# Earth Observation in Support of Science-Driven Policy & Decision Making:

## *GEO Global Agricultural Monitoring (GEOGLAM)*

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*on behalf of the GEOGLAM Crop Monitor team*

# 1. Earth Observation & Agricultural Monitoring

*already more than 40 years…*

- late 1960's, early satellite remote sensing: major emphasis on agricultural remote sensing
- 1970's: first large EO demonstration projects developed by NASA
  - Corn Blight Watch (ERIM, LARS etc, airborne multi-spectral capabilities),
  - LACIE - Large Area Crop Inventory Experiment (wheat production – US & Russia )
- 1980's: AgRISTARS (Agriculture & Resources Inventory Surveys through Aerospace Remote Sensing), in partnership with USDA, with a focus on global wheat, corn, rice
  - Area Estimation, Crop Type discrimination, Crop Calendars
  - Considerable emphasis by researchers on plot level radiometry
  - Spectral requirements for next sensor, Thematic Mapper – vegetation (TM Simulator)
  - Dependence on Landsat (16 day repeat!) - early evaluation of AVHRR
- 1989: NASA's focus shifted to… Earth System Science
  - AgMon transition from research to operations never realized, although adoption of some methods by USDA (FAS, NASS)
- 1988: EU-JRC Project MARS - Monitoring Agriculture with Remote Sensing - started

Source: C. Justice

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# 2. Earth Observation

## *growth & maturation of space segment; decline of in situ*

- Since 1980's considerable advances in sensing technologies
- Evolution & Maturation of the EO Capabilities
  - Geostationary – GOES/Meteosat > GOES R/ MSG
  - Coarse Resolution (Daily, VIS, NIR, SWR, LW) – wall to wall, AVHRR > MODIS/SPOT VGT/METOP/PROBA-V
  - Moderate Resolution Optical (c. 16 day, VIS, NIR, SWR, *LW*) – on request > LTAP
    - *Landsat MSS > ETM / SPOT/AWiFS/CBERS > LDCM, Sentinel 2*
  - Moderate Resolution Microwave (Periodic, X, C, L Multi-polarization)
    - *ERS/JERS > Radarsat/ALOS > Sentinel 1*
  - Fine Resolution (on request, Panchromatic, Multispectral)
    - *Aerial Photography> Ikonos / Quickbird / RapidEye > small satellites*
- In Situ and agro-meteorological data
  - a general decline in support – some notable data gaps
  - Very few standards for ground data collection

Source: C. Justice

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# 3. Earth Observation

*where we are today*

- Increasing maturity in terms of Data Products, QA, Validation
  - MODIS Surface Reflectance and Land Product Suite
  - Web Enabled Landsat Data (Roy) > Global Landsat Composites
  - Community Validation Protocols (CEOS WGCV LPV)
- Considerable increase in computational and processing capabilities
  - SAR processing
  - Global Daily 250m data; 8-day 30m data; 5-day 10m data
  - Land Atmosphere Near Real-Time Capability for EOS (LANCE)

STILL:

- Considerable variability in data policy, availability, pre-processing, and accessibility
- Challenges with accessing and utilizing vast quantities of data
- Need for operationalization of research results

Source: C. Justice

# The G20 Agricultural Monitoring Mandate

*(France)*

## G20 Final Declaration

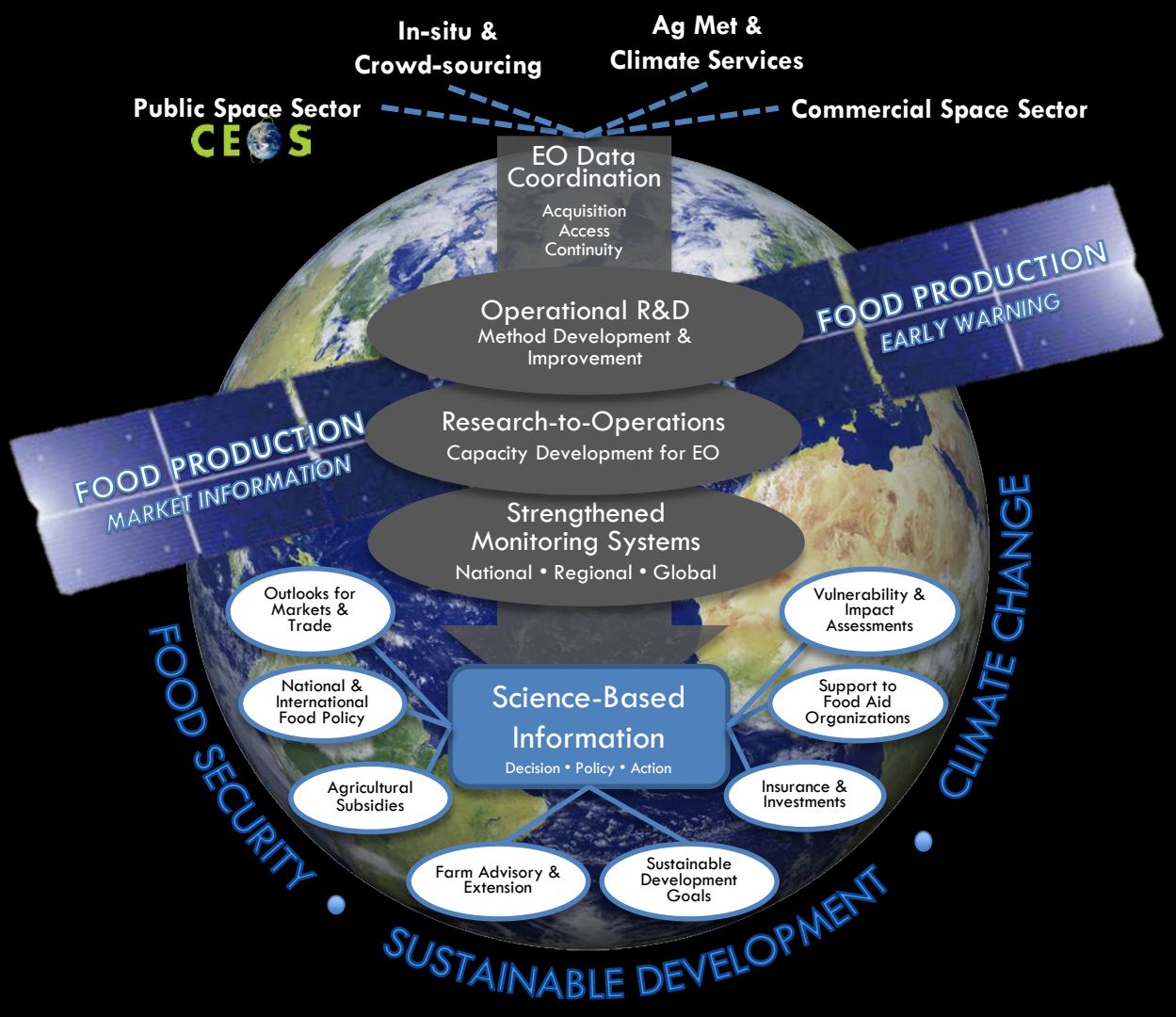
44. We commit to improve market information and transparency in order to make international markets for agricultural commodities more effective. To that end, we launched:

- The "Agricultural Market Information System" (AMIS) in Rome on September 15, 2011, to improve information on markets ...;
- The **"Global Agricultural Geo-monitoring Initiative" (GEO-GLAM)** in Geneva on September 22-23, 2011. This initiative will coordinate satellite monitoring observation systems in different regions of the world in order to enhance crop production projections and weather forecasting data.

***Two initiatives to increase information availability, quality and transparency***

***AMIS:***
***improve information on markets***

***GEOGLAM:***
***improve information on supply***

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# Earth Observations Among Earliest Indicators of Major Drought Events

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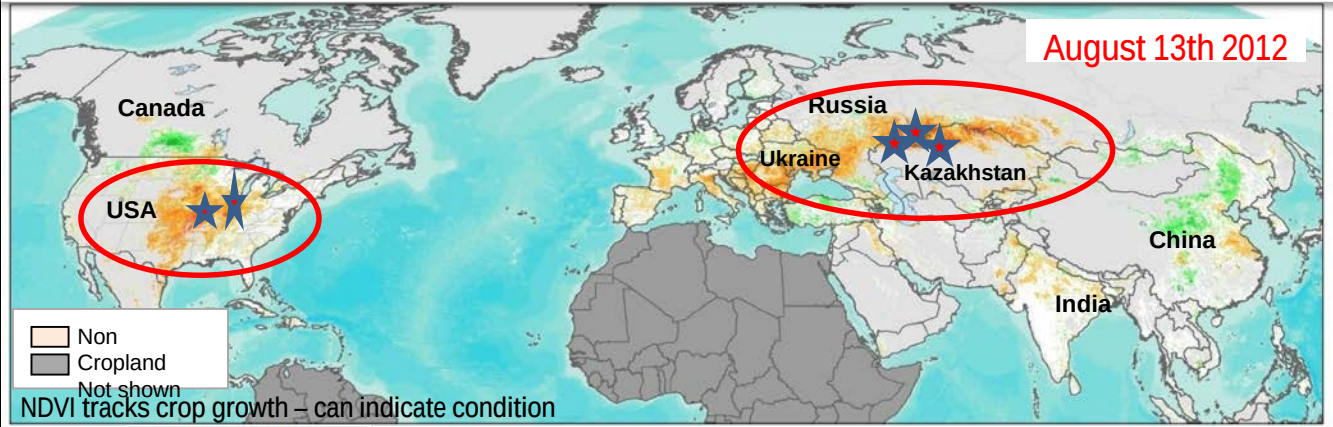
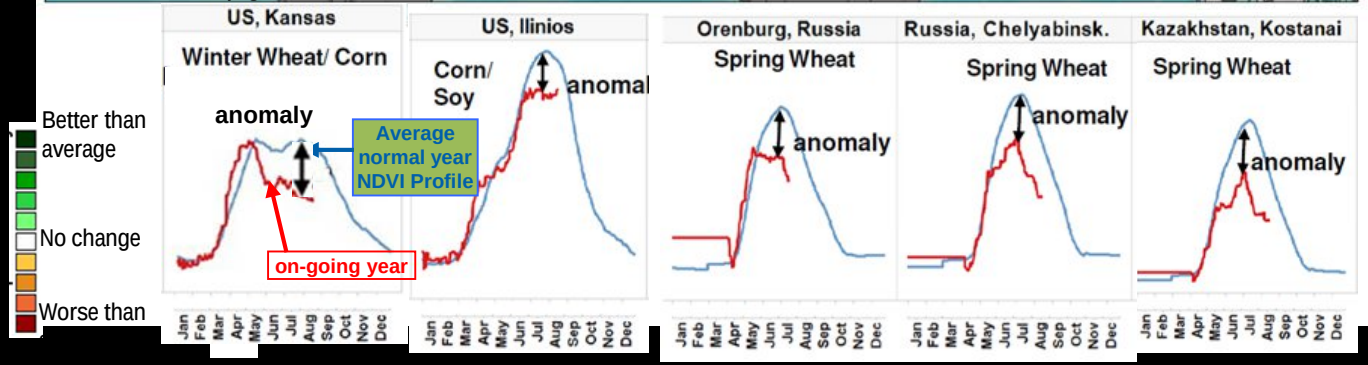
Use of NDVI, Normalised Difference Vegetation Index : $NDVI = \frac{Red - InfraRed}{Red + InfraRed}$

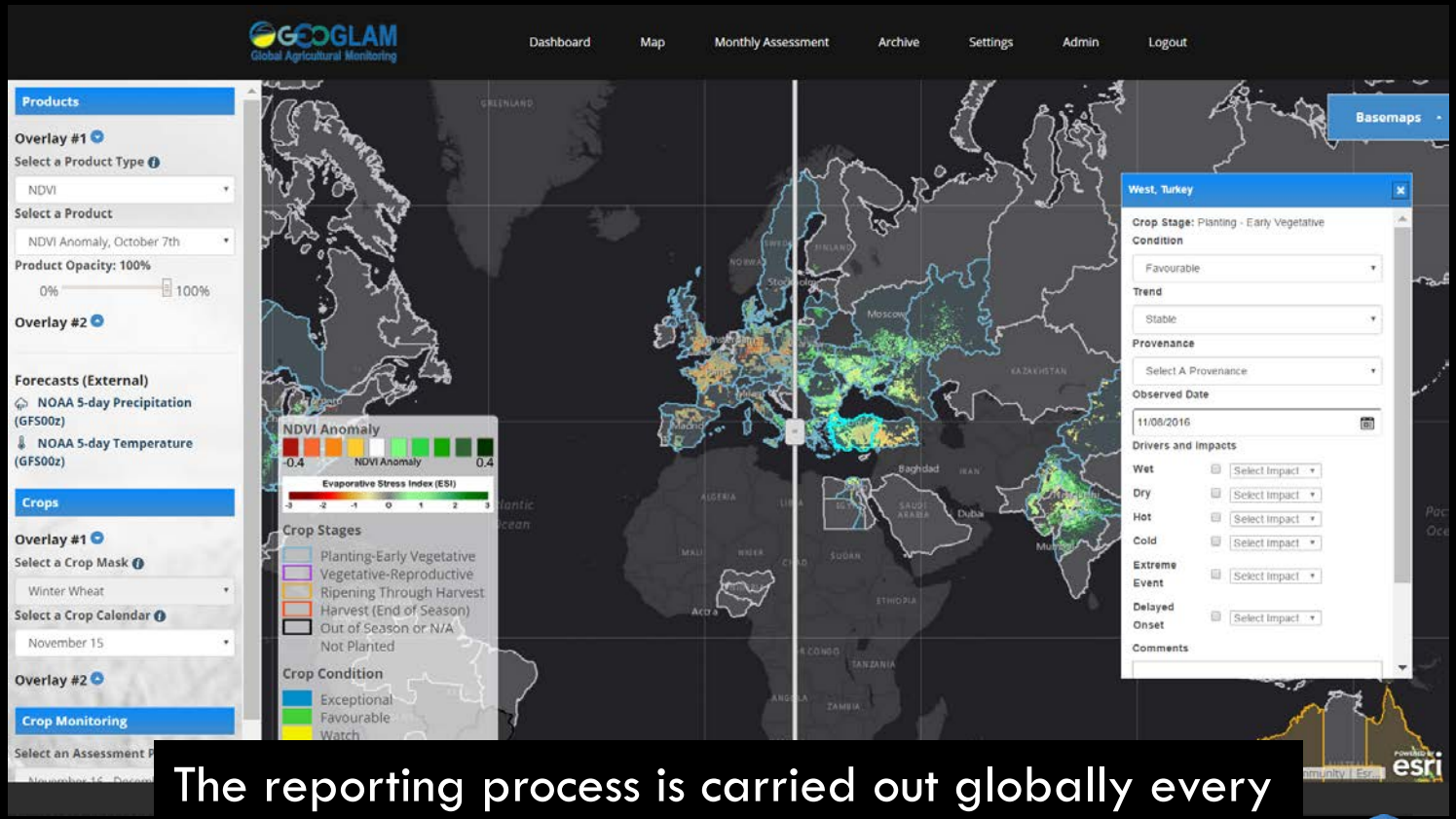



Becker-Reshef et al.

University of Maryland

# Crop Condition Reporting




The reporting process is carried out globally every month on the web-based Crop Assessment Tool

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# Crop Monitor is an integral part of the AMIS Market Monitor

*GEOGLAM became the 11th member of the AMIS Secretariat in 2016*


- First time the international community comes together to produce operational crop assessments with 40 contributing organizations & Ministries of Agriculture
- Strong collaboration between GEOGLAM and AMIS
- Bridging the gap between the Earth Observations and Economics communities
- Crop Monitor operational since 2013

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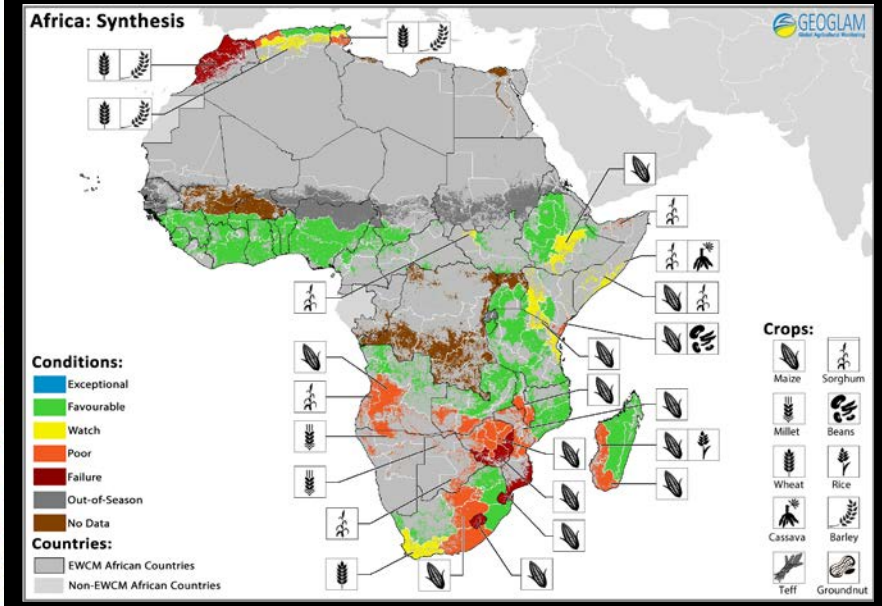
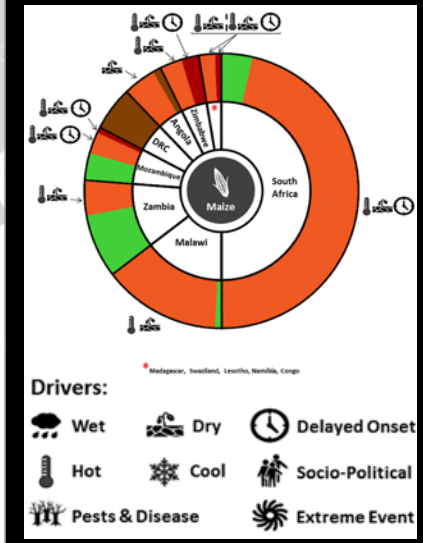
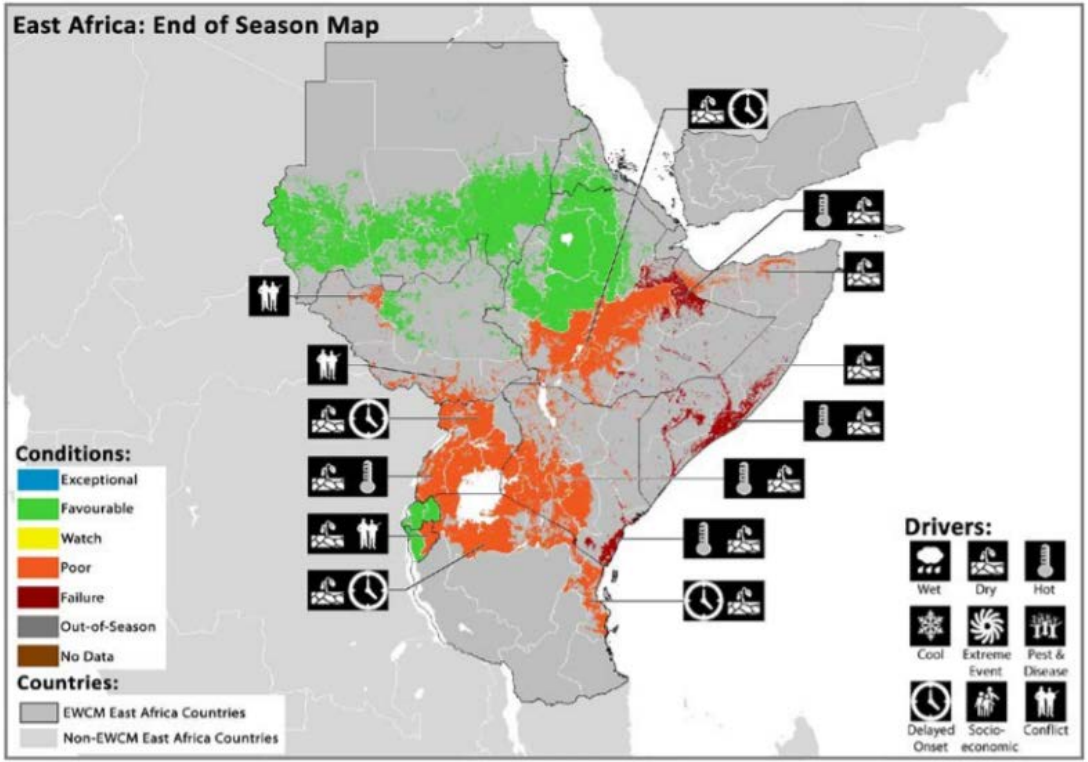
# Severe Conditions Underpin the Need for Crop Monitor for Early Warning


Crop Conditions in May 2016 showing devastating effects of southern Africa drought that left millions in need of humanitarian assistance



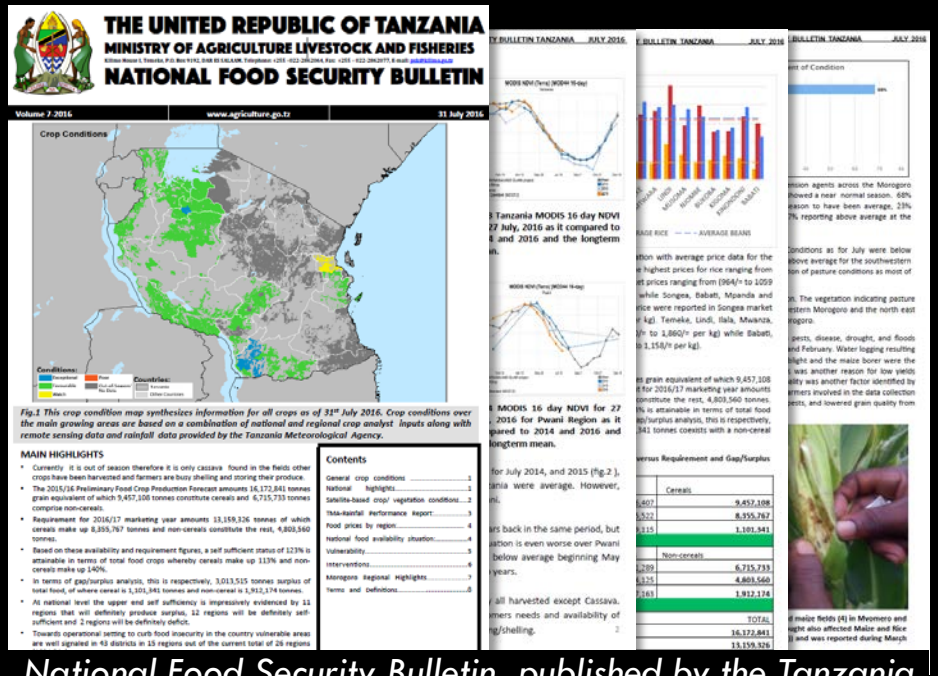

*Crop condition map synthesizing information as of January 28th. End of main season conditions are shown covering the long rains in Ethiopia, Sudan, South Sudan, and Eritrea. End of secondary season conditions are shown covering the short rains in Kenya, Uganda, Somalia, Rwanda, Burundi, Tanzania and Yemen. Crop conditions over the main growing areas are based on a combination of inputs including remotely sensed data, ground observations, field reports, national, and regional experts.* ***Conditions that are other than favourable are labeled on the map with their driver.***

End of Season Synthesis

published last week (conditions as of 28 Jan 2017)

Failure & poor conditions in primary & secondary seasons (just ending)

# Development of National Crop Monitors, Facilitating National Food Security Reports


THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF AGRICULTURE LIVESTOCK AND FISHERIES
NATIONAL FOOD SECURITY BULLETIN

Volume 7 2016 | www.agriculture.go.tz | 31 July 2016

Crop Conditions

Fig.1 This crop condition map synthesizes information for all crops as of 31st July 2016. Crop conditions over the main growing areas are based on a combination of national and regional crop analyst inputs along with remote sensing data and rainfall data provided by the Tanzania Meteorological Agency.

MAIN HIGHLIGHTS

- Currently it is out of season therefore it is only cassava found in the fields other crops have been harvested and farmers are busy shelling and storing their produce.
- The 2015/16 Preliminary Food Crop Production Forecast amounts 16,172,841 tonnes grain equivalent of which 9,457,108 tonnes constitute cereals and 6,715,733 tonnes comprise non-cereals.
- Requirement for 2016/17 marketing year amounts 13,159,326 tonnes of which cereals make up 8,355,767 tonnes and non-cereals constitute the rest, 4,803,560 tonnes.
- Based on these availability and requirement figures, a self sufficient status of 123% is attainable in terms of total food crops whereby cereals make up 113% and non-cereals make up 140%.
- In terms of gap/surplus analysis, this is respectively, 3,013,515 tonnes surplus of total food, of where cereal is 1,101,941 tonnes and non-cereal is 1,912,174 tonnes.
- At national level the upper end self sufficiency is impressively evidenced by 11 regions that will definitely produce surplus, 12 regions will be definitely self-sufficient and 2 regions will be definitely deficit.
- Towards operational setting to curb food insecurity in the country vulnerable areas are well signaled in 43 districts in 15 regions out of the current total of 26 regions

Contents



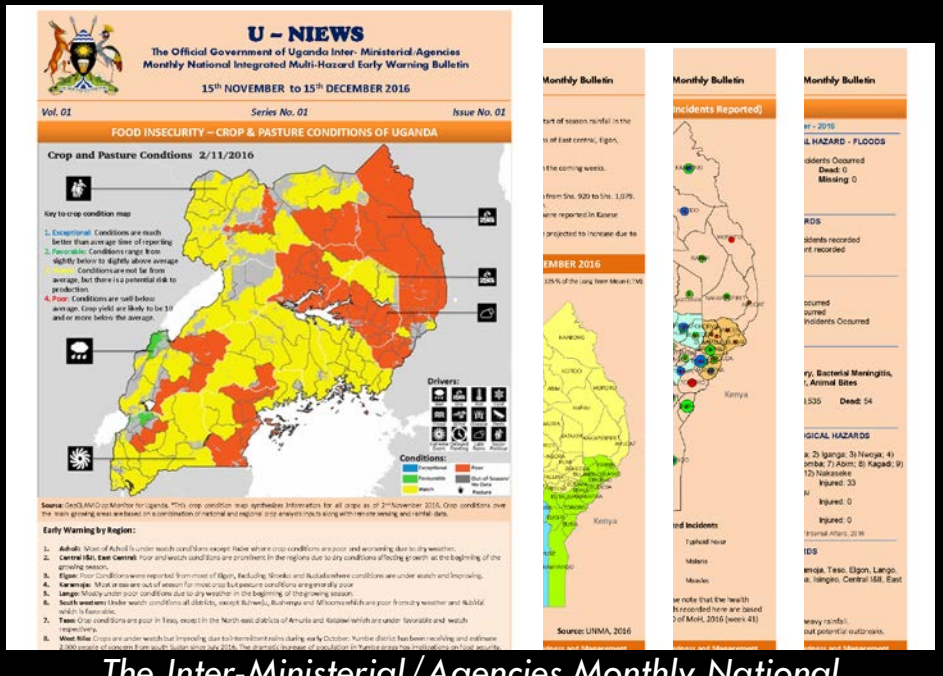

Tanzania MODIS 16 day NDVI for 27 July, 2016 as it compared to 2014 and 2016 and the longterm mean.

MODIS 16 day NDVI for 27 July, 2016 for Pwani Region as it compared to 2014 and 2016 and longterm mean.

Requirement and Gap/Surplus

| | |
|---|---|
| Cereals | |
| | 9,457,108 |
| | 8,355,767 |
| | 1,101,941 |
| Non-cereals | |
| | 6,715,733 |
| | 4,803,560 |
| | 1,912,174 |
| TOTAL | |
| | 16,172,841 |
| | 13,159,326 |

*National Food Security Bulletin, published by the Tanzania Ministry of Agriculture Food Security, National Food Security Division*


U – NIEWS
The Official Government of Uganda Inter- Ministerial Agencies Monthly National Integrated Multi-Hazard Early Warning Bulletin
15th NOVEMBER to 15th DECEMBER 2016

Vol. 01 | Series No. 01 | Issue No. 01

FOOD INSECURITY – CROP & PASTURE CONDITIONS OF UGANDA

Crop and Pasture Condtions 2/11/2016

Key to crop condition map

1. Exceptional: Conditions are much better than average time of reporting
2. Favorable: Conditions range from slightly below to slightly above average
3. Normal: Conditions are not far from average, but there is a potential risk to production
4. Poor: Conditions are well below average. Crop yield are likely to be 10 and or more below the average.

Drivers:

Conditions:

Source: GeoGLAM Crop Monitor for Uganda. *This crop condition map synthesizes information for all crops as of 2nd November 2016. Crop conditions over the main growing areas are based on a combination of national and regional crop analysts inputs along with remote sensing and rainfall data.

Early Warning by Region:

1. Acholi: Most of Acholi is under watch conditions except Nwoe where crop conditions are poor and worsening due to dry weather.
2. Central I&II, East Central: Poor and watch conditions are prominent in the regions due to dry conditions affecting growth at the beginning of the growing season.
3. Elgon: Poor Conditions were reported from most of Elgon, including Sironko and Bududa where conditions are under watch and improving.
4. Karamoja: Most areas are out of season for most crops but pasture conditions are generally poor
5. Lango: Mostly under poor conditions due to dry weather in the beginning of the growing season.
6. South western: Under watch conditions all districts, except Buhweju, Bushenyi and Mbarara which are poor from dry weather and Rubirizi which is favorable.
7. Teso: Crop conditions are poor in Teso, except in the North east districts of Amuria and Katakwi which are under favorable and watch respectively.
8. West Nile: Crops are under watch but improving due to intermittent rains during early October. Yumbe district has been receiving and estimate 2,000 people of concern from south Sudan since July 2016. The dramatic increase of population in Yumbe areas has implications on food security

Monthly Bulletin

Monthly Bulletin

Monthly Bulletin

*The Inter-Ministerial/Agencies Monthly National Integrated Multi-Hazard Early Warning Bulletin, published by the Uganda Office of the Prime Minister*

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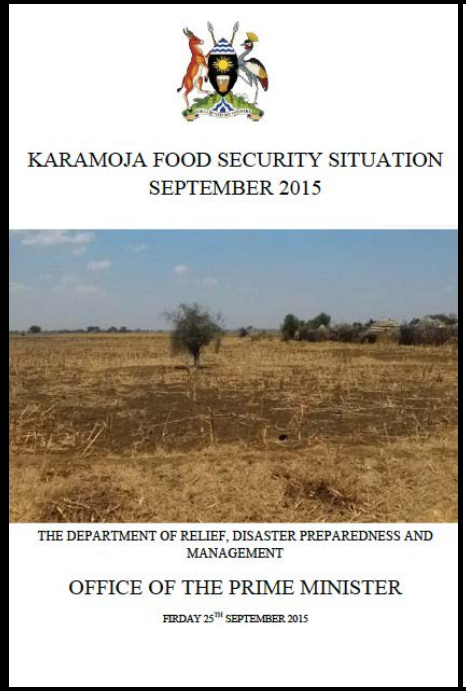
# Uganda: September 2015:

"**Karamoja Food Security Situation**" report used to justify mobilization of food aid in the Karamoja region.

Report applied remote sensing for timely, accurate, actionable in-season monitoring of crop conditions.


KARAMOJA FOOD SECURITY SITUATION
SEPTEMBER 2015

THE DEPARTMENT OF RELIEF, DISASTER PREPAREDNESS AND MANAGEMENT

OFFICE OF THE PRIME MINISTER

FIRDAY 25TH SEPTEMBER 2015

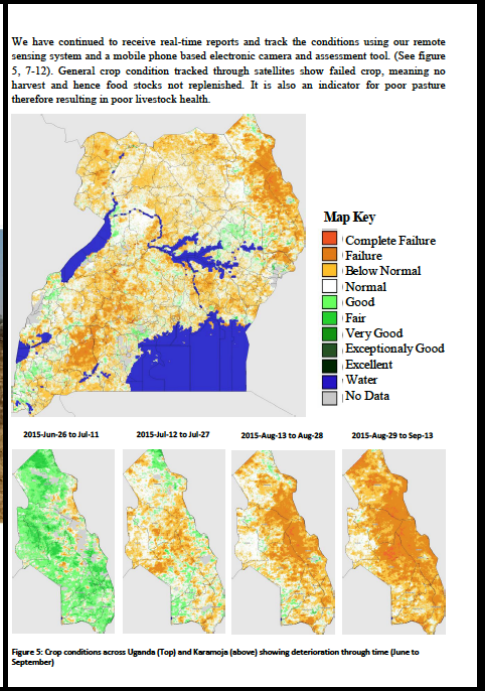

We have continued to receive real-time reports and track the conditions using our remote sensing system and a mobile phone based electronic camera and assessment tool. (See figure 5, 7-12). General crop condition tracked through satellites show failed crop, meaning no harvest and hence food stocks not replenished. It is also an indicator for poor pasture therefore resulting in poor livestock health.



Figure 5: Crop conditions across Uganda (Top) and Karamoja (above) showing deterioration through time (June to September)

**Food security report presented to Inter-Ministerial Committee**
**September 25, 2015**


**First trucks of relief food dispatched to Karamoja**
**September 26, 2015**

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# EO Requirements for Agricultural Monitoring

## *Version 1 (2012-2014) Requirements Table*

CEOS

- CEOS coordinating data for JECAM
- GEOGLAM translating JECAM results into req's:
  - What?
  - When & How Often?
  - Where?
  - Why?
- CEOS responding by matching missions to req's, developing strategic response
  - Current implementation = JECAM & Asia-RICE

| A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Target Products | | | | | | |
| Req # | Spatial Resolution | Spectral Range | Effective observ. frequency (cloud free) | Extent | Field Size | Crop Mask | Crop Type Area and Growing Calendar | Crop Condition Indicators | Crop Yield | Crop Biophys. Variables | Environ. Variables | Ag Practices / Cropping Systems |
| | **Coarse Resolution Sampling (>100m)** | | | | | | | | | | | |
| 1 | 500 - 2000m | optical | Daily | Wall-to-Wall | All | | | X | | L | | |
| 2 | 100-500m | optical | 2 to 5 per week | Cropland extent | All | X | X | X | L | L | X | L |
| 3 | 5-50 km | microwave | Daily | Cropland extent | All | | | X | X | X | X | |
| | **Moderate Resolution Sampling (10 to 100m)** | | | | | | | | | | | |
| 4 | 10-70m | optical | Monthly (min 3 in season + 2 out of season); Required every 1-3 years | Cropland extent (if #5 = sample, else skip) | All | X | L/M | | | | | X |
| 5 | 10-70m | optical | 8 days; min. 1 per 16 days | Sample (pref. Cropland extent) | All | X | X | X | X | X | X | X |
| 6 | 10-100m | SAR | 8 days; min. 1 per 16 days | Cropland extent of persistantly cloudy and rice areas | All | X | X | X | X | X | X | X |
| | **Fine Resolution Sampling (5 to 10m)** | | | | | | | | | | | |
| 7 | 5-10m | VIS NIR + SWIR | Monthly (min. 3 in season) | Cropland extent | M/S | M/S | M/S | | | | | |
| 8 | 5-10m | VIS NIR + SWIR | Approx. weekly; min. 5 per season | Sample | All | | M/S | X | | X | X | X |
| 9 | 5-10m | SAR | Monthly | Cropland extent of persistantly cloudy and rice areas | M/S | M/S | M/S | | | | | M/S |
| | **Very Fine Resolution Sampling (<5m)** | | | | | | | | | | | |
| 10 | < 5m | VIS NIR | 3 per year (2 in season + 1 out of season); Every 3 years | Cropland extent of small fields | S | S | S | | | | | |
| 11 | < 5m | VIS NIR | 1 to 2 per month | Refined Sample (Demo) | All | | X | | X | | | X |

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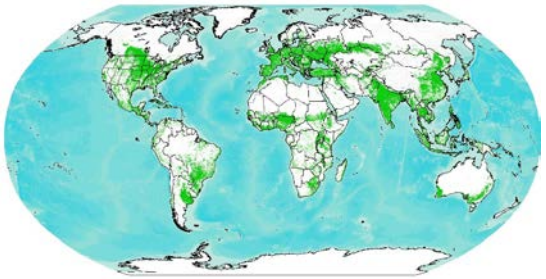
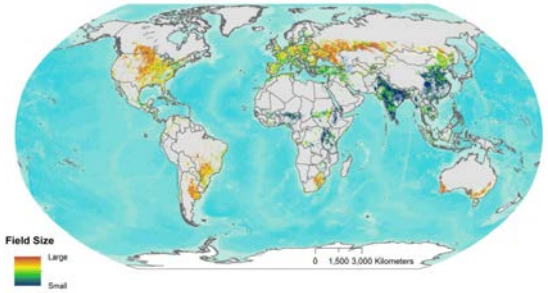
# Development of Baseline Datasets – “Best Available”

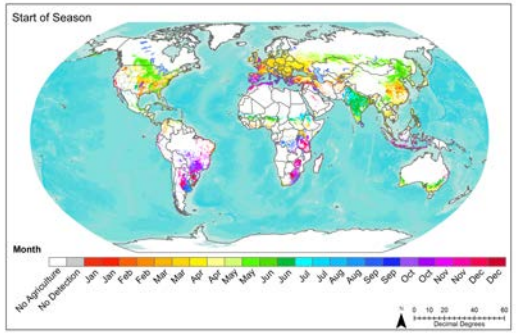
## Cropland Distribution
(Fritz et al., 2015)



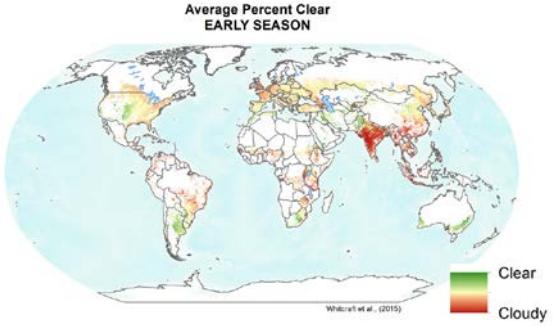
## Field Size Distribution
(Fritz et al., 2015)




## When are the crops growing?
(Whitcraft et al., 2014)



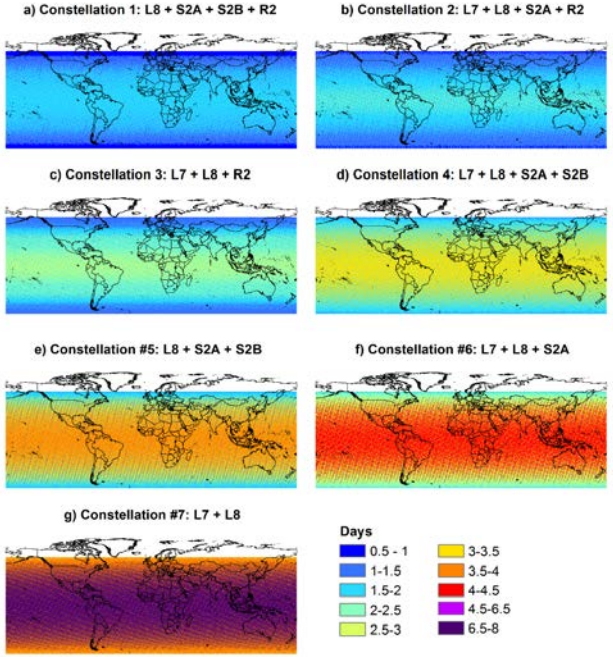

## How do clouds impact clear views? (Whitcraft et al., 2015)



*Can we meet these requirements for optical, moderate resolution (10-70m) data within 8 days during the growing season with current & planned missions?*

| | Agency, Satellite, Sensor | Revisit | Spatial Res |
|---|---|---|---|
| **L7** | NASA/USGS Landsat 7 ETM+ | 16 Days | 30-60 m |
| **L8** | NASA/USGS Landsat 8 OLI, TIRS | 16 Day | 30-100 m |
| **S2A** | ESA Sentinel-2A MSI | 10 Days | 10-20 m |
| **S2B** | ESA Sentinel-2B MSI | 10 Days | 10-20 m |
| **R2** | ISRO Resourcesat-2 AWiFS | 5 Days | 56 m |

Overpass Analysis: CEOS SEO




**Revisit Capabilities**
of 7 Hypothetical Constellations

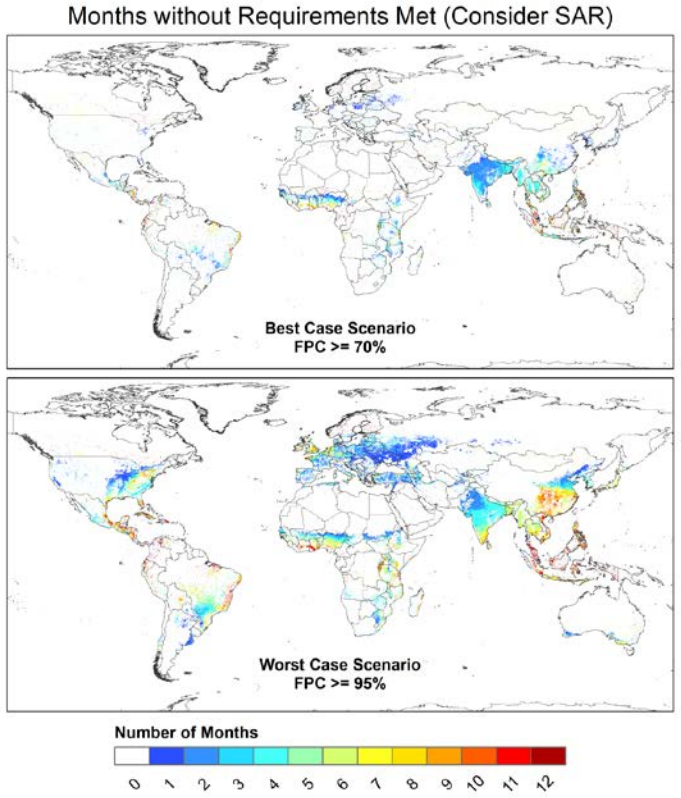
Whitcraft, Killough et al., 2015c, *Rem. Sens.*

# GAP ANALYSIS

*where is there insufficient optical data?*

Meeting the Requirement for a view **≥ 70% Cloud Free** within 8 days *(over global in season croplands)*

Meeting the Requirement for a view **≥ 95% Cloud Free** within 8 days *(over global in season croplands)*




| # | Satellites |
|---|---|
| 1 | L8, S2A, S2B, R2 |
| 2 | L7, L8, S2A, R2 |
| 3 | L7, L8, R2 |
| 4 | L7, L8, S2A, S2B |
| 5 | L8, S2A, S2B |
| 6 | L7, L8, S2A |
| 7 | L7, L8 |

Whitcraft, Killough et al., 2015c, *Rem. Sens.*

# Summary & the Way Forward

- Crop Monitors providing a public good: open, timely, science-driven, actionable information on global crop conditions
  - Already informing decisions
- Bridging the gap between the policy/econ and EO communities
  - Ensuring user community is driving the satellite monitoring research agenda
- Increasing communication and knowledge transfer amongst countries and monitoring systems
  - Thereby strengthening national monitoring systems
- Strong focus on strengthening national partnerships; expanding participation in regional networks and national systems, particularly in 'countries at risk'

*Please get in touch for more information or if interested in contributing to this effort:*

www.cropmonitor.org, Inbal Becker-Reshef: ireshef@geoglam.org

# Thank You!

## Crop Monitor for AMIS Partners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