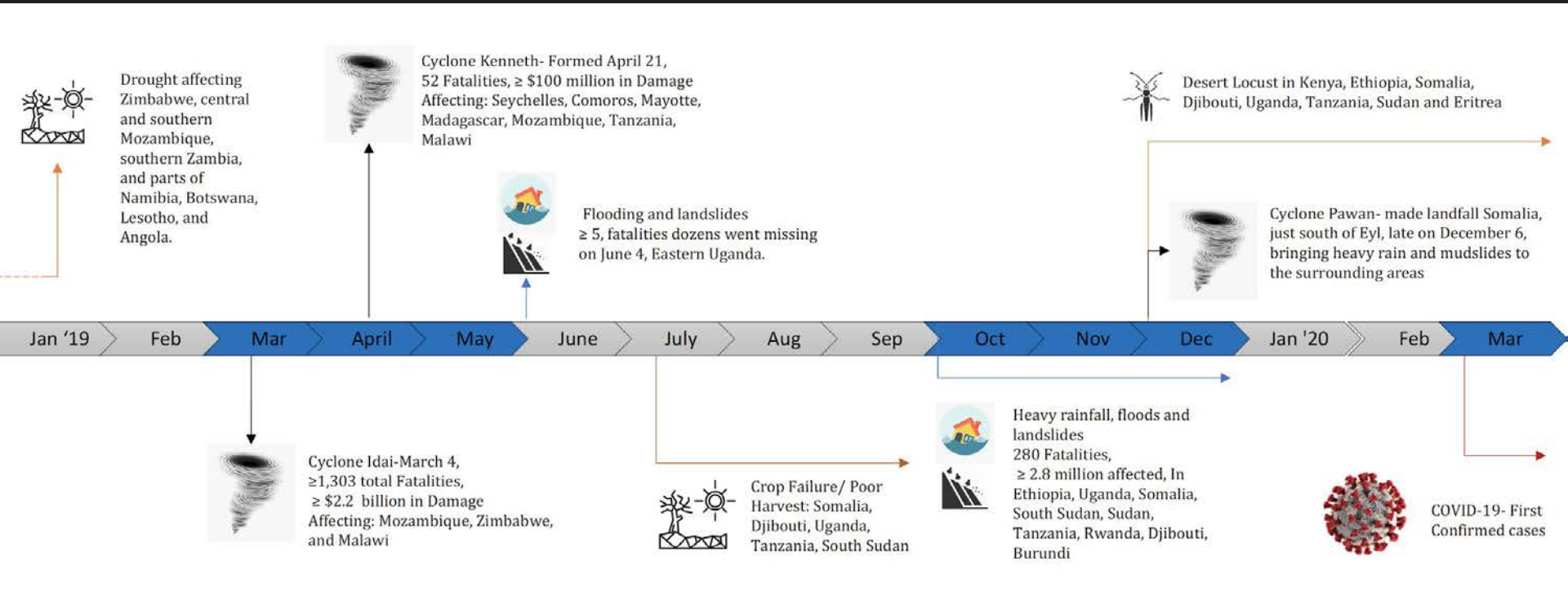
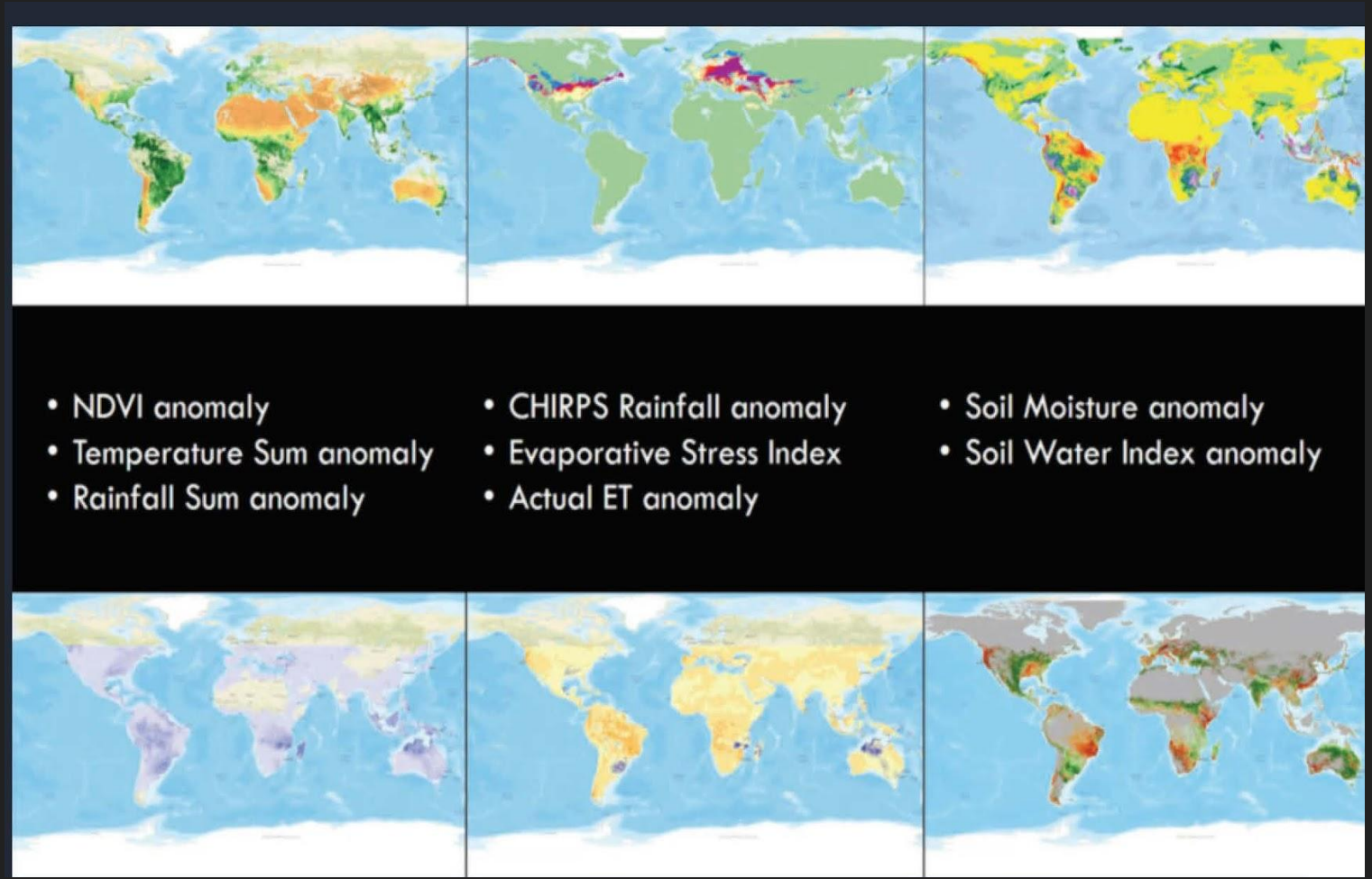


Figure 1. Kenya crop condition map summarizing conditions as of September 24th (source: GEOGLAM CM4EW). Note: updated crop conditions for Kenya will be published October 3rd, in the CM4EW October Bulletin.

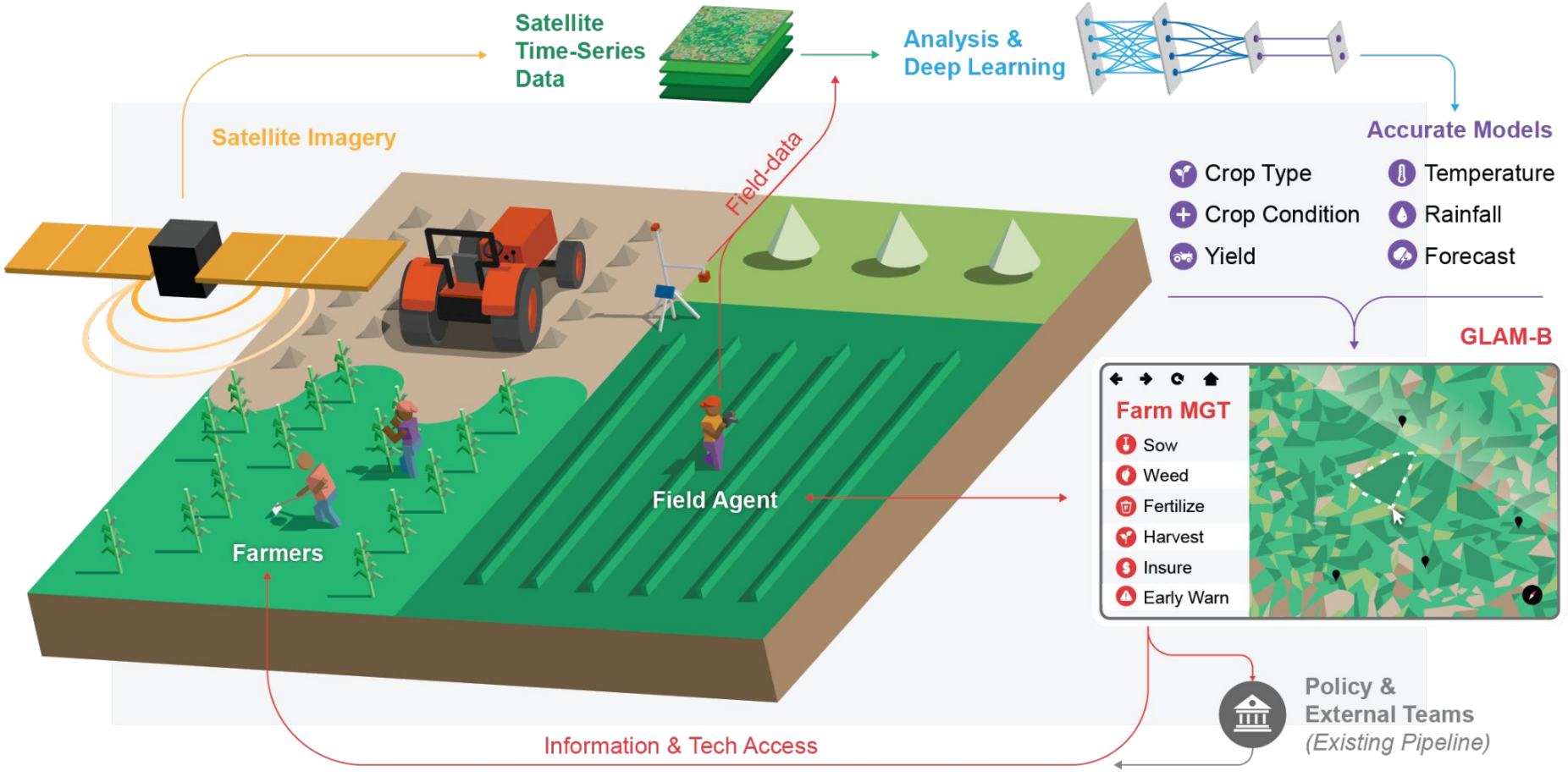


Nakalembe, C. (2020). Urgent and critical need for sub-Saharan African countries to invest in Earth observation-based agricultural early warning and monitoring systems. *Environmental Research Letters*, *15*(12), 1–3. https://doi.org/10.1088/1748-9326/abc0bb

Earth Observations Data for Crop Monitoring



https://cropmonitor.org/index.php/eodatatools/eodata/


Satellite
Time-Series
Data
Analysis &
Deep Learning
Satellite Imagery
Field-data
Accurate Models
Crop Type
Crop Condition
Yield
Temperature
Rainfall
Forecast
GLAM-B
Farm MGT
Sow
Weed
Fertilize
Harvest
Insure
Early Warn
Field Agent
Farmers
Policy &
External Teams
(Existing Pipeline)
Information & Tech Access

NASA Harvest Africa Program Priorities

1. Improving monitoring and early warning systems that provide actionable data and information on agricultural productivity and food security at multiple scales,

2. Advancing methods that underpin the data and systems,

3. Developing and transferring capacity to national and local users that influence decision making, and

4. Developing strong, long-term, sustainable partnerships

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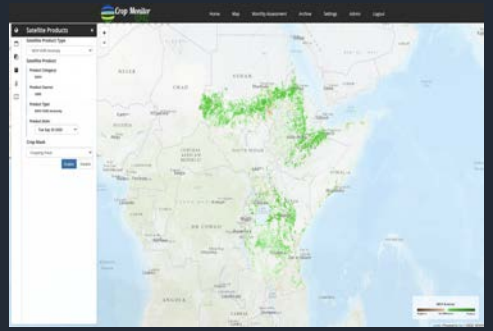
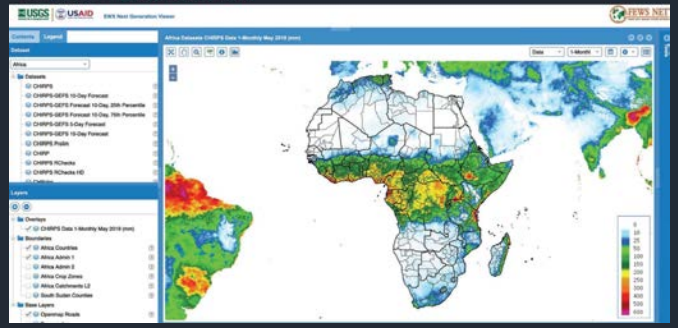
EO Improves monitoring and early warning through systems that provide actionable data and information on agricultural productivity and food security at multiple scales



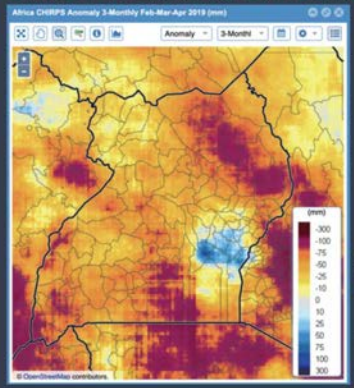
- Tested, applied and used global systems
- GEOGLAM Crop Monitors
- Global Agriculture Monitoring System
- Harvest Covid-19 Dashboard
- Early Warning Explorer (Harvest Partner CHG)
- In Kenya, Mali, Rwanda, Tanzania, Uganda, IGAD countries, Brazil, Argentina, Pakistan, and Globally
- Leveraging open access and/or easily customizable tools that offer solutions to monitoring.

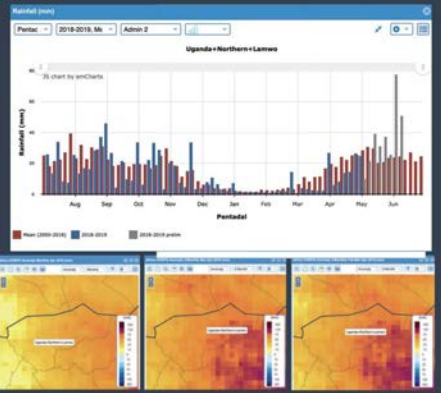
Early Warning eXplorer (EWX)



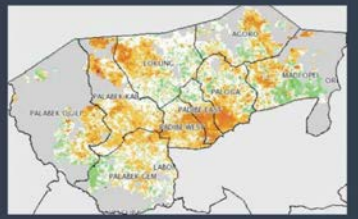
Nakalembe, C., Becker-Reshef, I., Bonifacio, R., Hu, G., Humber, M. L., Justice, C. J., … Sanchez, A. (2021). A review of satellite-based global agricultural monitoring systems available for Africa. Global Food Security, 29, 1–38. https://doi.org/10.1016/j.gfs.2021.100543

EARLY WARNING EXPLORER



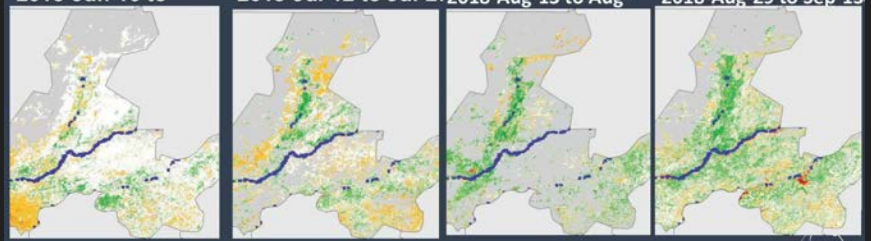


GLAM SATELLITE DATA PORTAL



GLAM SATELLITE DATA PORTAL

Segou 2018



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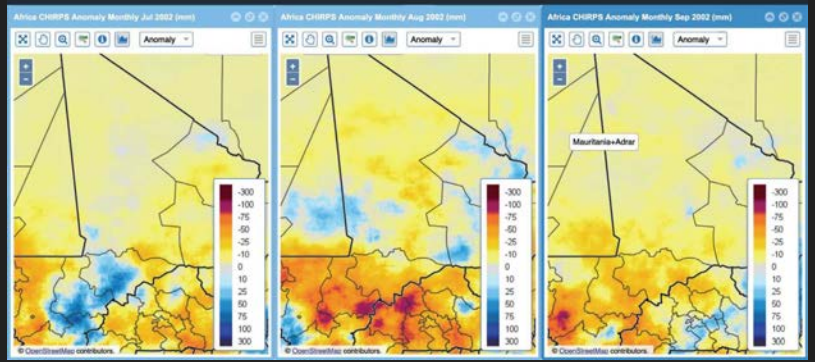
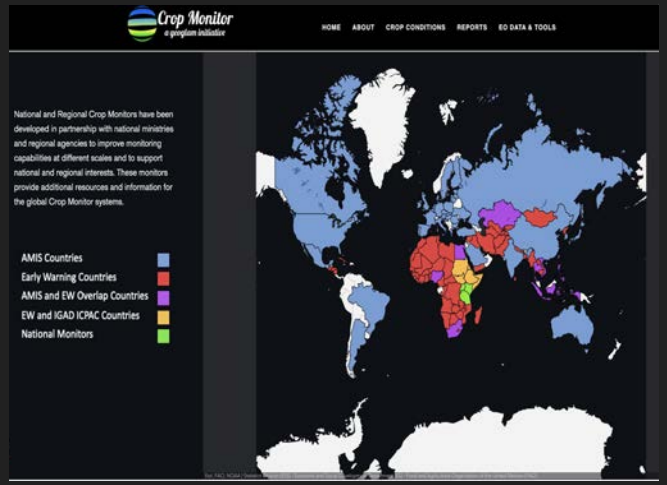
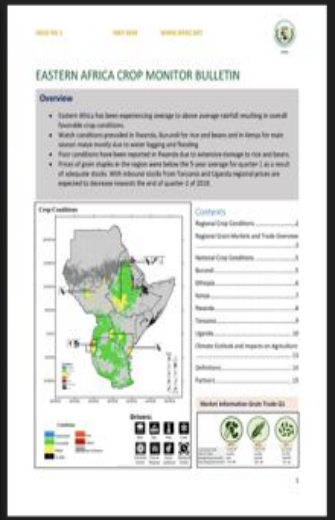
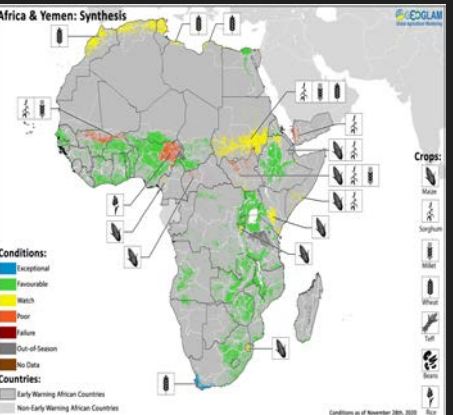
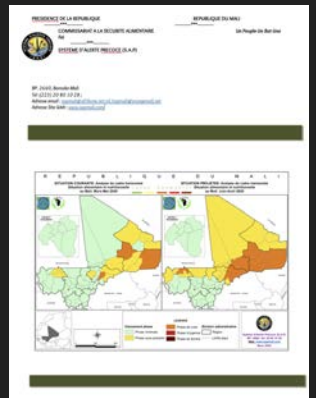


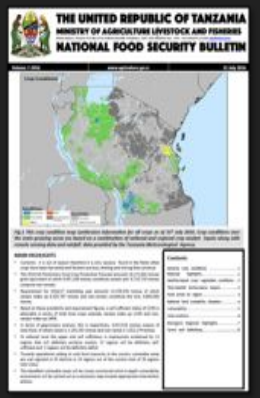
Effective early warning and monitoring systems are fundamental for early action and strengthening residence

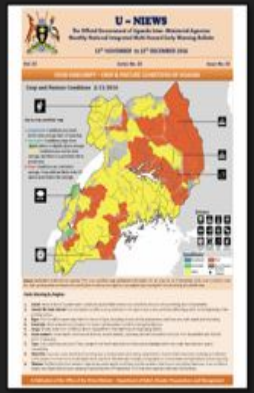


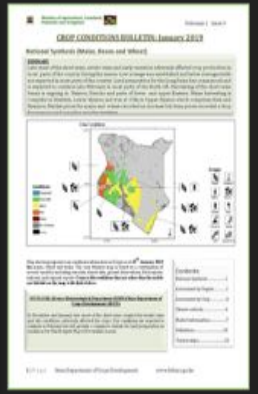












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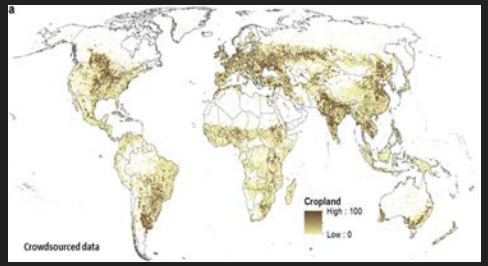
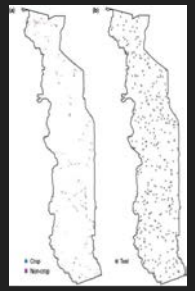
Why so little progress?

Monitoring Smallholder Agriculture

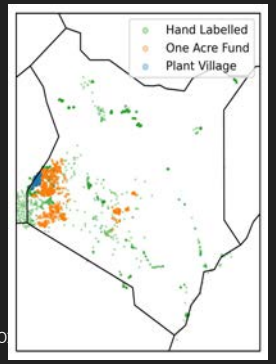



EO + ML for cropland mapping



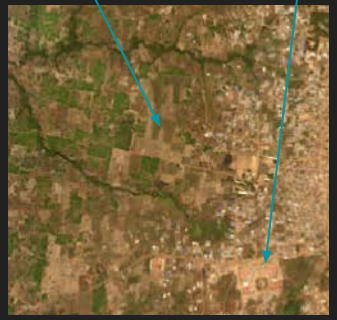


Kerner & Tseng et al., 20



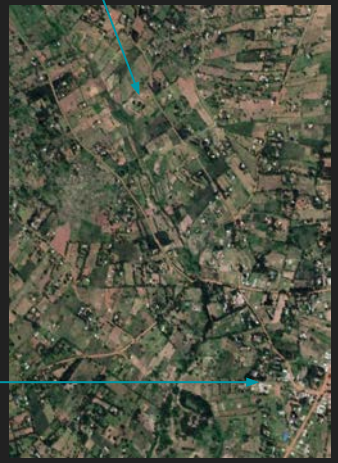
crop

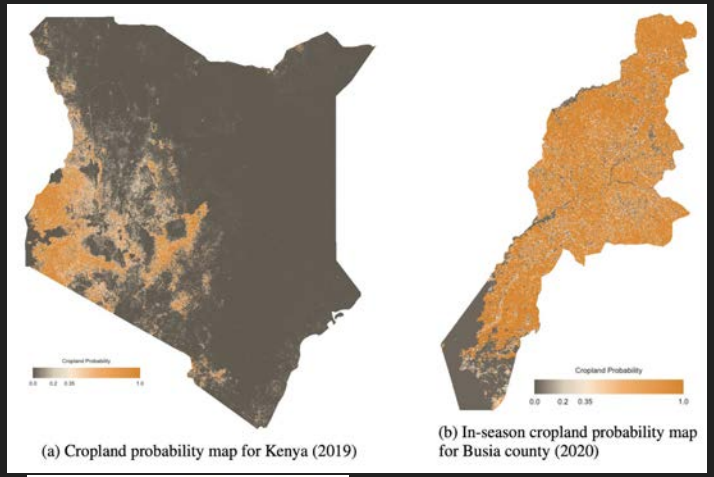
non-crop



crop

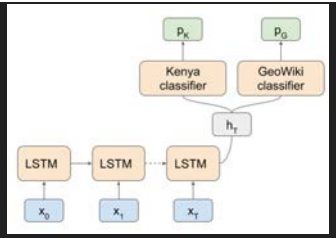
non-crop

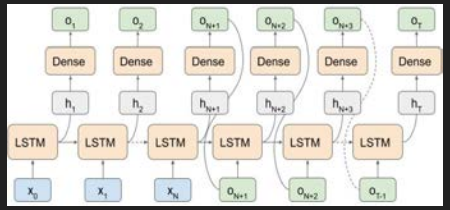


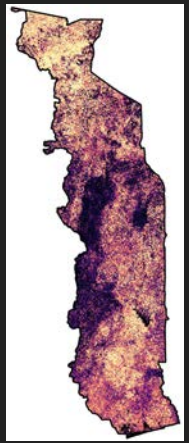


(a) Cropland probability map for Kenya (2019)

(b) In-season cropland probability map for Busia county (2020)

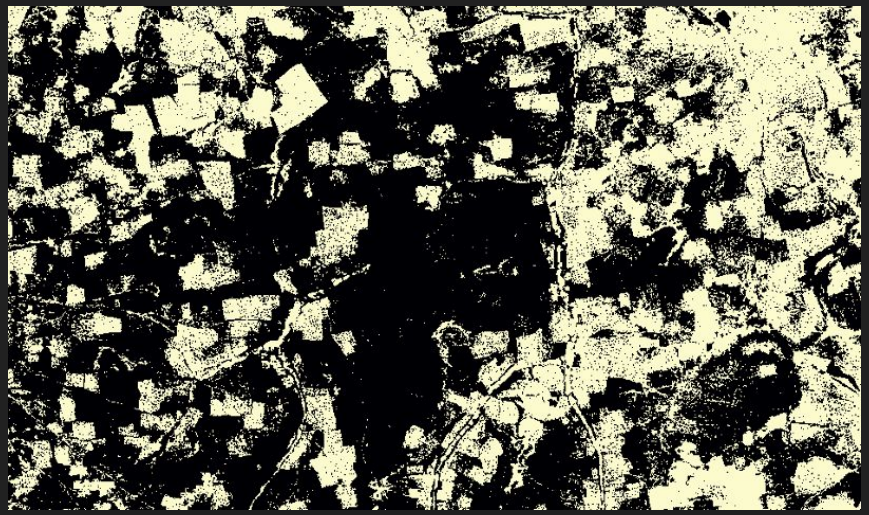




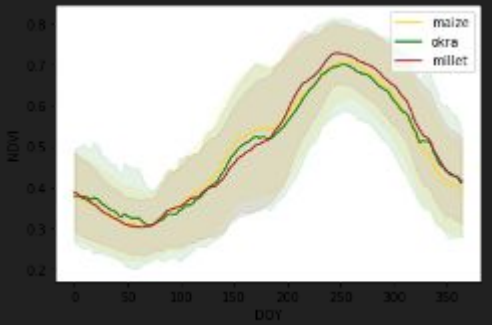


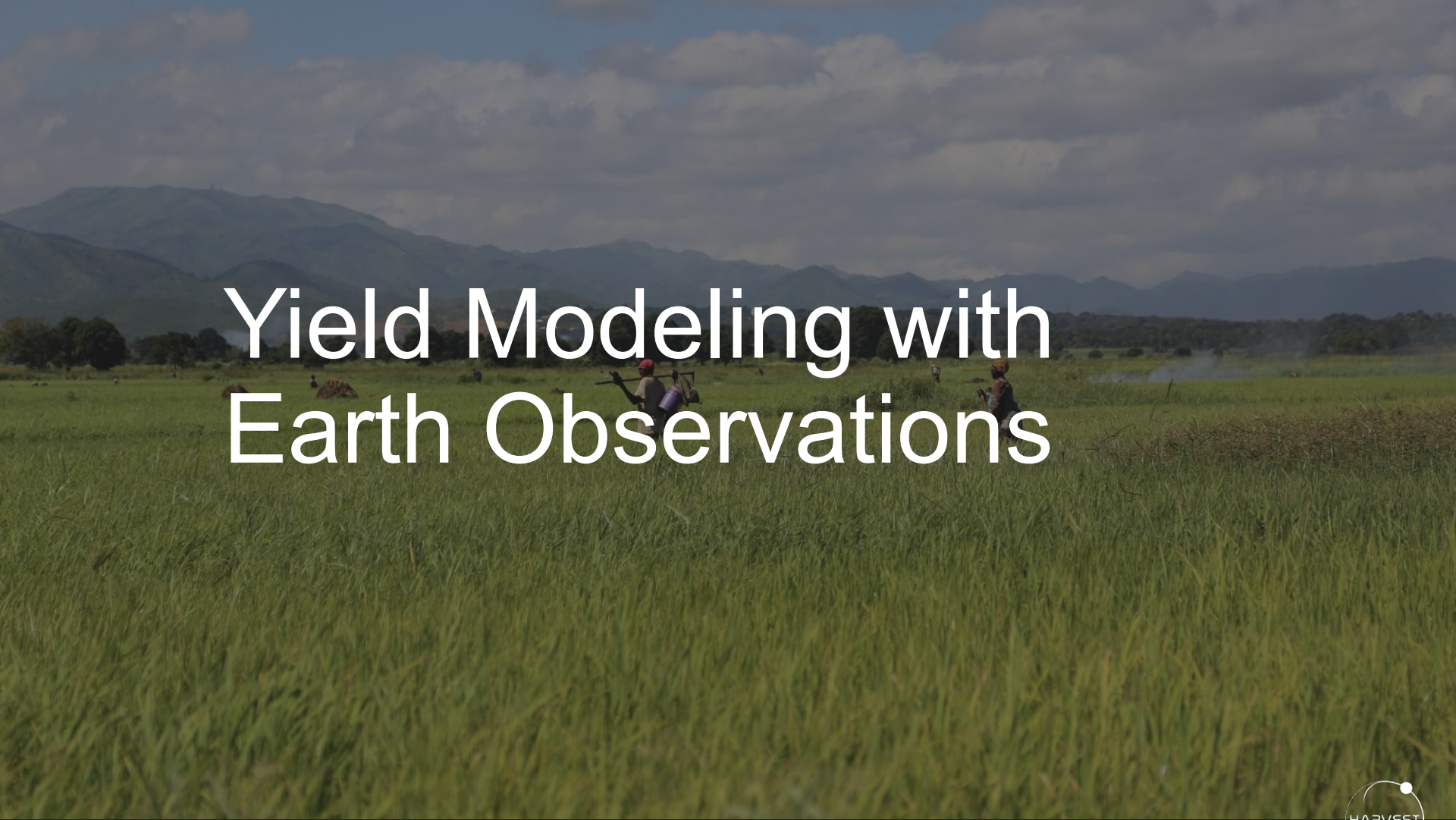
Cropland mapping and tree masking in Mali

Clustering of daily time series



- L3H/Planet Fusion: unprecedented daily gap-filled time series at 3m resolution
- Fine-scale temporal resolution could enable simpler and/or unsupervised approaches
- K-means clustering of daily NDVI time series (k=2)
-





Yield Modeling with Earth Observations

HARVEST

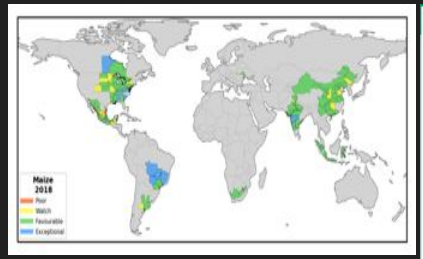
Yield Forecast/Assessment:
Global to National to Sub-national to Field scales

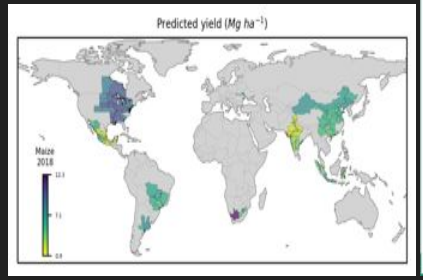
Global Scale
Forecasts within 3-5% error, 2 months prior to harvest

National Scale
3-8% error 1.5-2 months prior to harvest

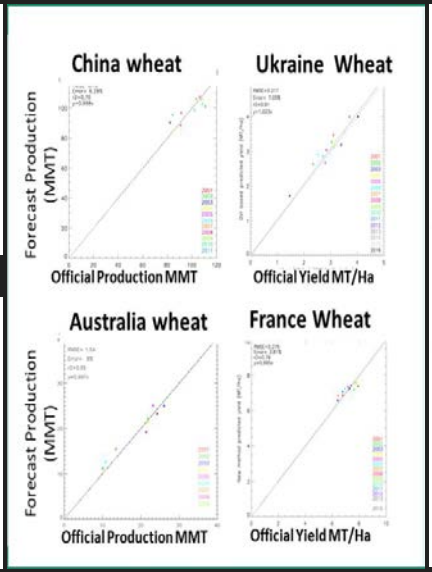
Sub-National Scale
8-14% error 1.5-2 months prior to harvest

Field Scale Argentina/ Iowa

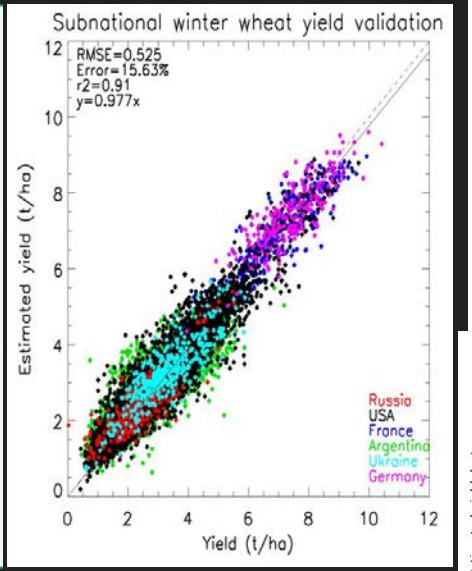


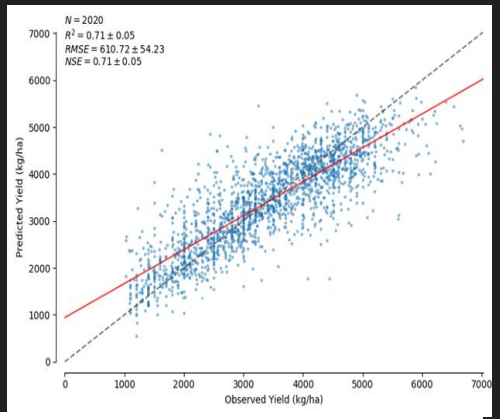


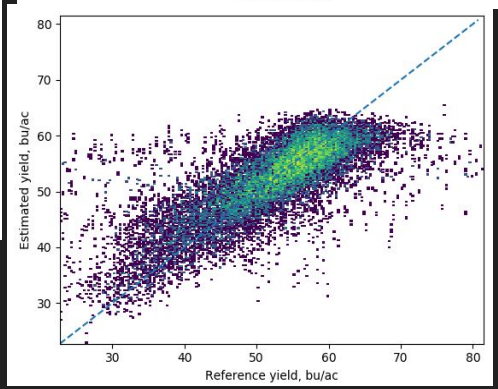
Sahajpal et al.



Franch, Skakun, Becker-Reshef et al. UMD

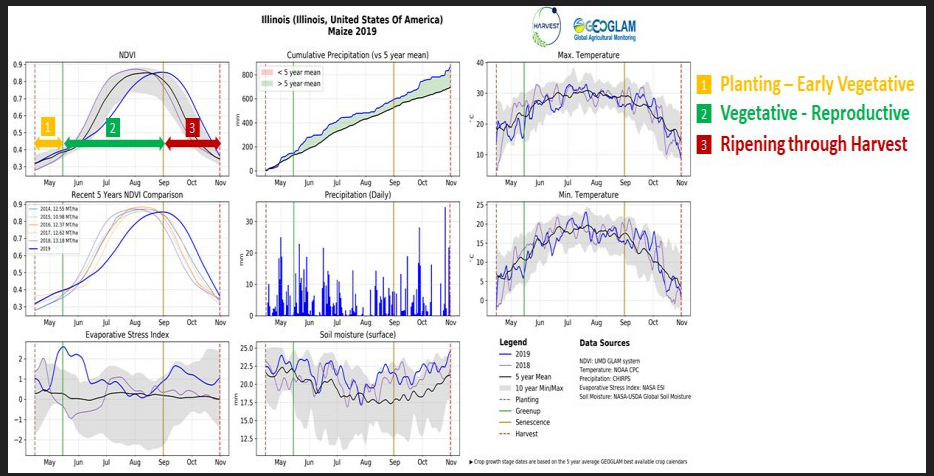


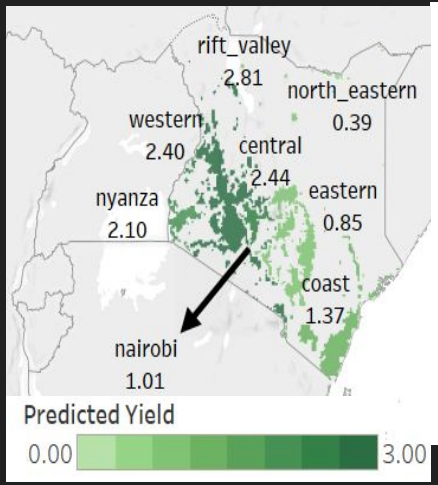


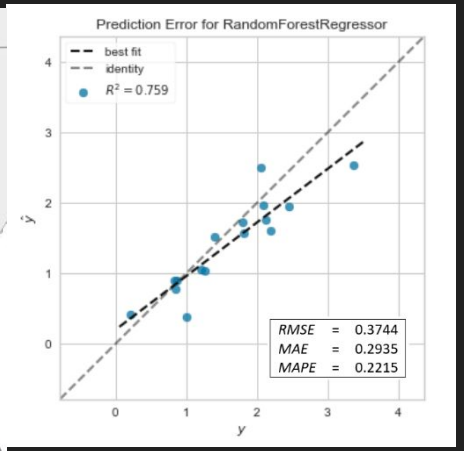


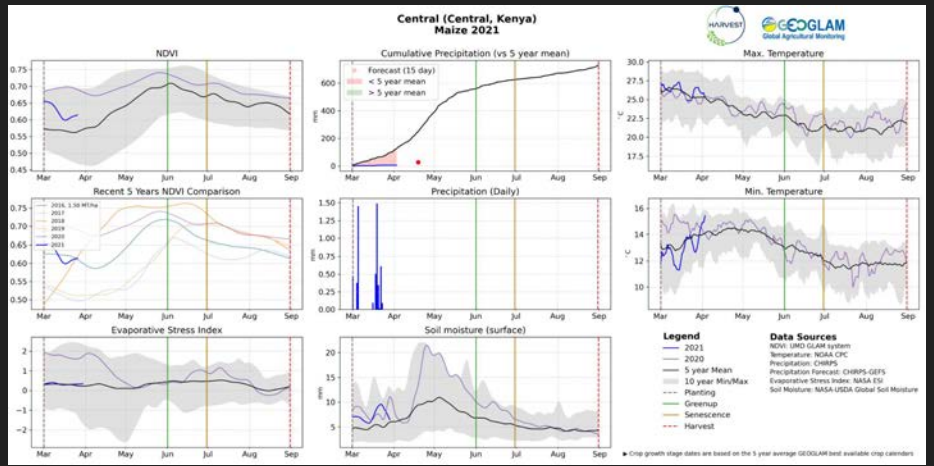
Skakun et al. / UMD

Global Earth Observations for Crop Inventory Forecasting (GEOCIF).









An automated system that produces alerts to assesses crop conditions globally by applying machine-learning algorithms on EO data

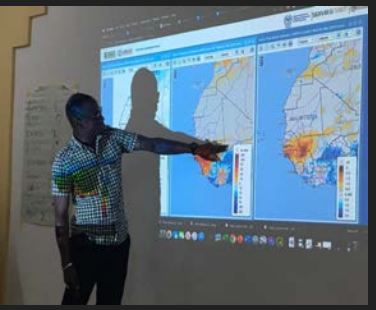
NASA Harvest Africa Program Priorities

1. Improving monitoring and early warning systems that provide actionable data and information on agricultural productivity and food security at multiple scales,

2. Advancing methods that underpin the data and systems,

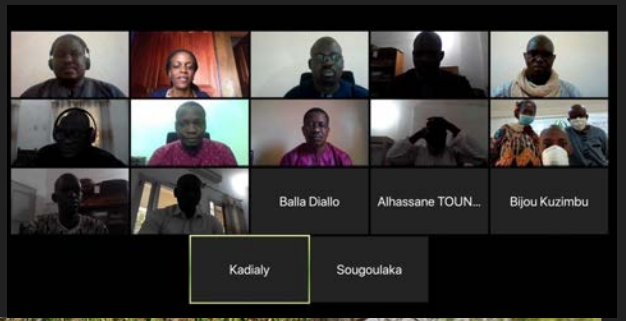
3. **Developing and transferring capacity to national and local users that influence decision making, and**

4. Developing strong, long-term, sustainable partnerships









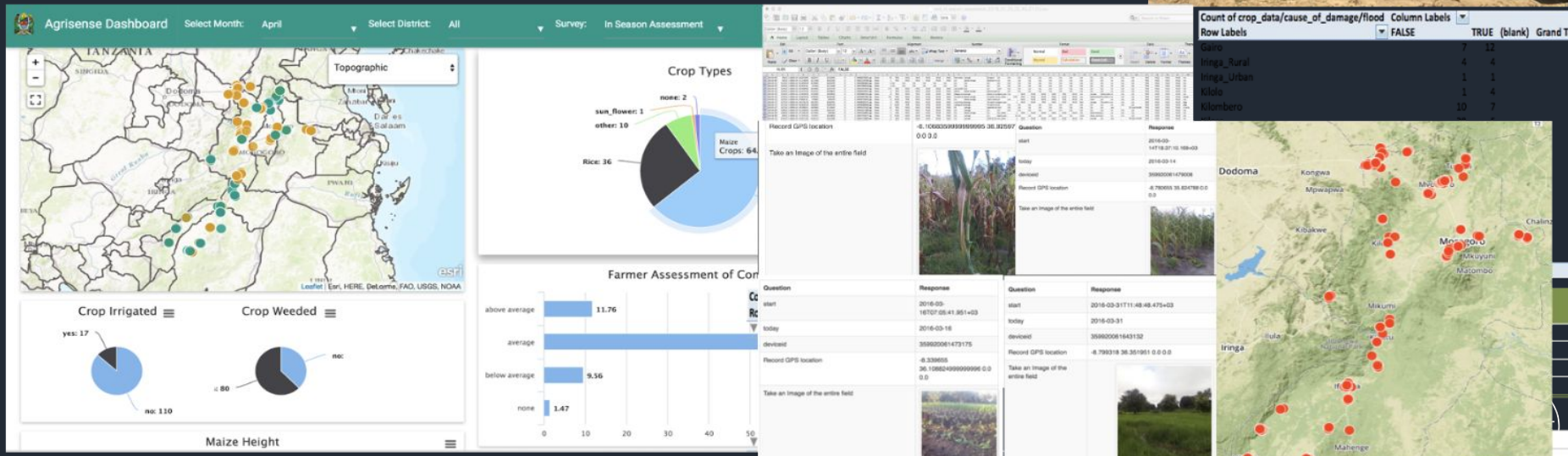
Training Programs: Crop Monitor Champions







Field-data collection



NASA Harvest Africa Program Priorities

1. Improving monitoring and early warning systems that provide actionable data and information on agricultural productivity and food security at multiple scales,

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Partnerships

Prepared by members of the GEOGLAM Community of Practice, coordinated by the University of Maryland Center for Global Agricultural Research and funded through NASA Harvest.

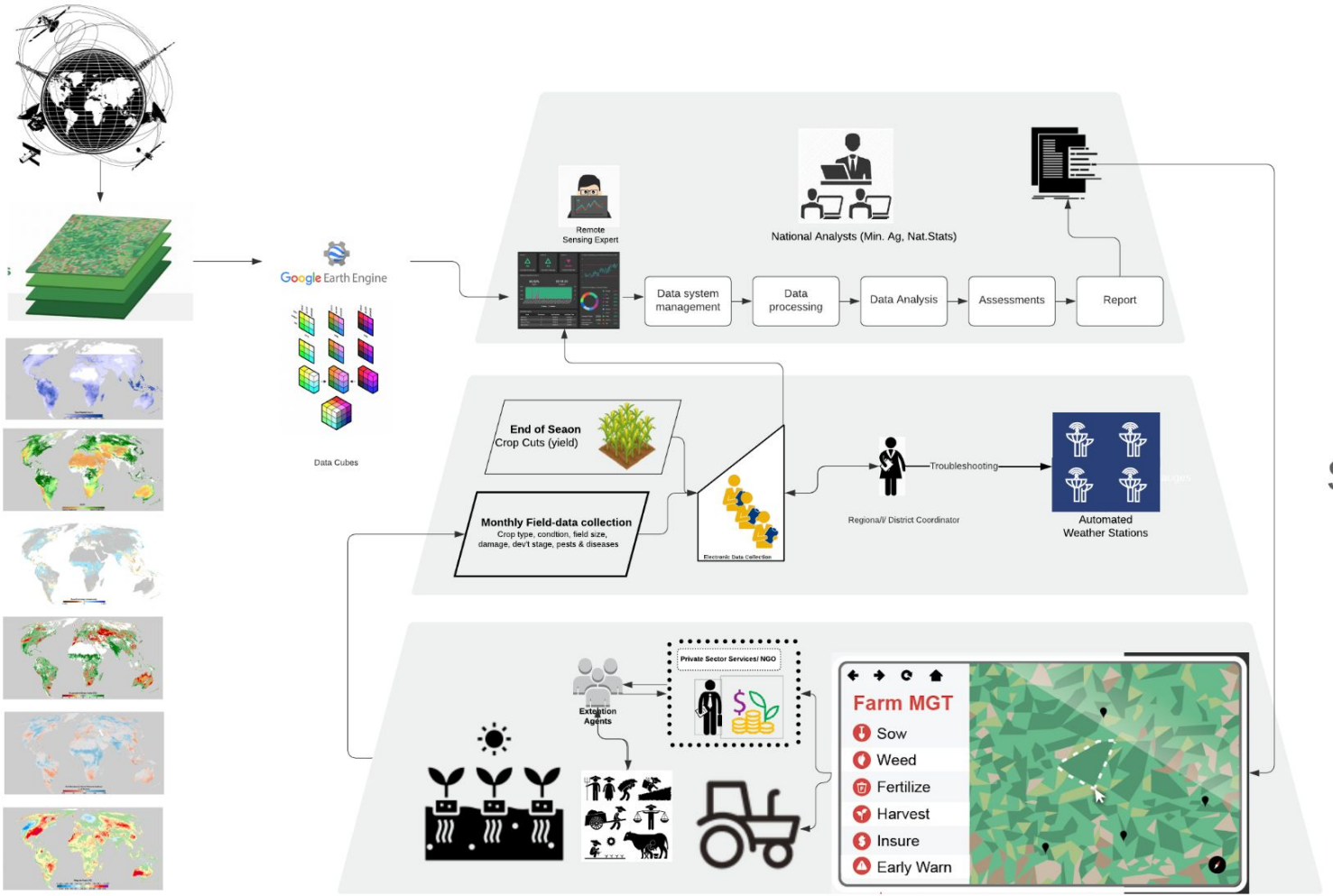
GROUP ON EARTH OBSERVATIONS — The Crop Monitor is a part of GEOGLAM, a GEO global initiative.

Cover Photo by Christina Justice

Contributing partners

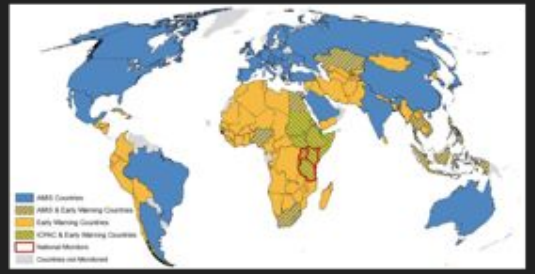
Partnerships

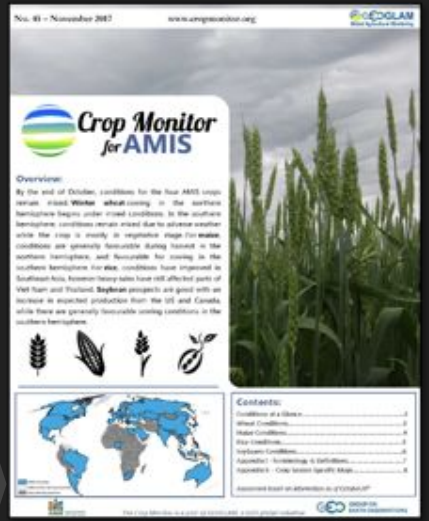
Building Blocks

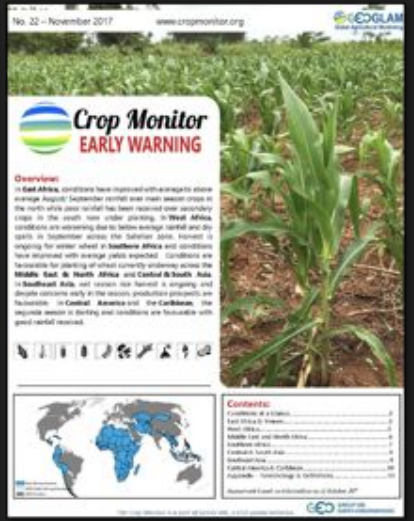

Google Earth Engine
Data Cubes
Remote Sensing Expert
National Analysts (Min. Ag, Nat.Stats)
Data system management
Data processing
Data Analysis
Assessments
Report
National
End of Seaon Crop Cuts (yield)
Monthly Field-data collection
Crop type, condition, field size, damage, dev't stage, pests & diseases
Troubleshooting
Regional/ District Coordinator
Automated Weather Stations
Sub-National
Private Sector Services/ NGO
Extention Agents
Farm MGT
Sow
Weed
Fertilize
Harvest
Insure
Early Warn
Field-Scale

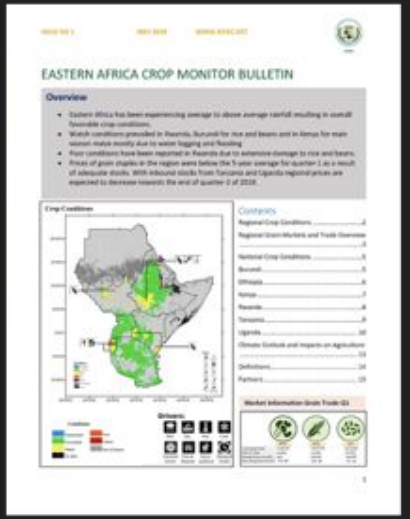
Impact Examples

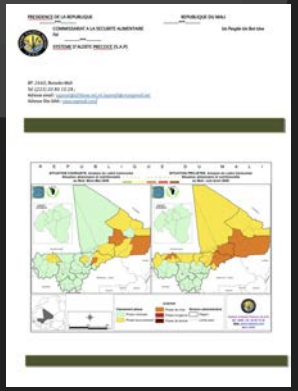
Embedding Knowledge in institutions and processes

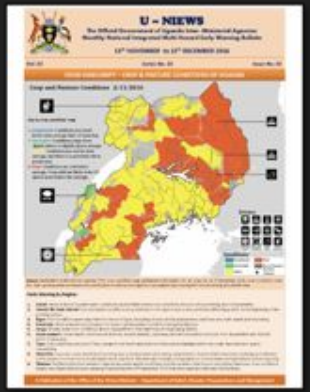


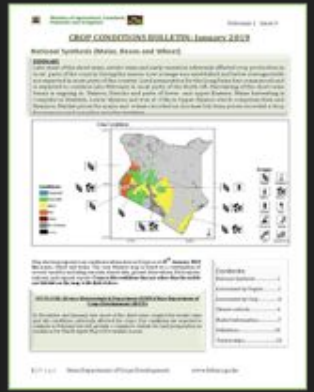




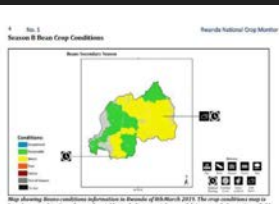


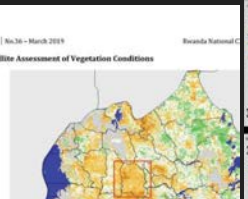


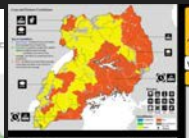


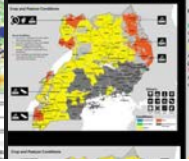


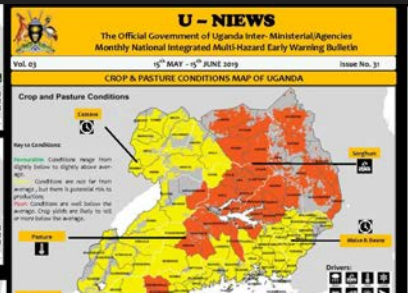

Issue No. 01 March 2019 www.minagri.gov.rw Rwanda National Crop Monitor


Season B Bean Crop Conditions

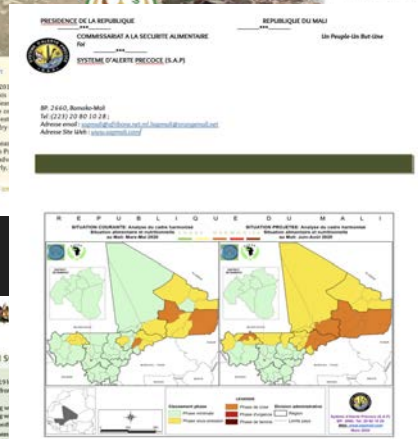

telite Assessment of Vegetation Conditions



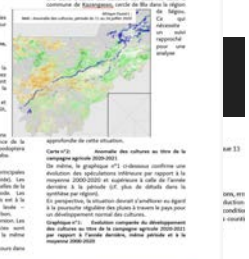



U – NIEWS
The Official Government of Uganda Inter- Ministerial|Agencies
Monthly National Integrated Multi-Hazard Early Warning Bulletin
CROP & PASTURE CONDITIONS MAP OF UGANDA

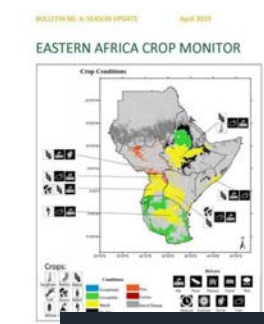

U – NIEWS
Uganda National Integrated Early Warning System – Monthly Bulletin
Normalized Different Vegetation Index Anomaly Image (April 30—May 7th 2019)

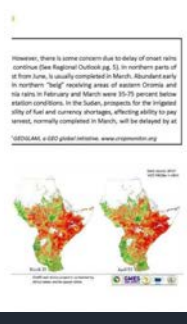

PRESIDENCE DE LA REPUBLIQUE
COMMISSARIAT A LA SECURITE ALIMENTAIRE
SYSTEME D'ALERTE PRECOCE (S.A.P)

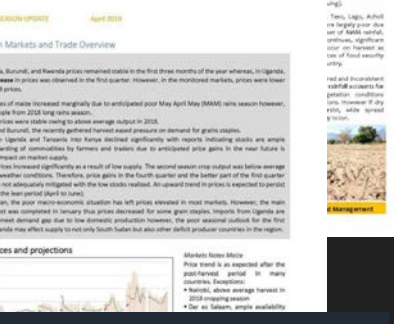

Bulletin Juillet 2020

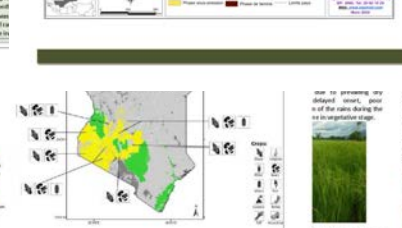


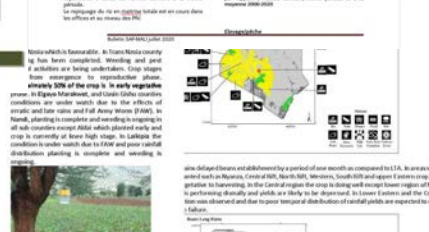
R E P U B L I Q U E D U M A L I

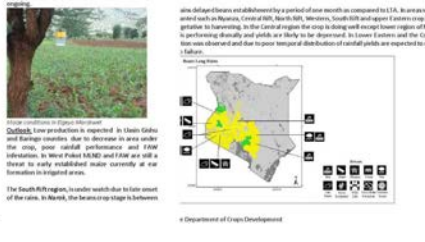

EASTERN AFRICA CROP MONITOR
Crop Conditions
Overview
The current crop season in the central and southern part of the region normally starts with onset of March to May rainfall season. However, majority of cropping regions have experienced extended dry conditions with delayed rainfall. This has disrupted planting activities in the countries where rainfall has commenced and delayed planting in those countries yet to receive rainfall. The Tropical Cyclone "Ida" experienced in early march in Mozambique area redirected precipitation away from the Eastern Africa region resulting persisting dry conditions.
60%
Below Average Rainfall in Most Countries in March

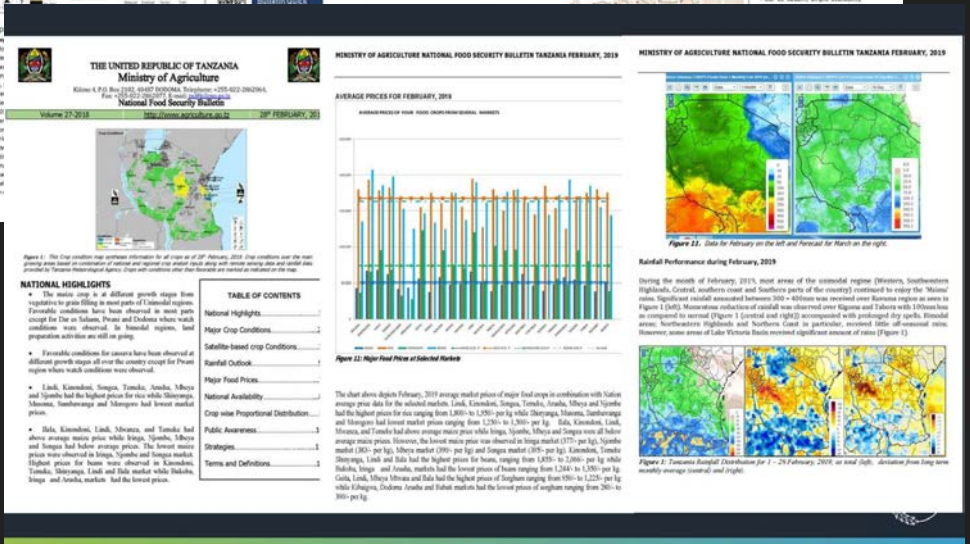



Markets Notes Maize
Price trend is as expected after the post-harvest period in many countries. Exceptions:
• Nairobi, above average harvest in the surplus areas
• Dar es Salaam, ample availability








THE UNITED REPUBLIC OF TANZANIA
Ministry of Agriculture
National Food Security Bulletin
Volume 27-2018 http://www.agriculture.go.tz 28th FEBRUARY, 20
NATIONAL HIGHLIGHTS
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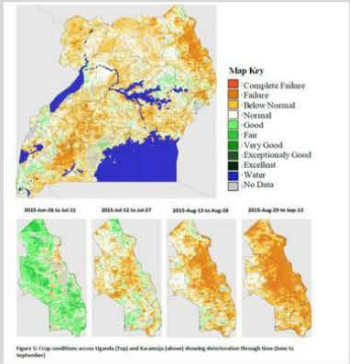
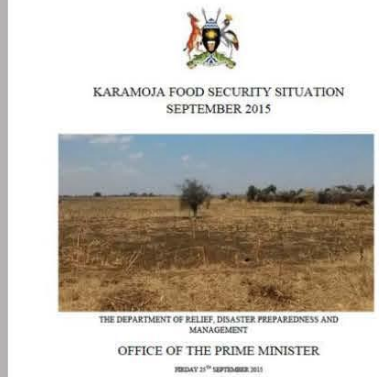
AVERAGE PRICES FOR FEBRUARY, 2019
Figure 12: Major Food Prices at Selected Markets
MINISTRY OF AGRICULTURE NATIONAL FOOD SECURITY BULLETIN TANZANIA FEBRUARY, 2019
Figure 11. Data for February on the left and Forecast for March on the right.
Rainfall Performance during February, 2019
Figure 1: Tanzania Rainfall Distribution for 1 – 28 February, 2019, as total (left), deviation from long term monthly average (central) and (right).

EO SUPPORTED IMMEDIATE DECISION AND ACTION

- Food security report presented to Inter-Ministerial Committee September 25, 2015
- First trucks of relief food dispatched September 26, 2015





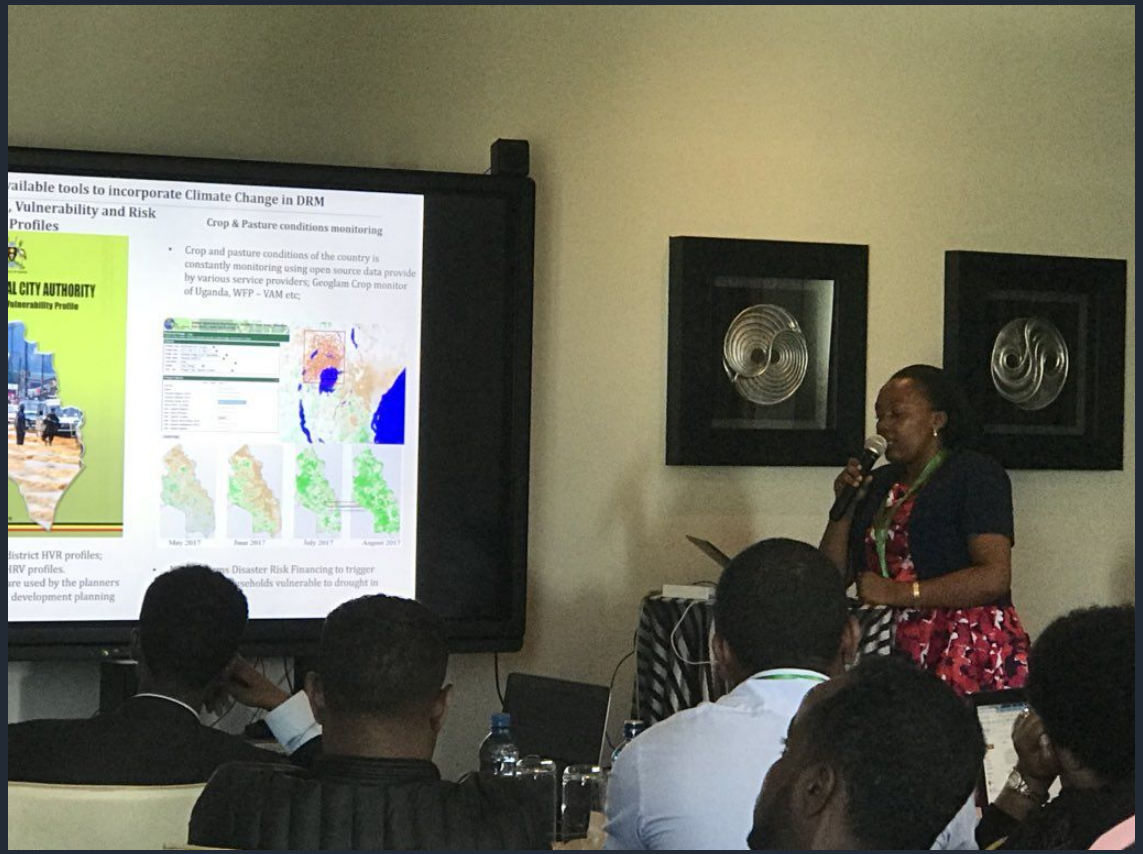
KARAMOJA FOOD SECURITY SITUATION
SEPTEMBER 2015

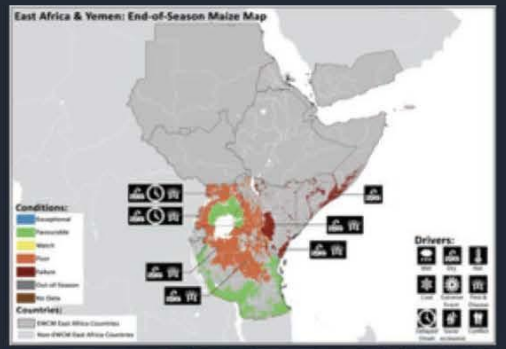
THE DEPARTMENT OF RELIEF, DISASTER PREPAREDNESS AND MANAGEMENT

OFFICE OF THE PRIME MINISTER

FRIDAY 25TH SEPTEMBER 2015

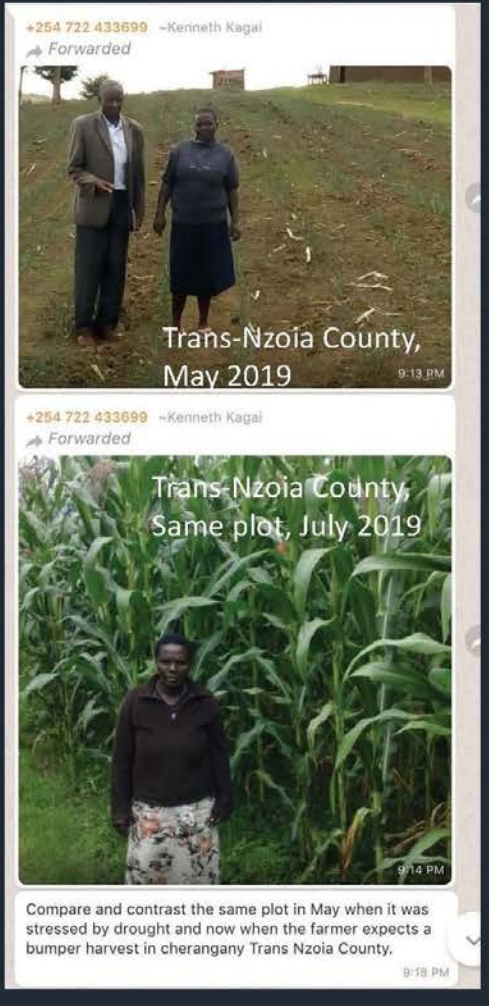
Disaster Risk Financing -Uganda

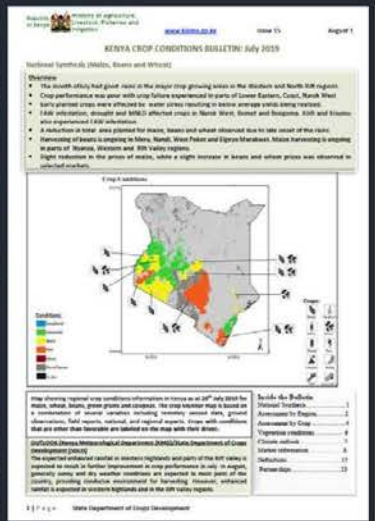


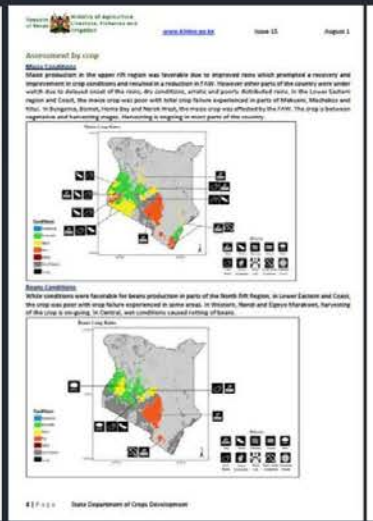


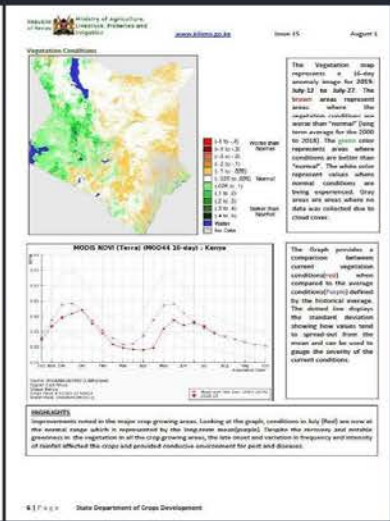
- Relies on GLAM data and Early warning explorer to inform scaling the DRF program in Uganda.
- Has supported over 300,000 people in the Karamoja region
- Government of Uganda realized a saving of US $2.6 M (51%) for FY ending 2016/17

KENYA EXAMPLES OF 2019 SEASON VARIABILITY IN KENYA



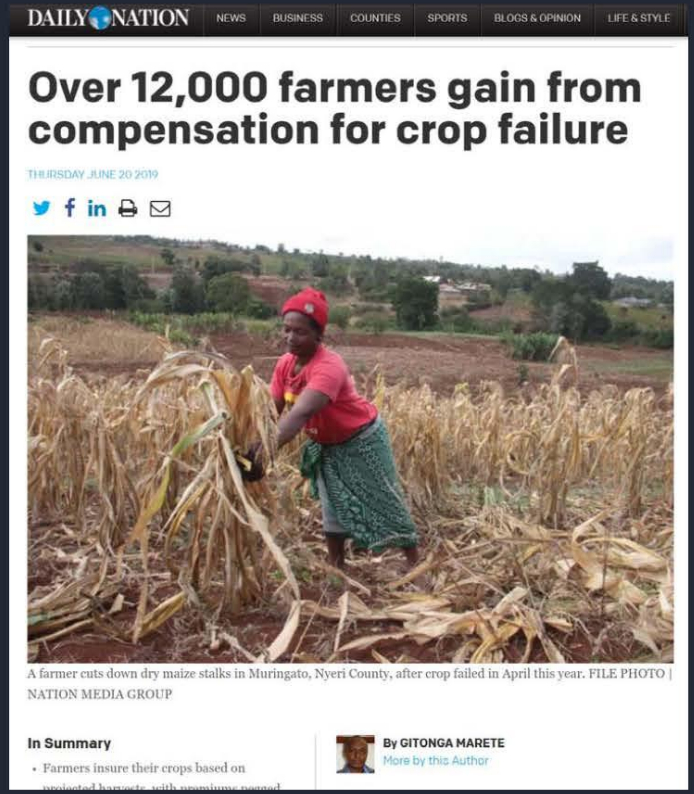






KENYA

- The Kenya Crop Monitor is helping streamline data collection
- Kenya SDA synthesizes crop conditions through a combination of field assessments and earth observation data.
- Information about crop conditions is supplemented with climate outlook and market information.
- The resulting maps provide an understanding of crop conditions and drivers of less than favorable conditions.
- The service facilitates a crop modeling framework to assess drought and yields.
- Supporting the **Kenya Government crop insurance program** by developing a geospatially informed sampling frame.
- The sampling frame
- Over **70% cost reduction and reduced sampling time** - increasing efficiency and reducing bias in sample selection. Overall, the service supports enhanced food security decisions from the local to regional levels.



DAILY NATION NEWS BUSINESS COUNTIES SPORTS BLOGS & OPINION LIFE & STYLE

Over 12,000 farmers gain from compensation for crop failure

THURSDAY JUNE 20 2019

A farmer cuts down dry maize stalks in Muringato, Nyeri County, after crop failed in April this year. FILE PHOTO | NATION MEDIA GROUP

In Summary

- Farmers insure their crops based on

By GITONGA MARETE
More by this Author

RCMRD SERVIR Eastern & Southern AFRICA USAID FROM THE AMERICAN PEOPLE NASA UNIVERSITY OF MARYLAND

Cina Lawson
Togolese Minister of Post, Digital Economy and Technological Innovation

"This map provides unmatched clarity into the nature and distribution of agricultural land nationwide [and helps] provide decisive knowledge being used to design social protection policies aimed at improving the livelihoods of agrarian rural communities."

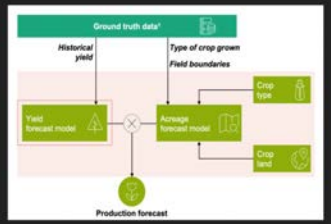
What will it take to realize the impact remote sensing + machine learning can have on global food security?

- Mitigating the training data bottleneck
- Open data, open methods
- Flexible tools and processing chains for scaling analysis
- Interdisciplinary teams of ML + domain scientists
- Capacity building and stakeholder engagement

New Initiatives/ Projects

AGRA - Alliance for a Green Revolution in Africa

Support to the development of a regional food balance sheet covering major crops in AGRA countries



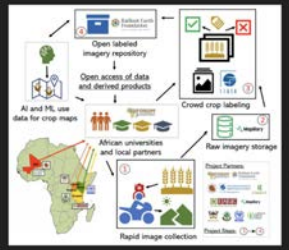
Use Case→ Regional Food Balance Sheet

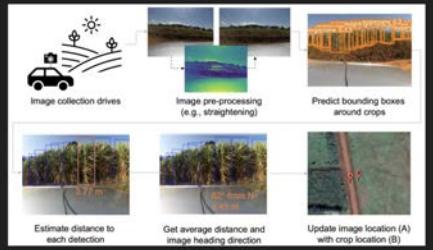
EO-Farm

NASA Harvest, in partnership with the Swiss Re Foundation, is developing EO-FARM: a modular and scalable machine learning tool supporting agricultural monitoring with Earth observations.

Use Case→ Insurance

Helmets Labeling Crops- Lacuna Fund



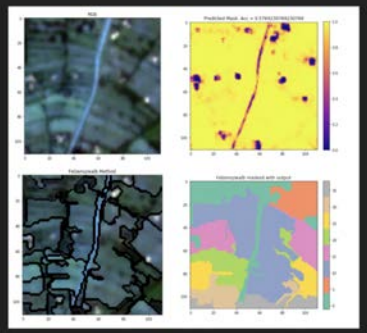


Use Case→ Filling data gaps

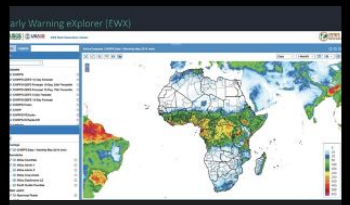
Pipeline

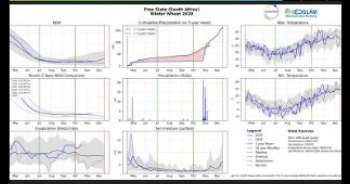
- Yield data
- Pest and disease impacts on yield/production
- Field boundary delineation

Segmentation with Planet 3m resolution- Kenya

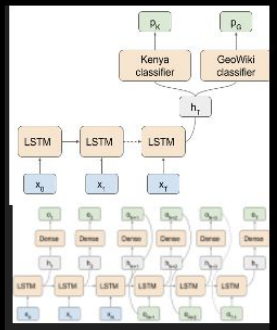


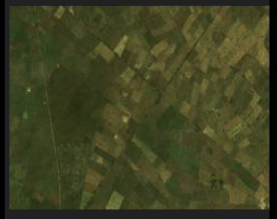
EO Data and Systems

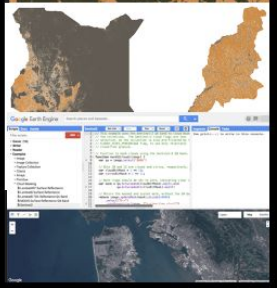




Methods + Analytics

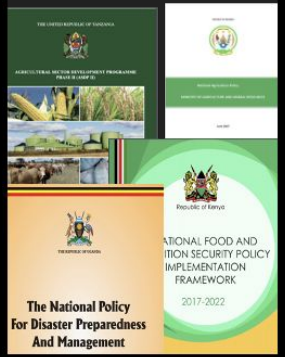




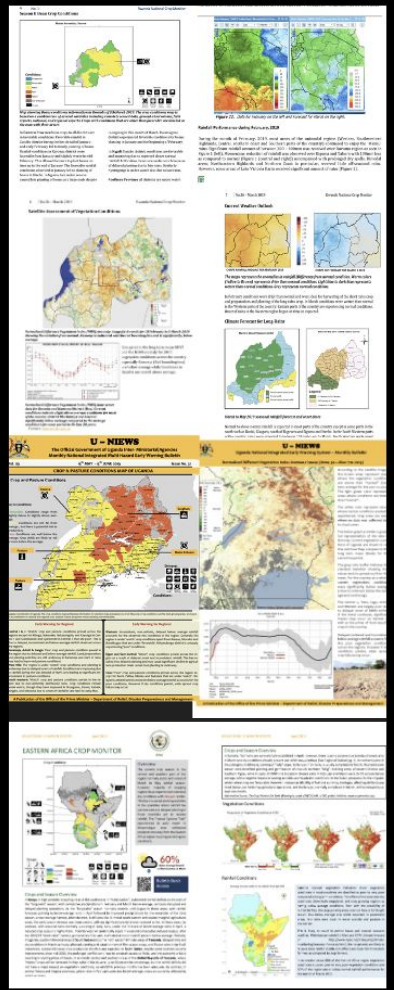


Capacity + Experts

Policies & Programs



Impact

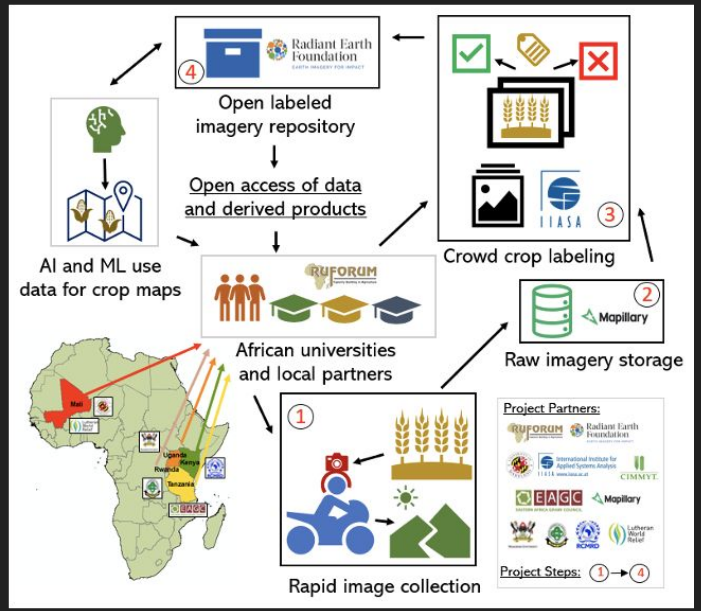


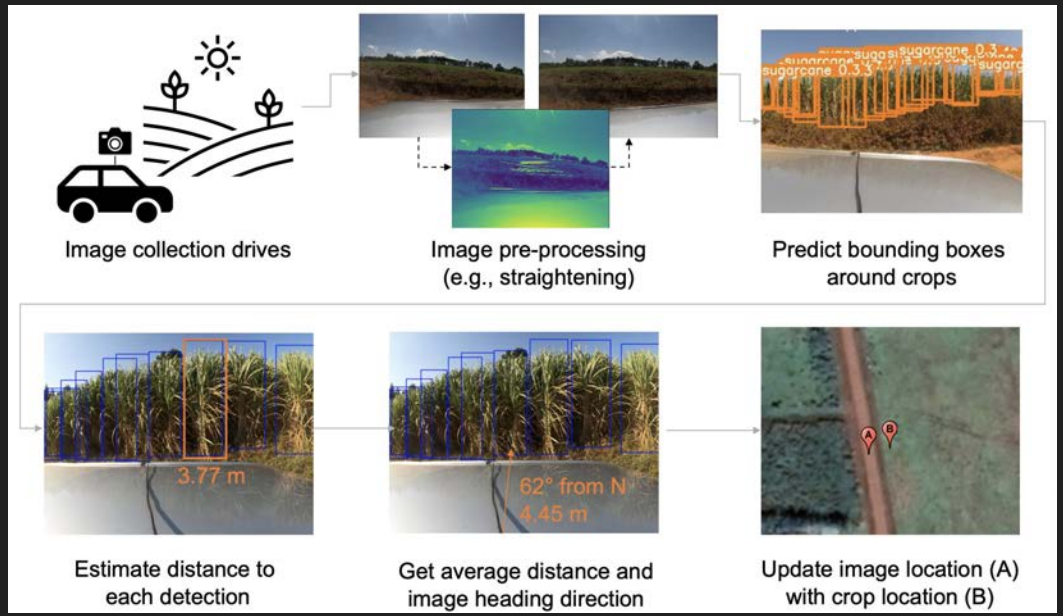
Thank you

Email: cnakalem@umd.edu

Twitter @CLNakalembe

Helmets Labeling Crops- Lacuna Fund





Use Case→ Filling data gaps