Remote Sensing in Food Security Analysis

WFP – World Food Programme, ODXF, Food Security Analysis Service

UNOOSA Meeting, 09 March 2012

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Usage of Remote Sensing Data at WFP

Earth Observation (EO) data has assumed growing importance for WFP over the past decade

Relevance :

- Provision of food assistance to beneficiaries – early warning, impact assessment
- Contribution to baseline Food Security surveys (climatology, zoning, history of shocks – extent, frequency, magnitude)
- Support to the design of WFP interventions

Food Security Analysis Service (ODXF/VAM) and Emergency Preparedness (ODEP)

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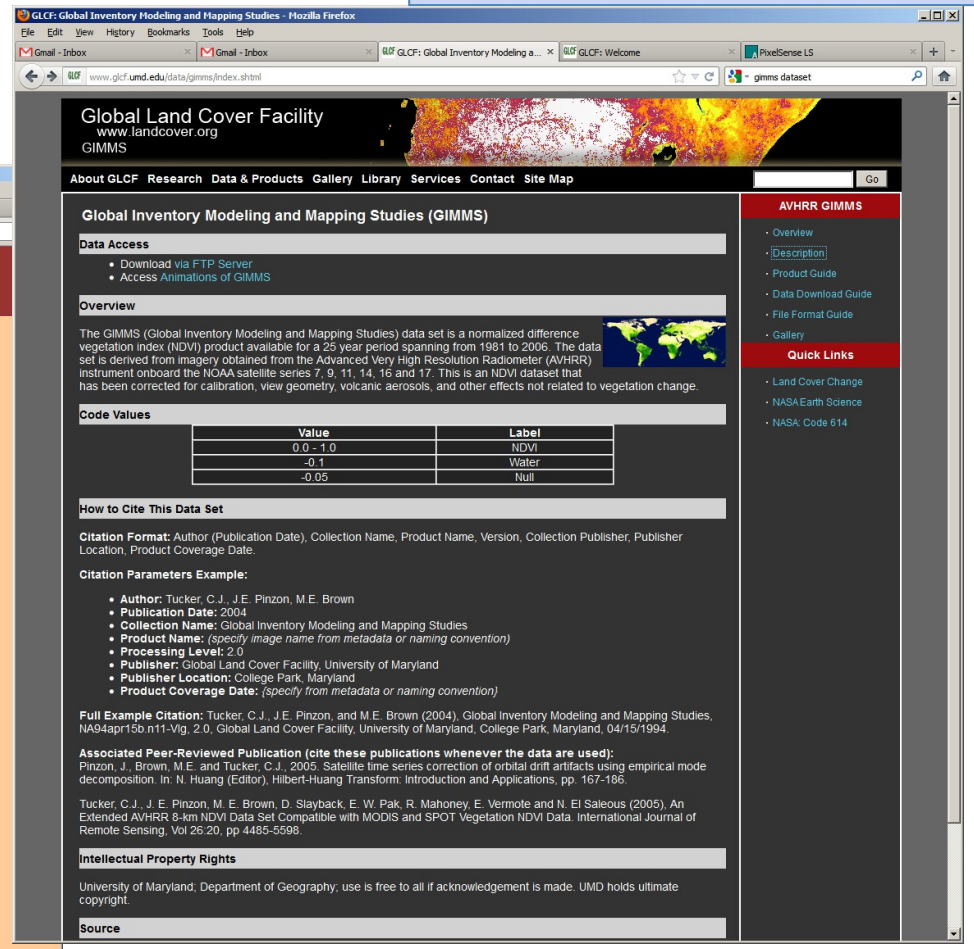
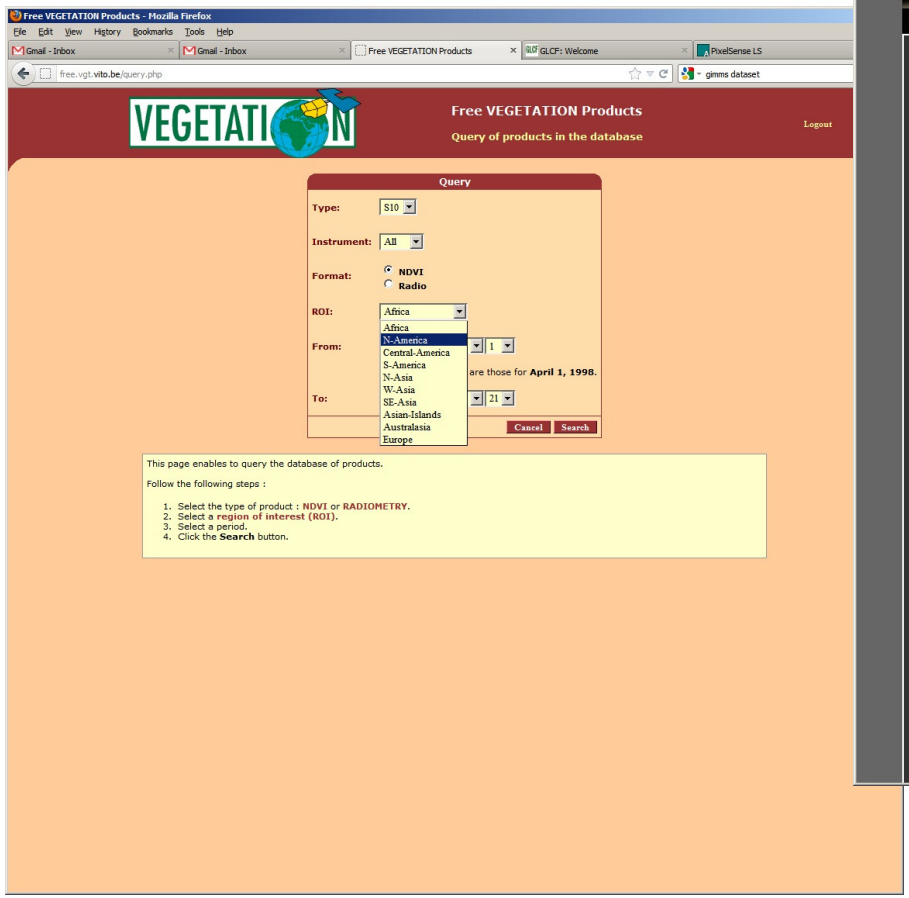
GIMMS NDVI: Global 1981 - 2006





SPOT-VGT Data: Global 1998 - present

Vast repositories of free access data

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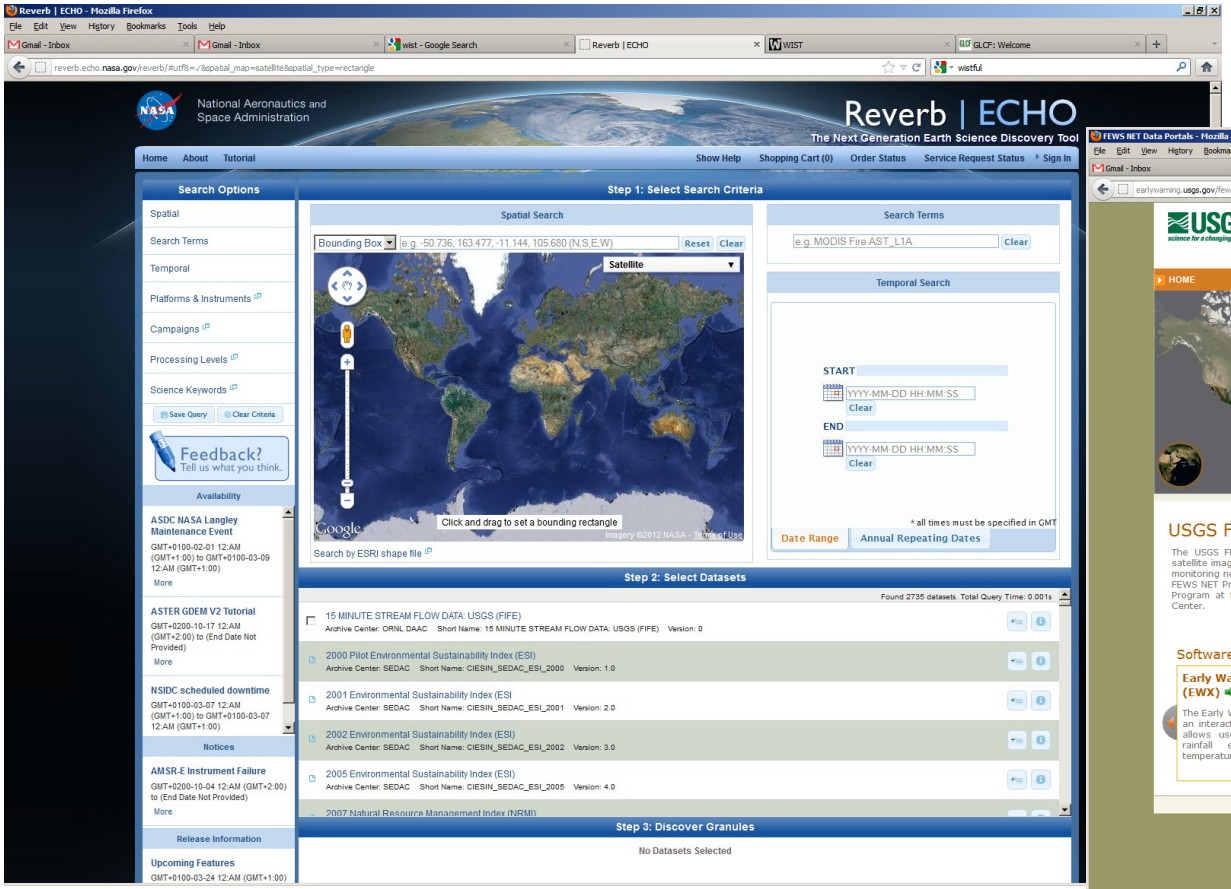
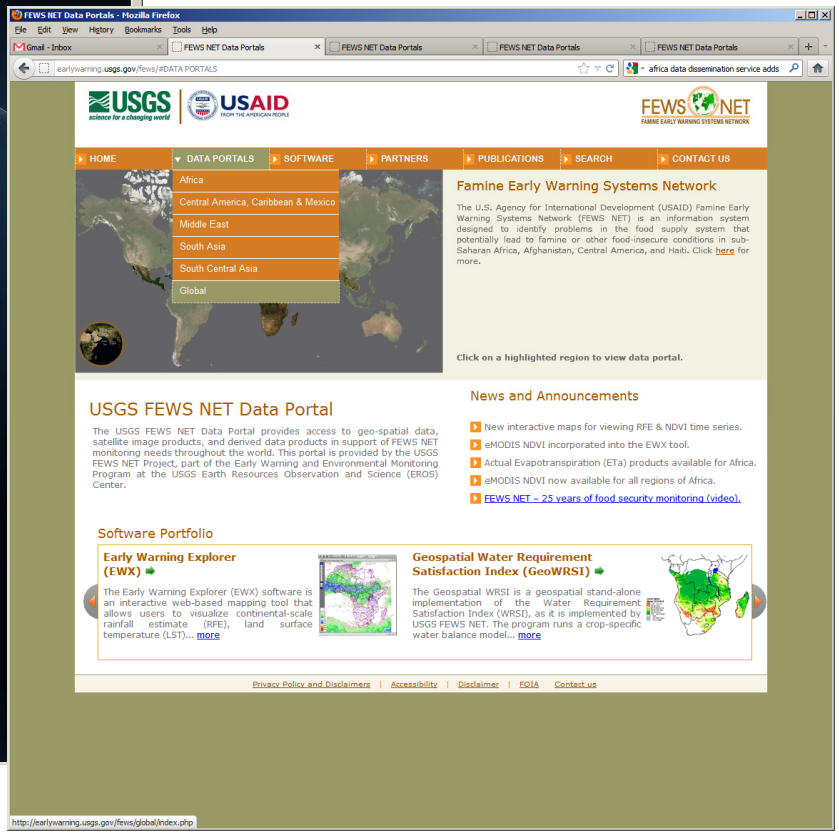


Reverb: access tool for NASA ESDIS ECHO



USGS FEWS-Net Data Portals

Vast repositories of free access data

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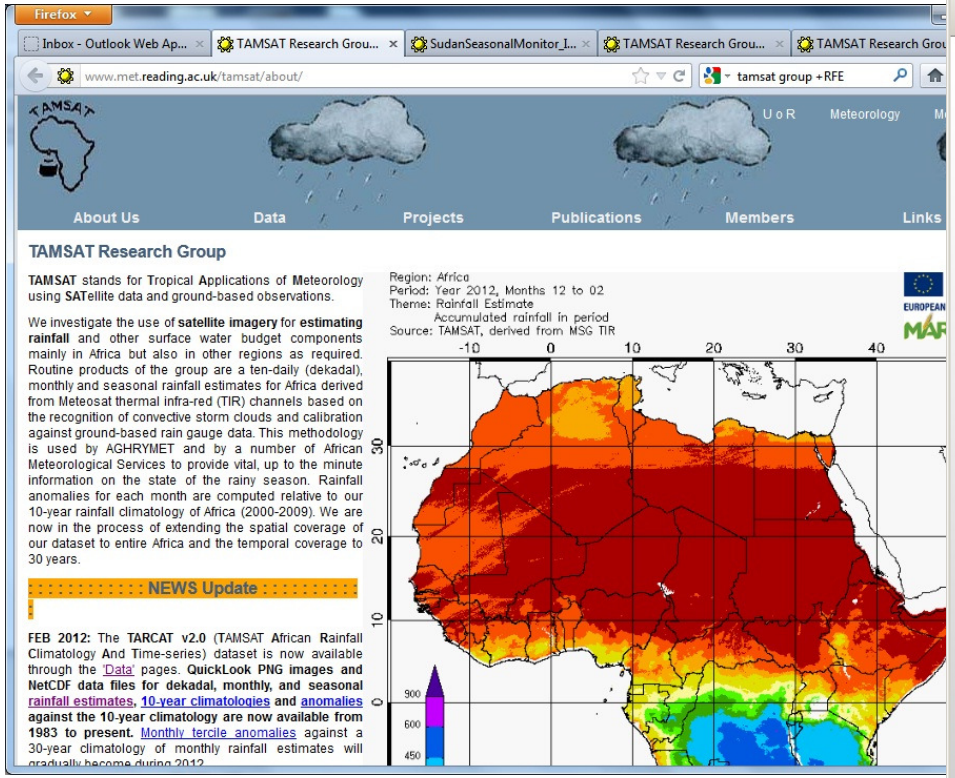

TAMSAT: RFE, 1983 - present

ESA

Vast repositories of free access data

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Data Sources

- Staple Data : RFE and NDVI.
  - RFE: Key driver for crop performance – USGS, U of Reading
  - NDVI: Direct indicator of vegetation status – (SPOT-VGT, MODIS)
    - Proxy for household resources (crop and pasture production)
    - Fine resolution, performance over irrigated areas
- Analysis of large number of images (36 / calendar year)
- Spatial – temporal information
- Long historical time series (reference scenarios)

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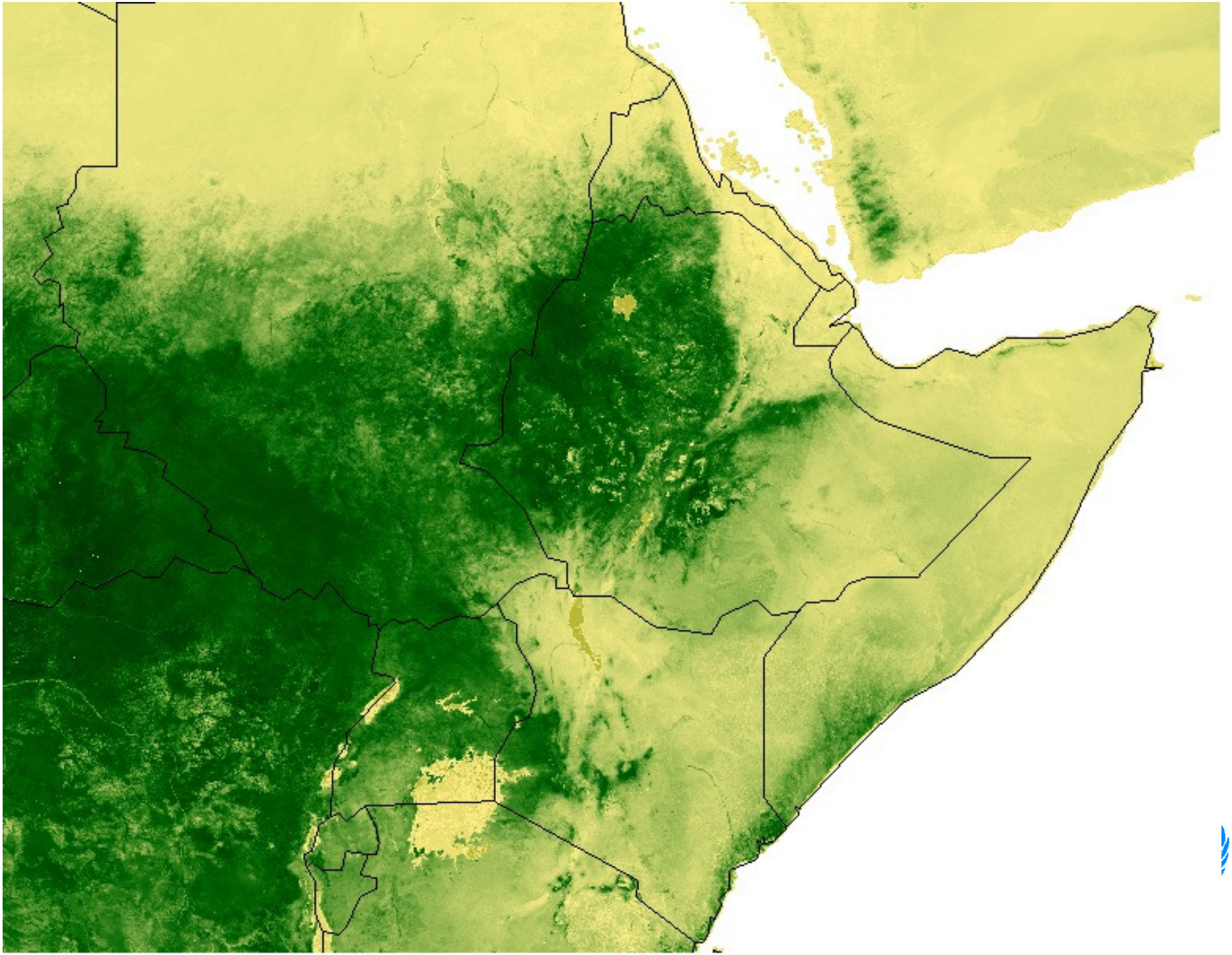

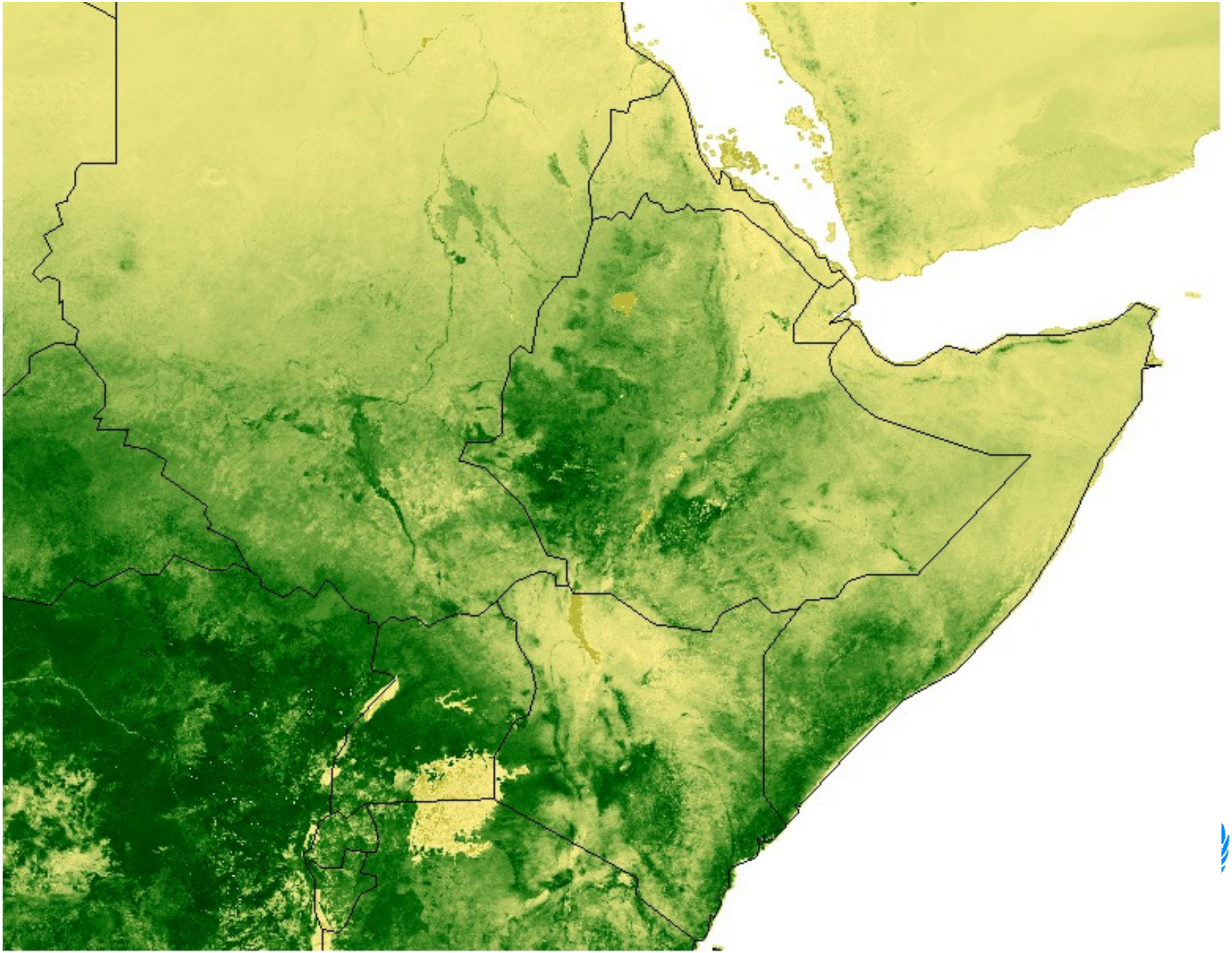

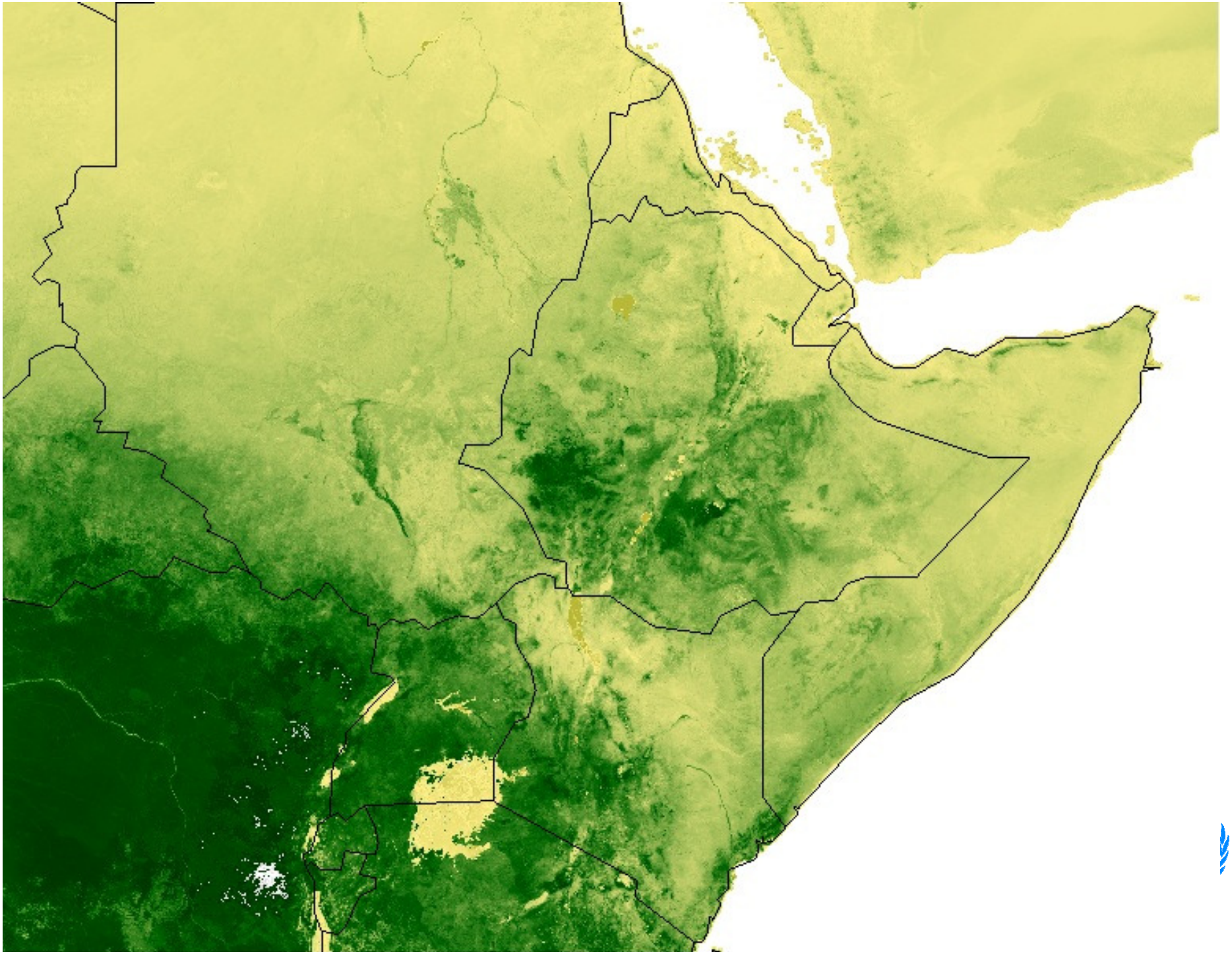

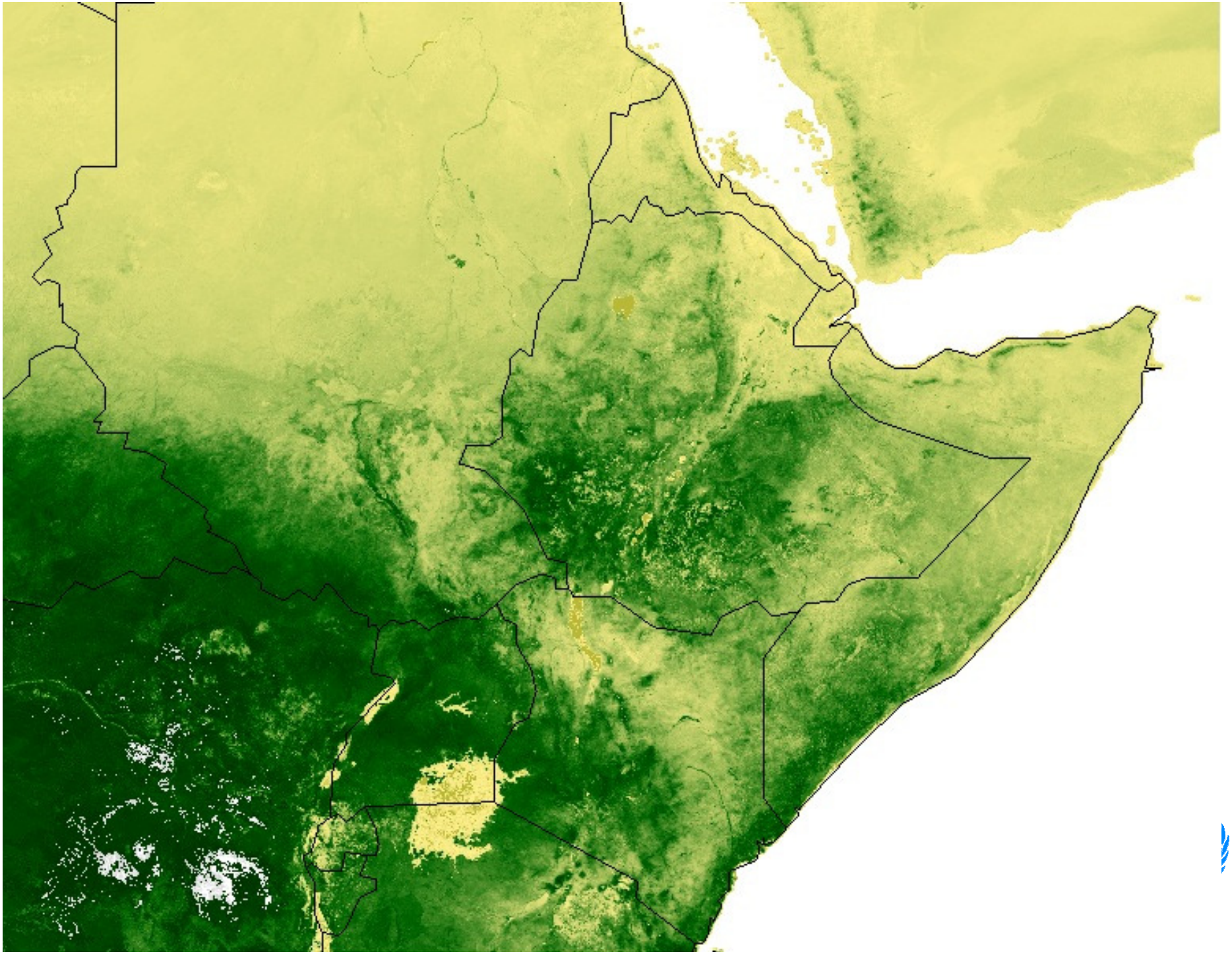

Applications

- Characterization of countries and regions
- Early Warning and impact assessment
- Crop production estimation
- The long term view

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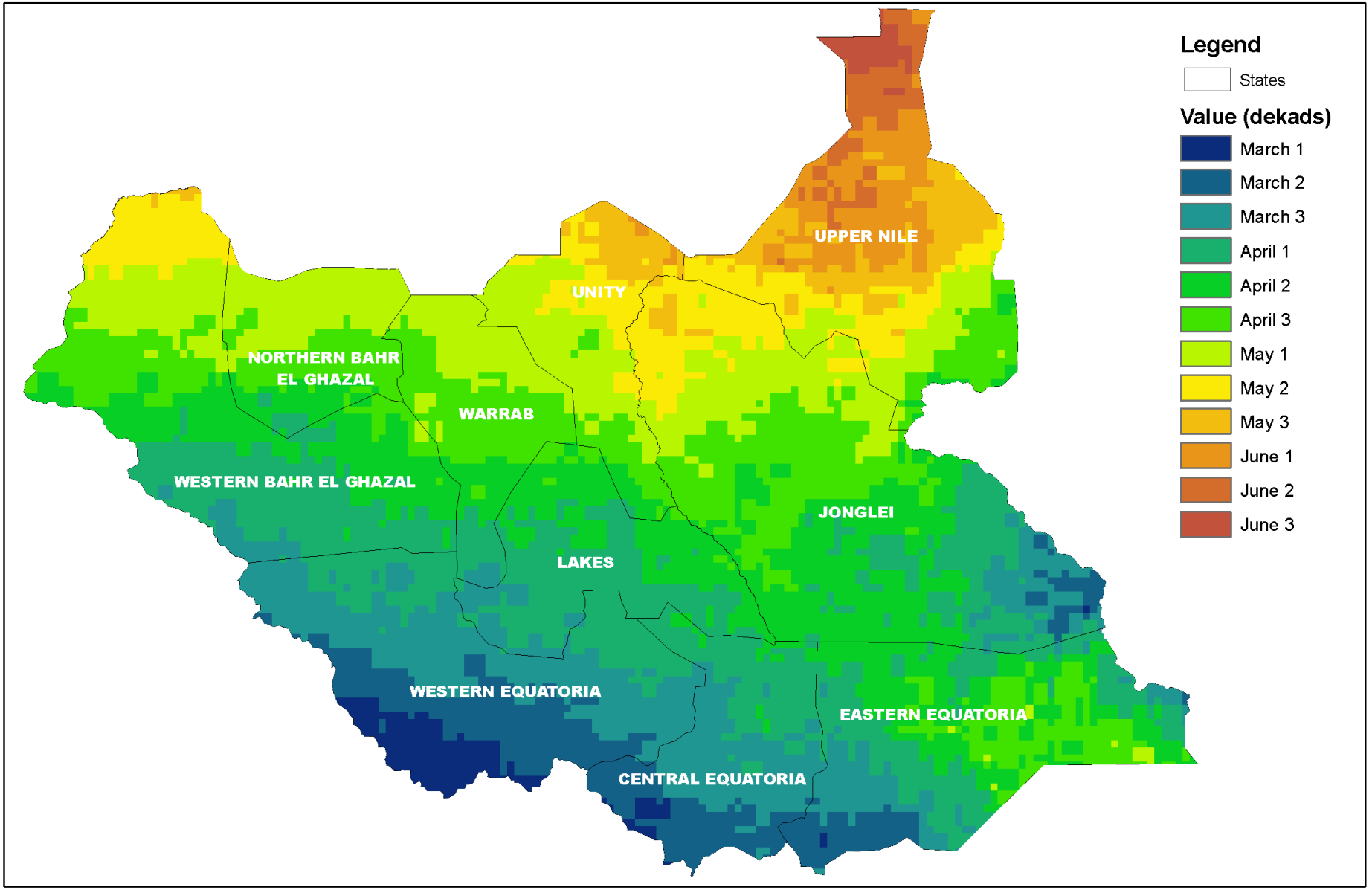
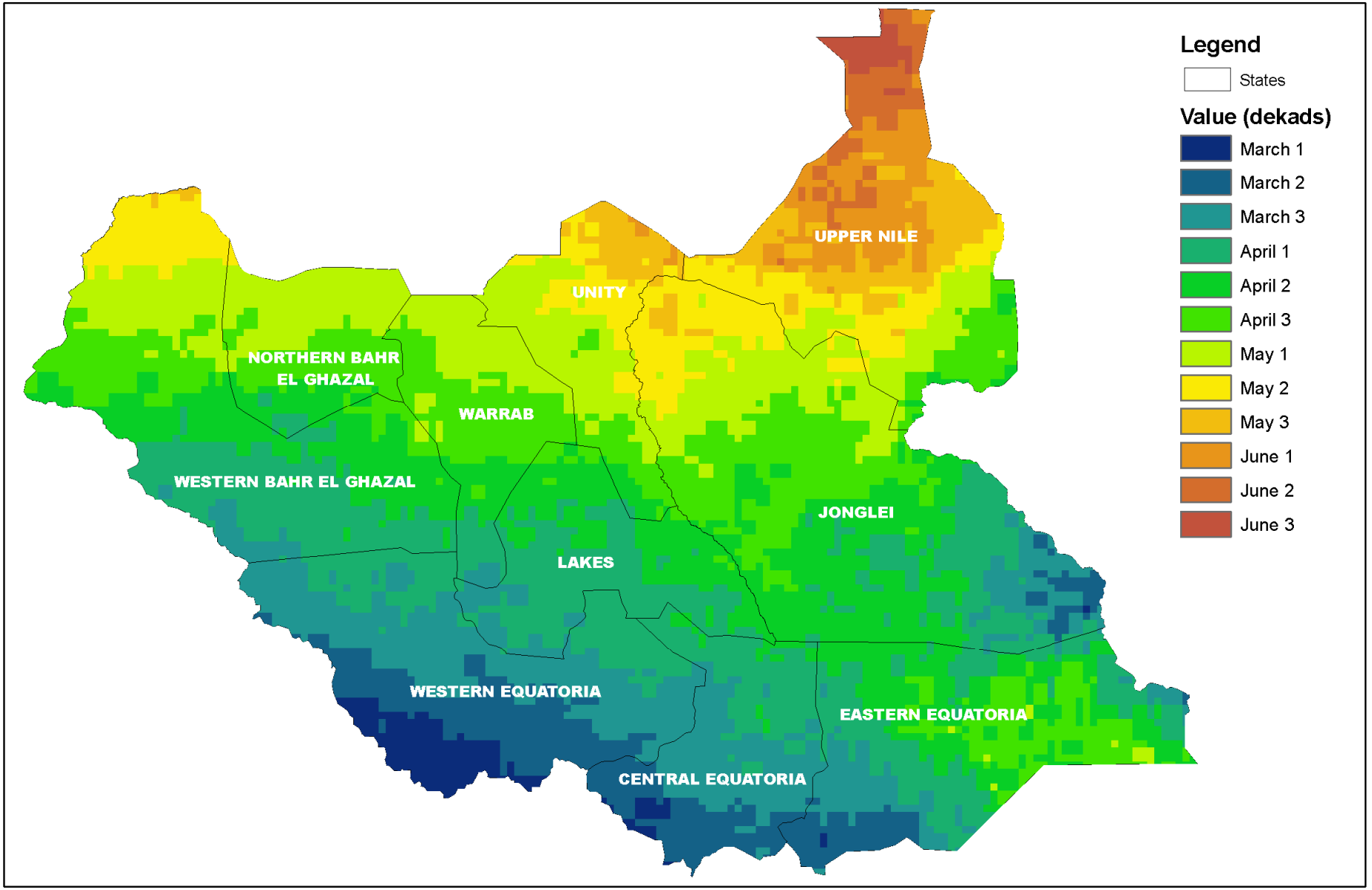
Applications - Characterization

South Sudan: Average date of beginning of growing season (1996 - 2010)



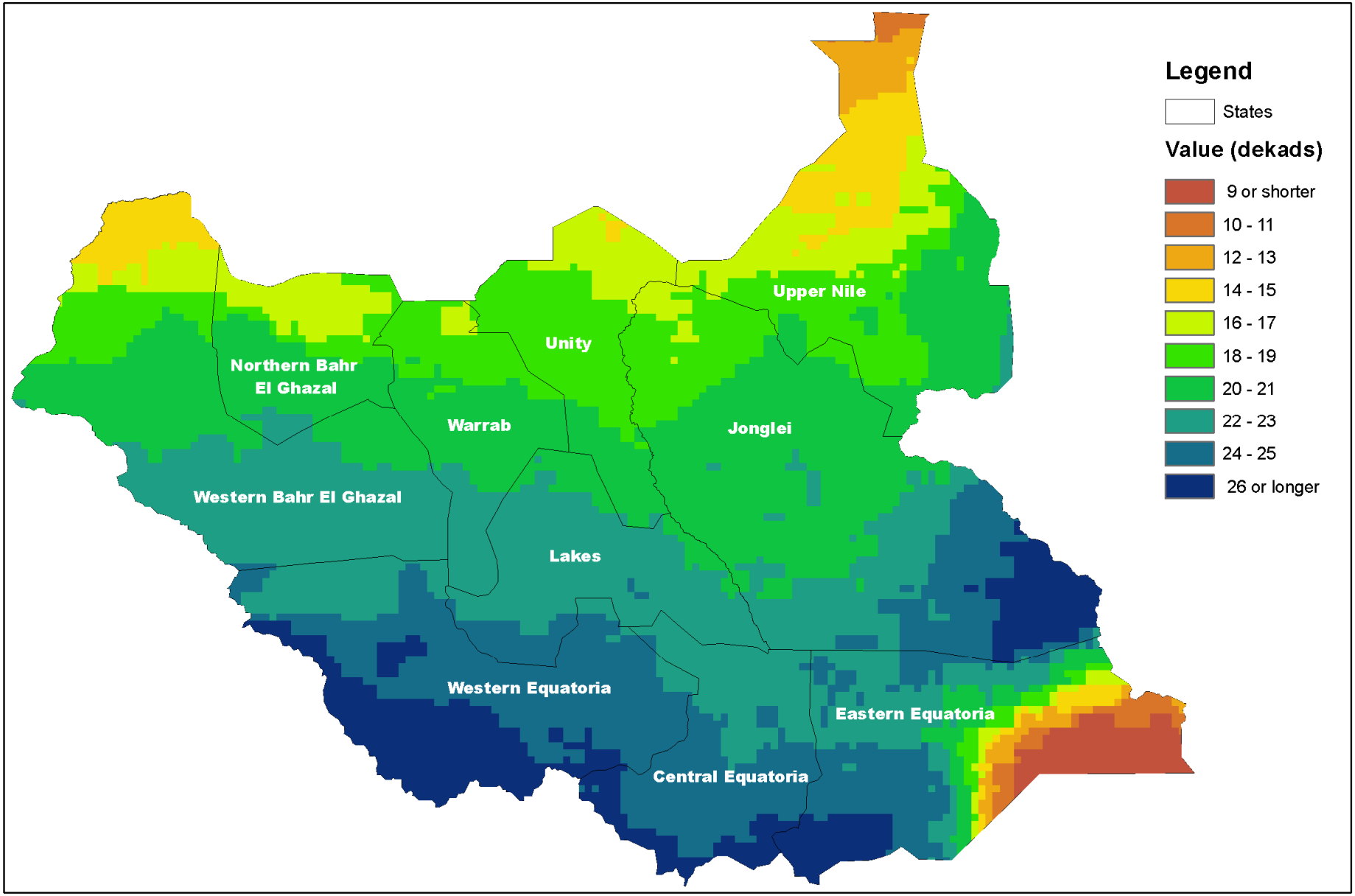
Applications - Characterization

South Sudan: Average date of beginning of growing season (1996 - 2010)



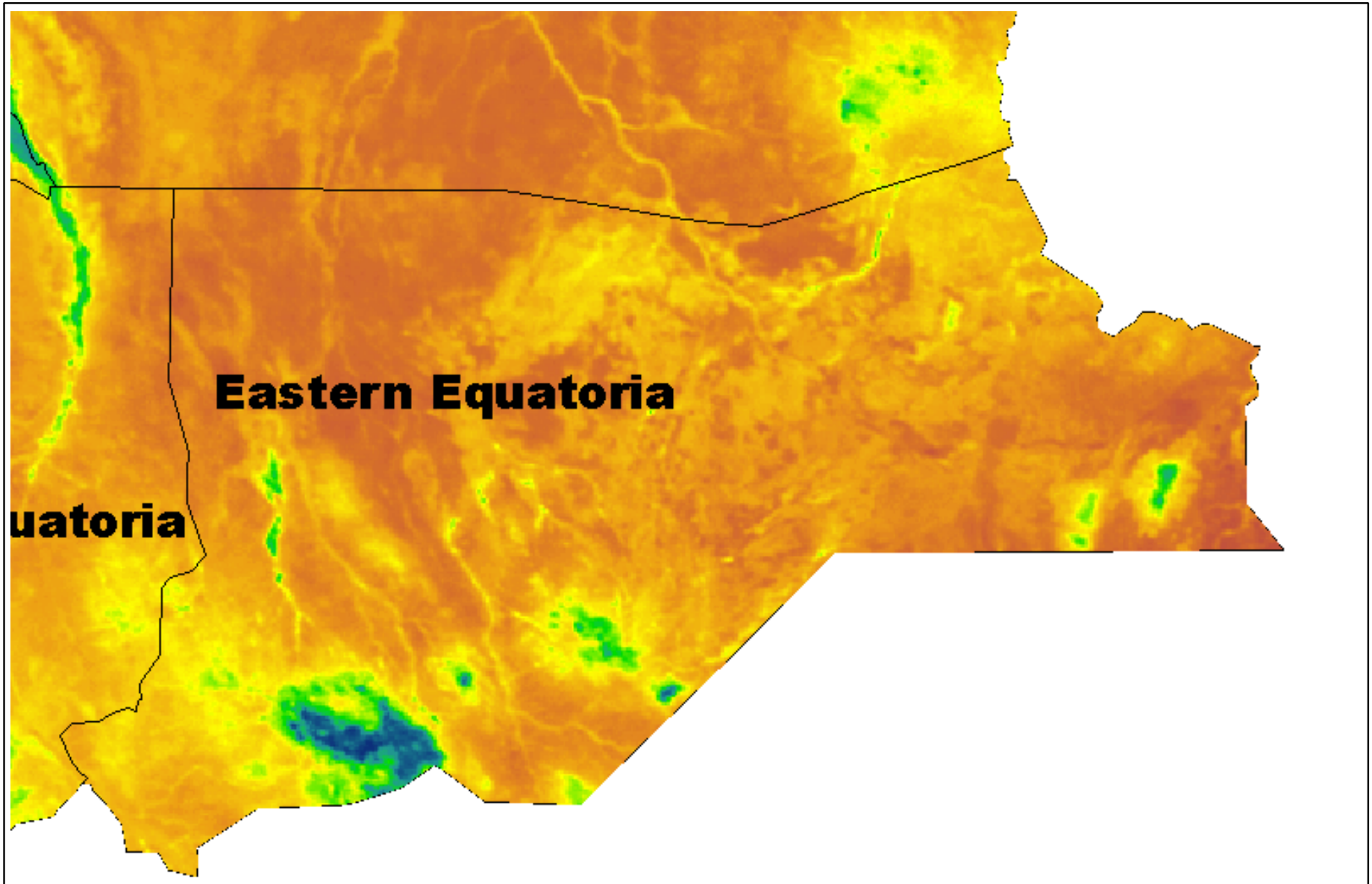
Applications - Characterization

South Sudan: Average length of growing period (1996 - 2010)

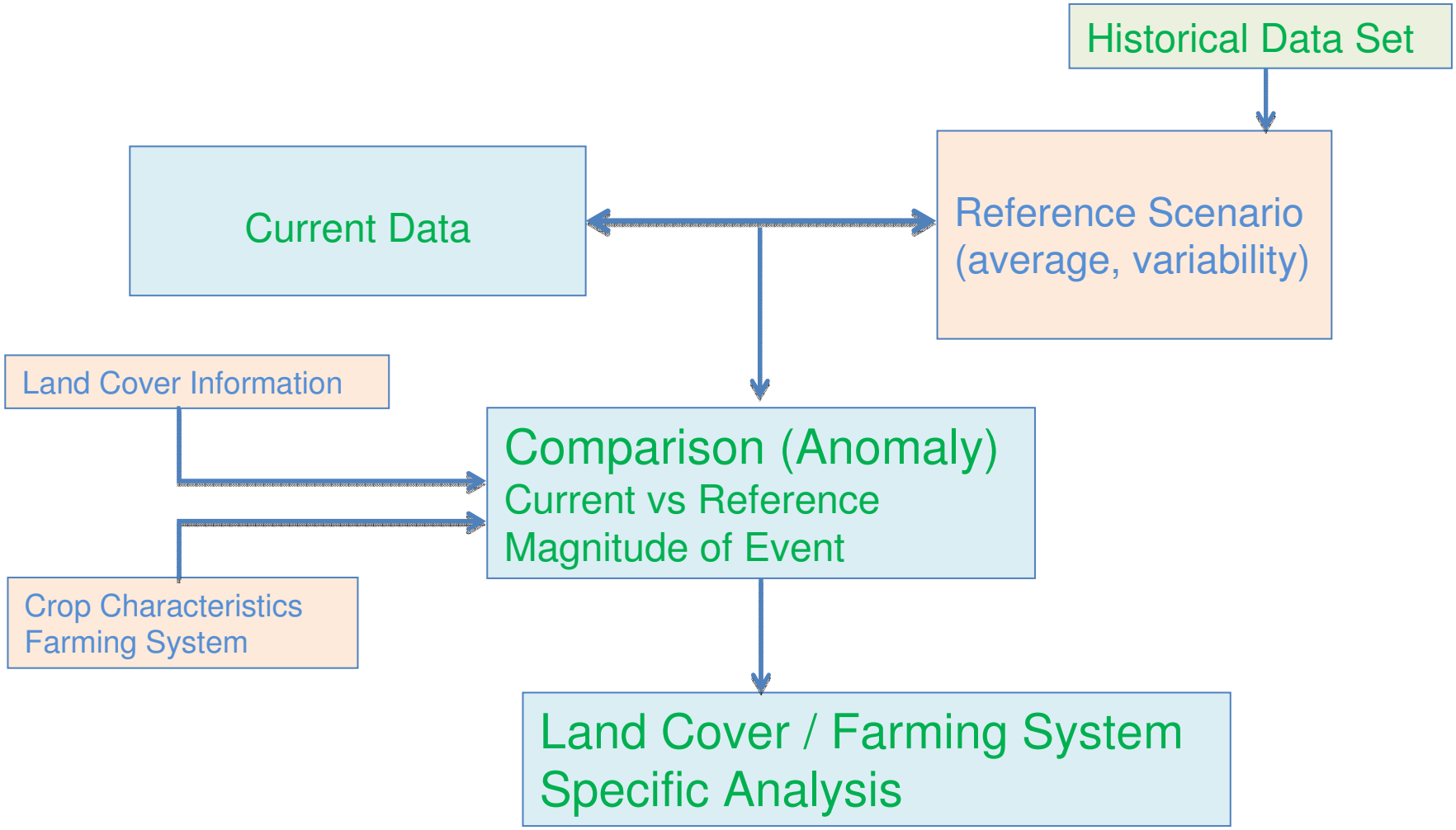


Applications - Characterization

South Sudan: Average NDVI - Late February (1998 - 2010)



Early Warning – Impact Assessment



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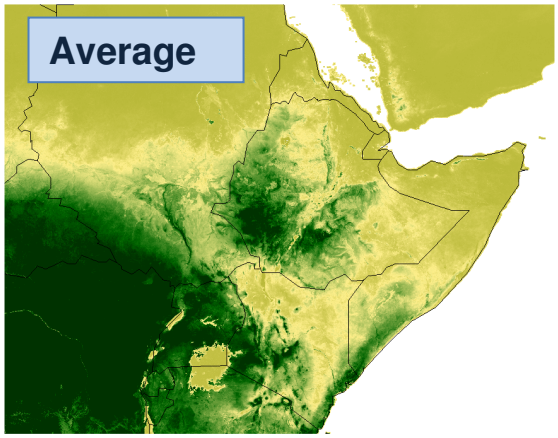
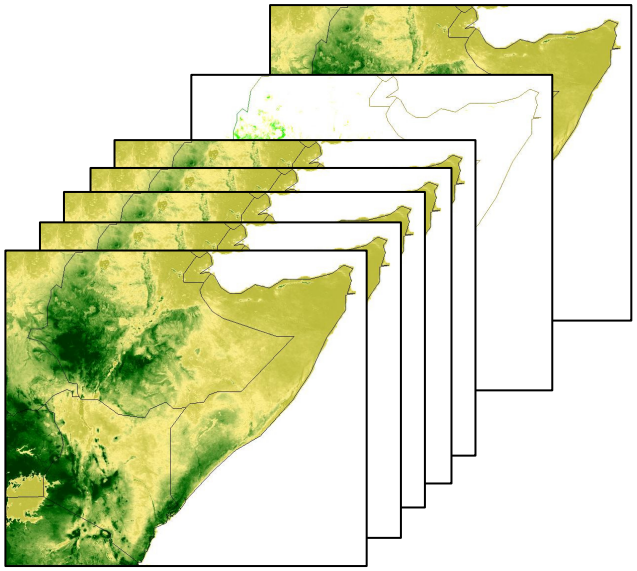
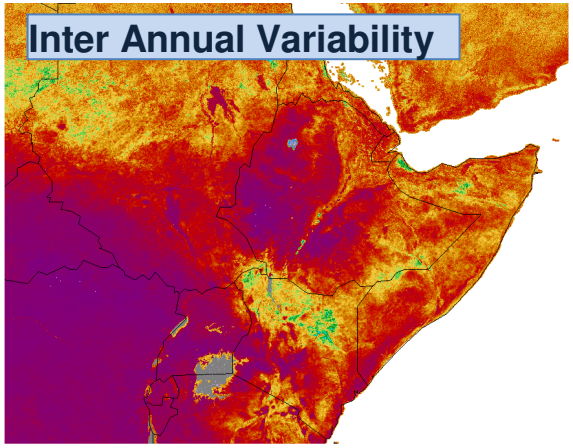
Build Reference Scenarios



Historical Data Set



Pixel by Pixel Statistics



Reference Scenarios

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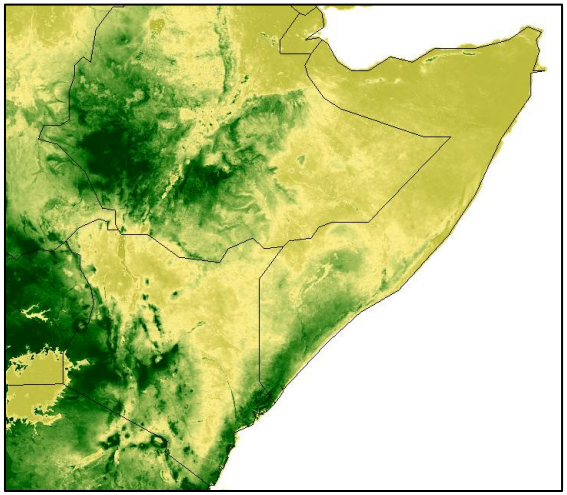
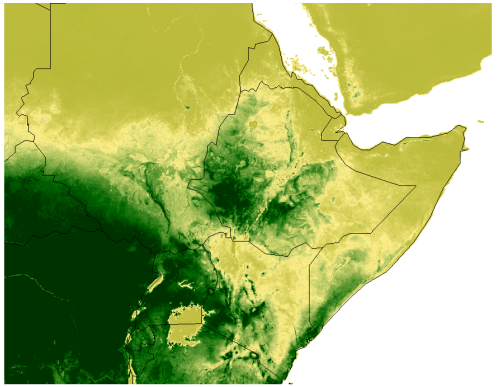
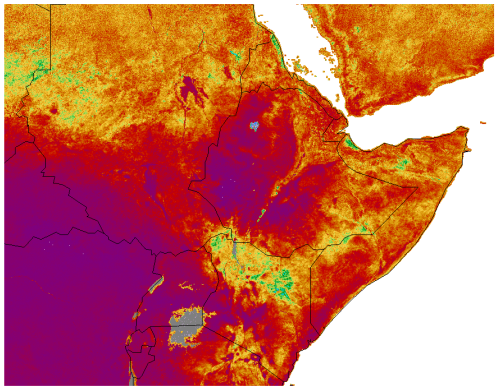
Comparison Current-Reference

Current Season Data



Reference Parameters





$$Z_{NDVI} = \frac{NDVI_i - \overline{NDVI}}{\sigma_{NDVI}}$$

Standardized Anomaly

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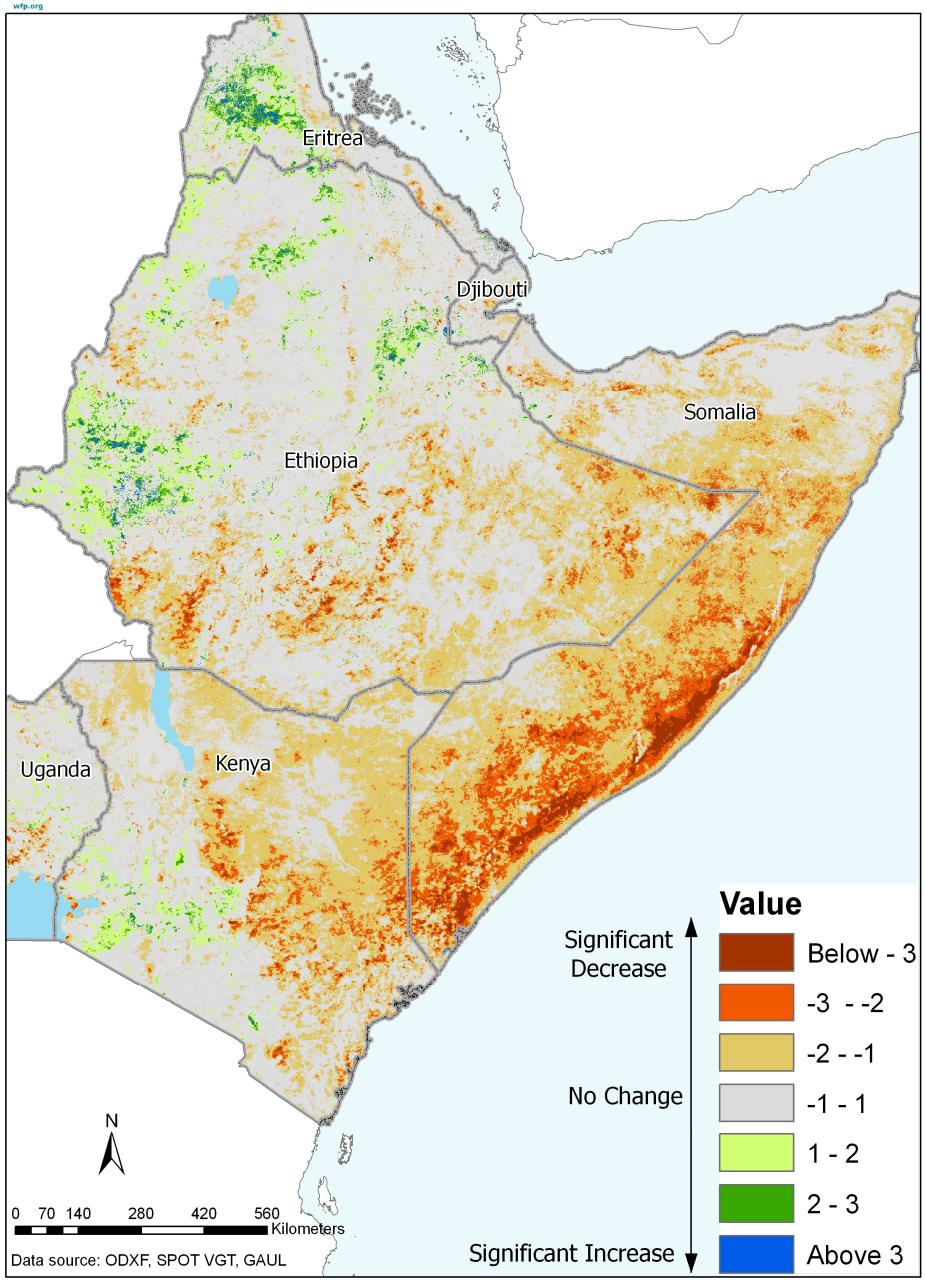
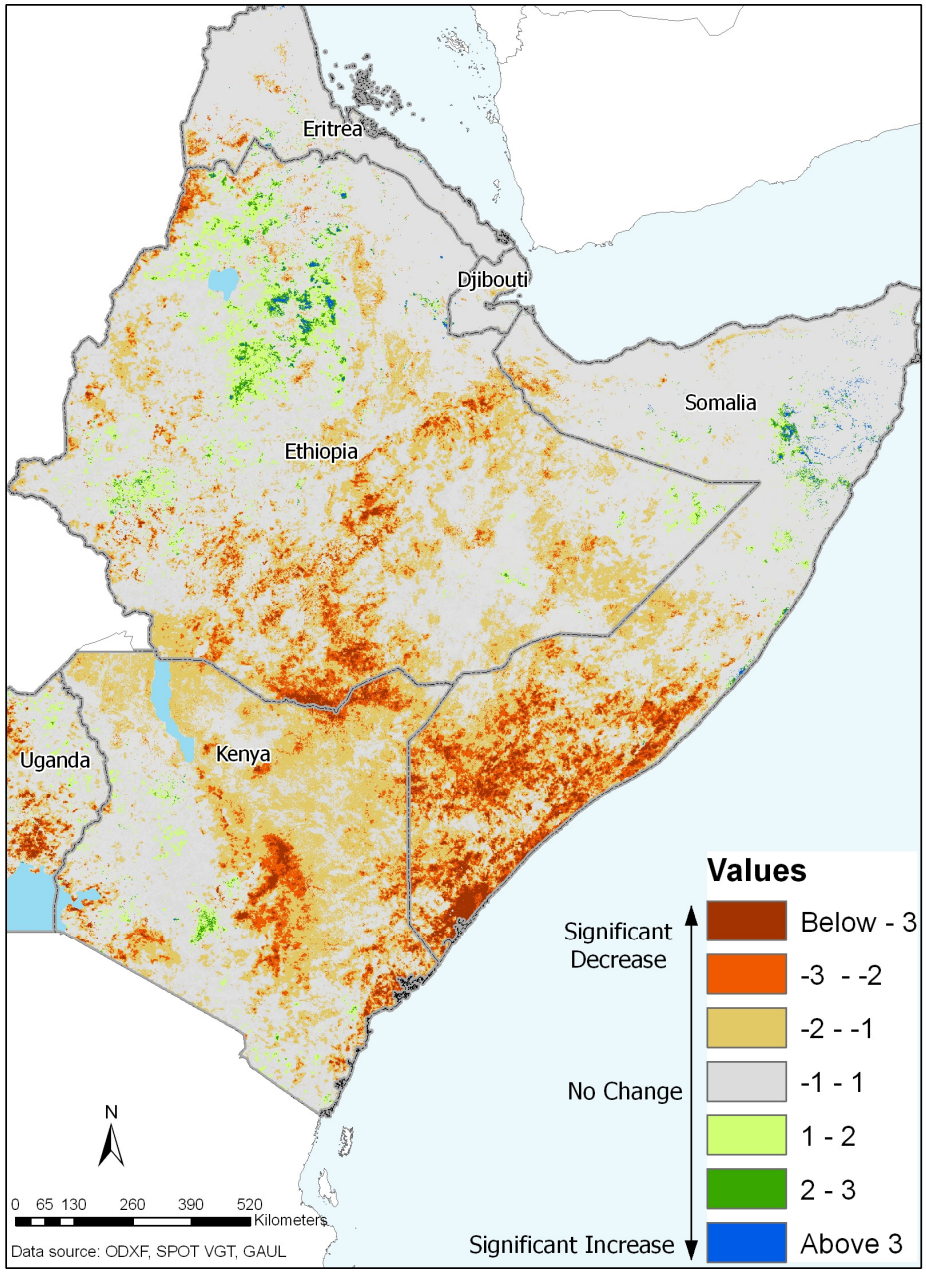
Horn of Africa: NDVI Oct 2010 to Feb 2011 Comparison to Average



Horn of Africa: NDVI March to July 2011 Comparison to Average



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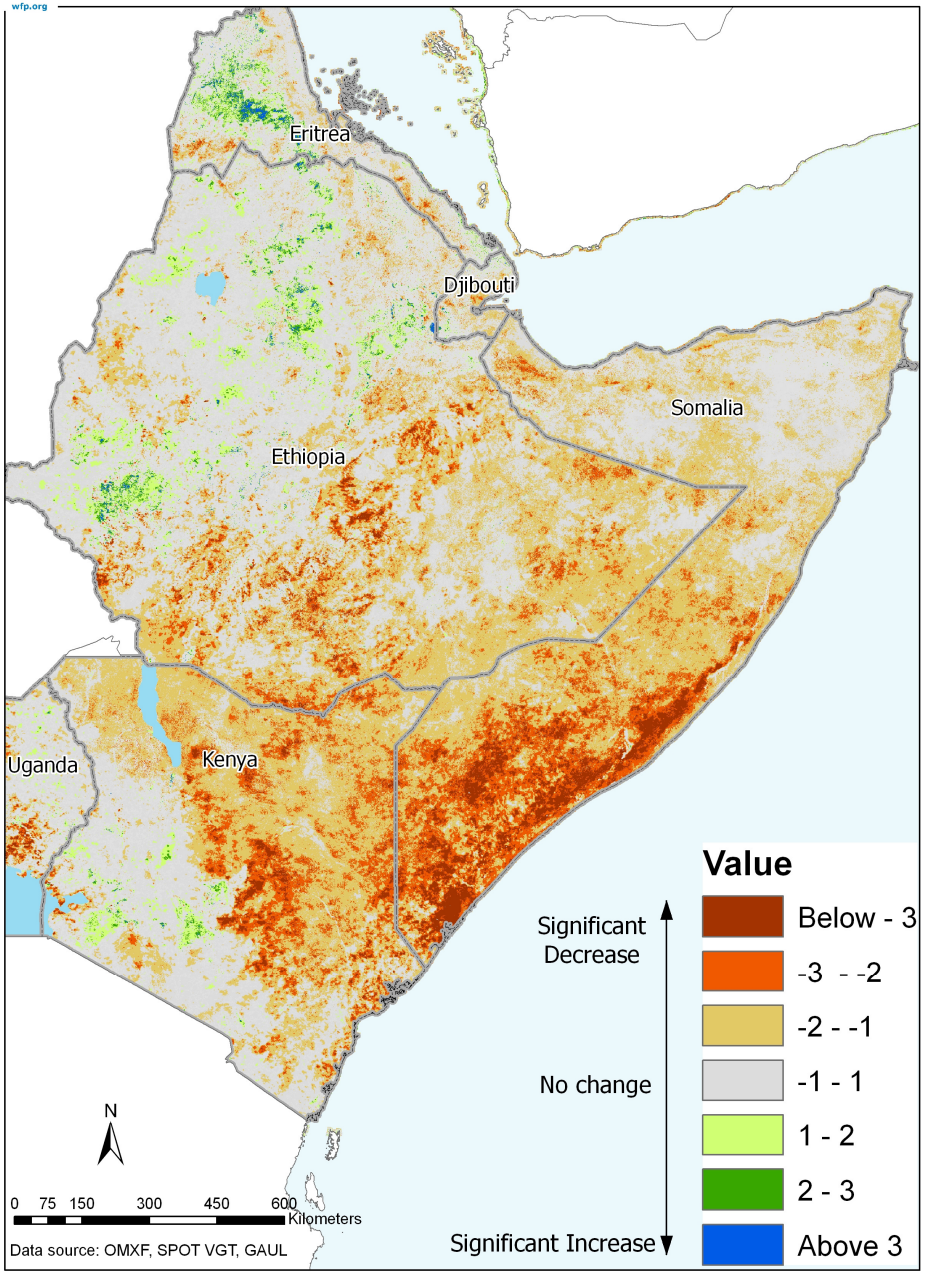
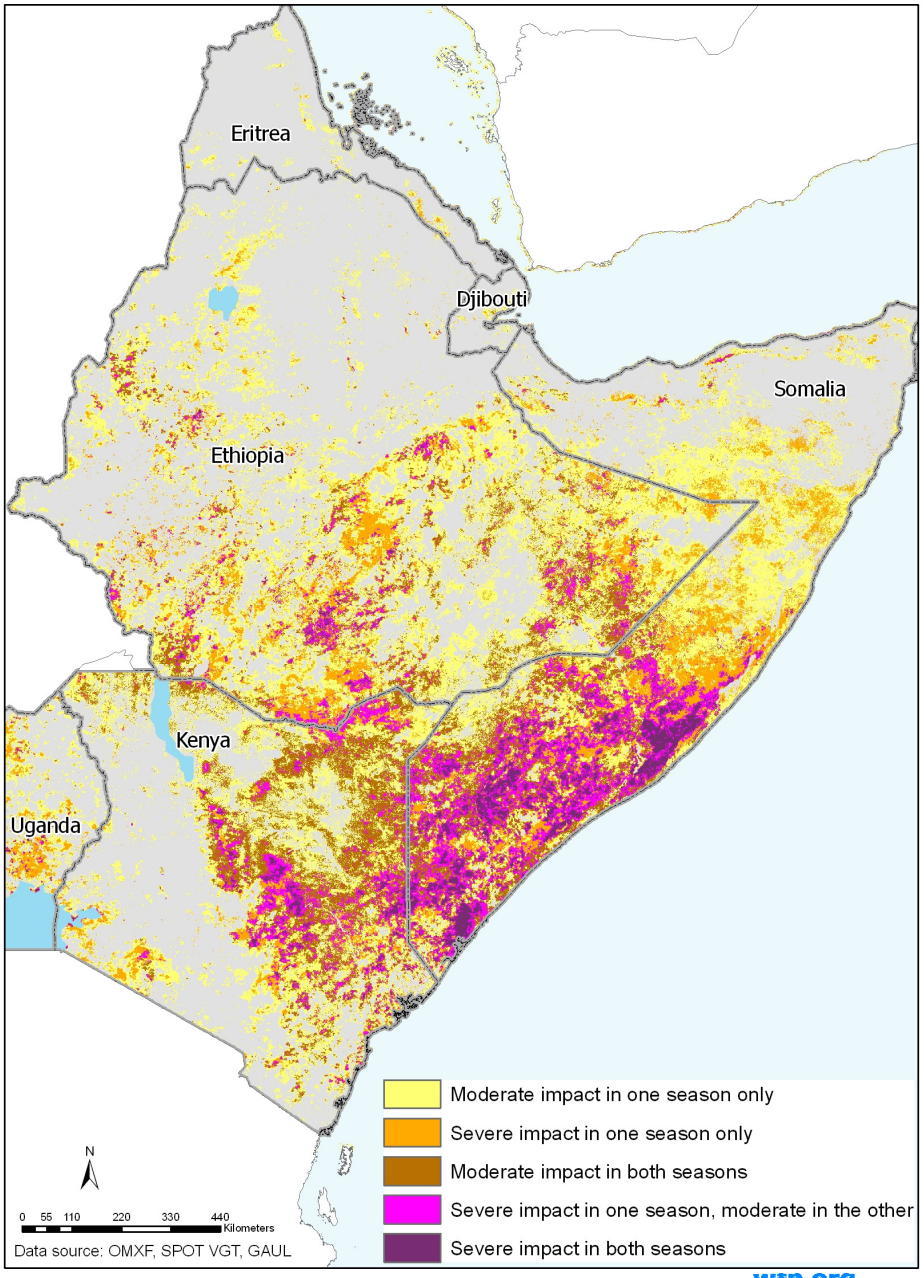
Horn of Africa: NDVI Oct 2010 - Jul 2011 Comparison to Average



Horn of Africa Affected Areas:
Type of Impact on growing seasons (Oct-Feb 2010 and Mar-Jul 2011)



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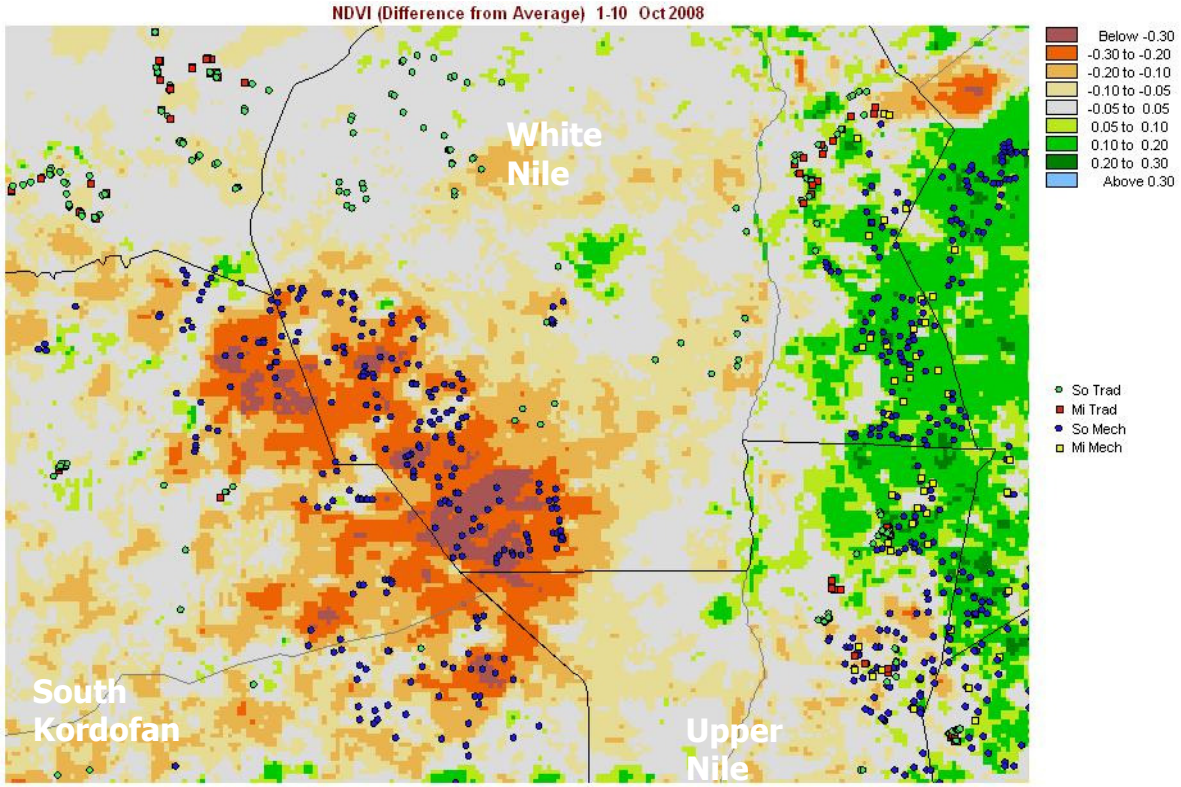
Central Sudan NDVI anomaly, semi-mechanized areas



Central Sudan NDVI anomaly – land cover information defines this as a semi-mechanized agriculture region.

Impact of crop failure on the rural subsistence households of the region is not through impacts on their own production but through the loss of labour income.

Magnitude of impact is evaluated against household income profile

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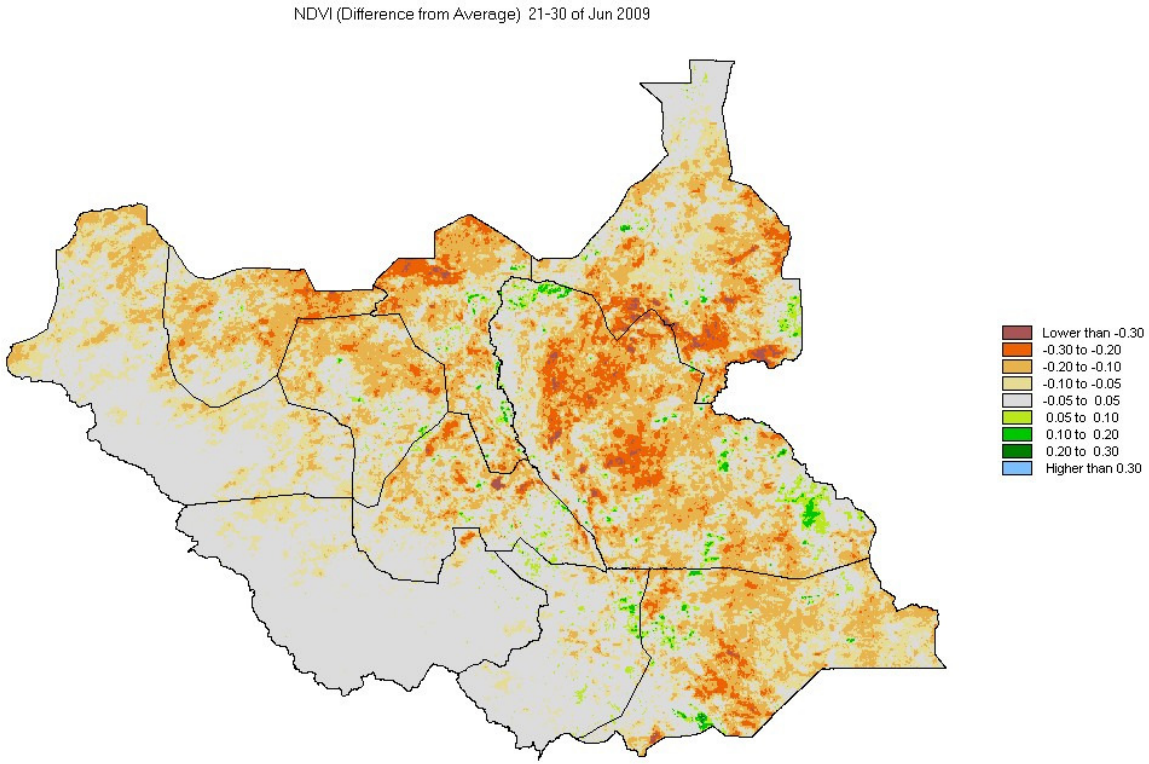
South Sudan early season RFE/NDVI anomaly



How is this translated into information of value for WFP? Know-how of farming systems and crop calendars :

Short maturing sorghum is planted early so as to yield the first grain harvest of the season.

The NDVI anomaly translates into a “hunger gap” longer by 4 to 6 weeks.

Impact of this has to be judged against status of household stocks, itself mostly a function of previous season’s production

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Estimating Crop Production : Afghanistan Winter Wheat

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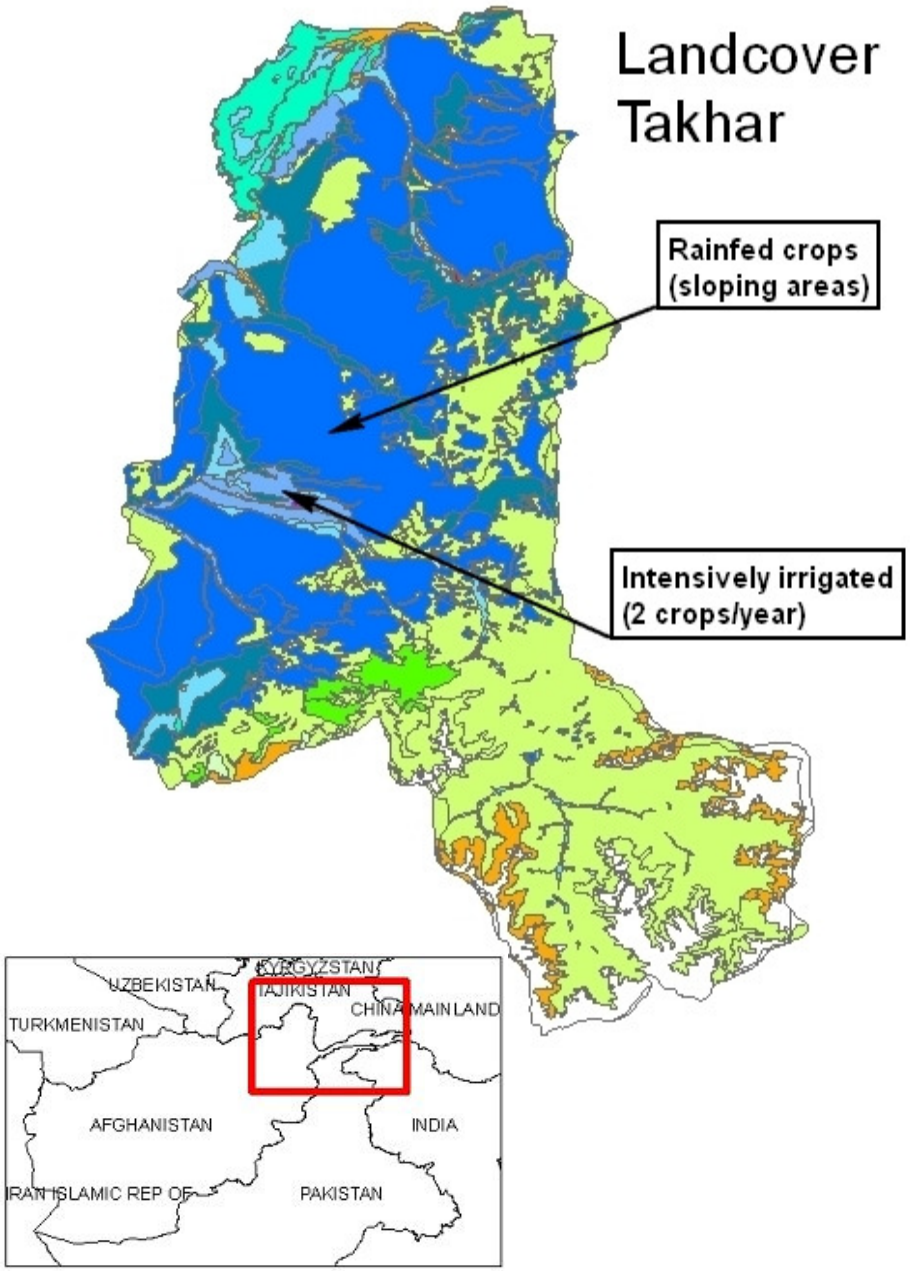
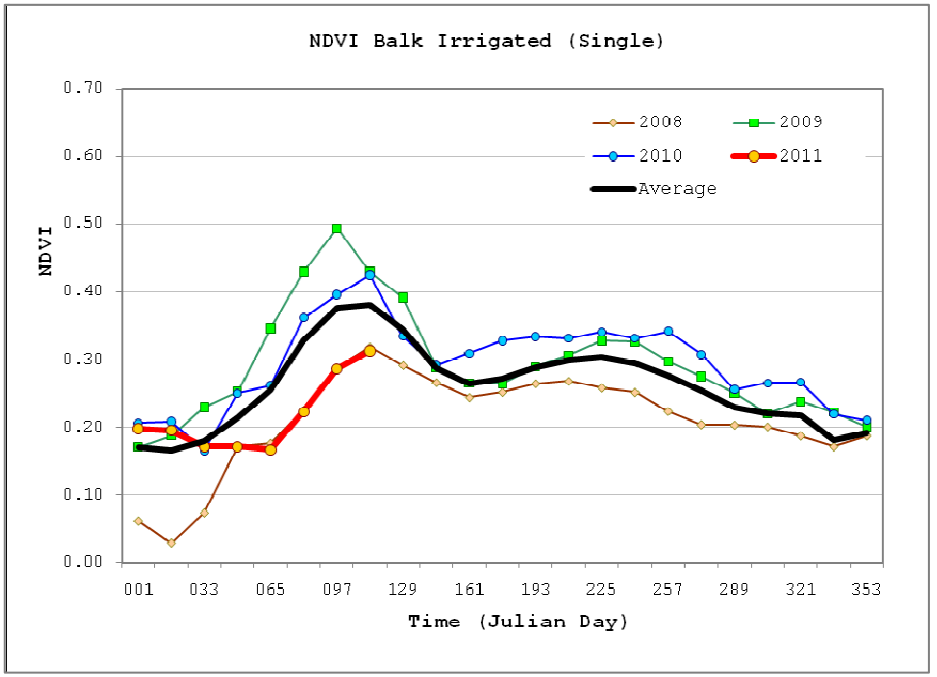
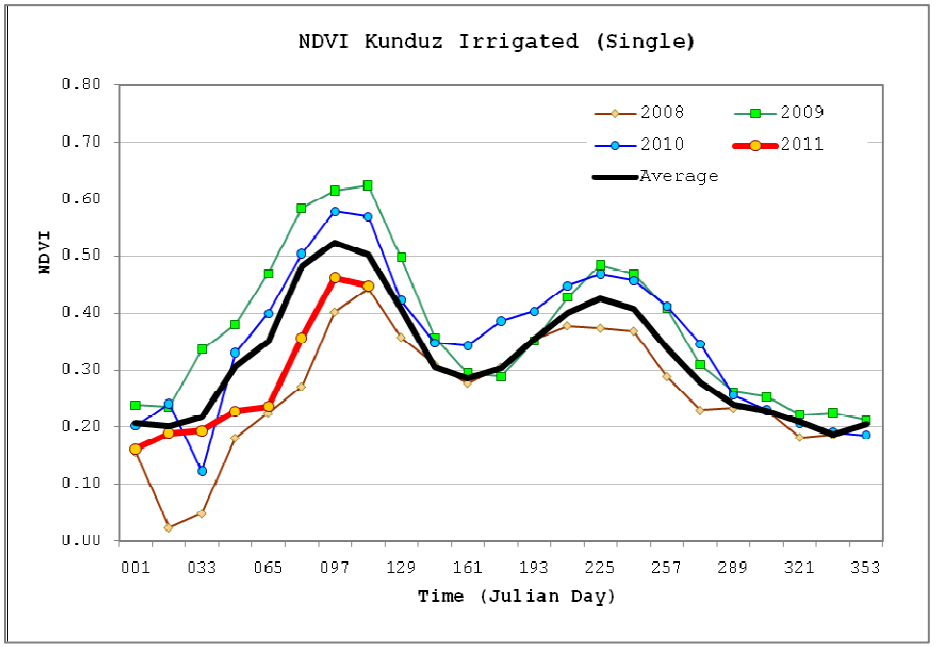
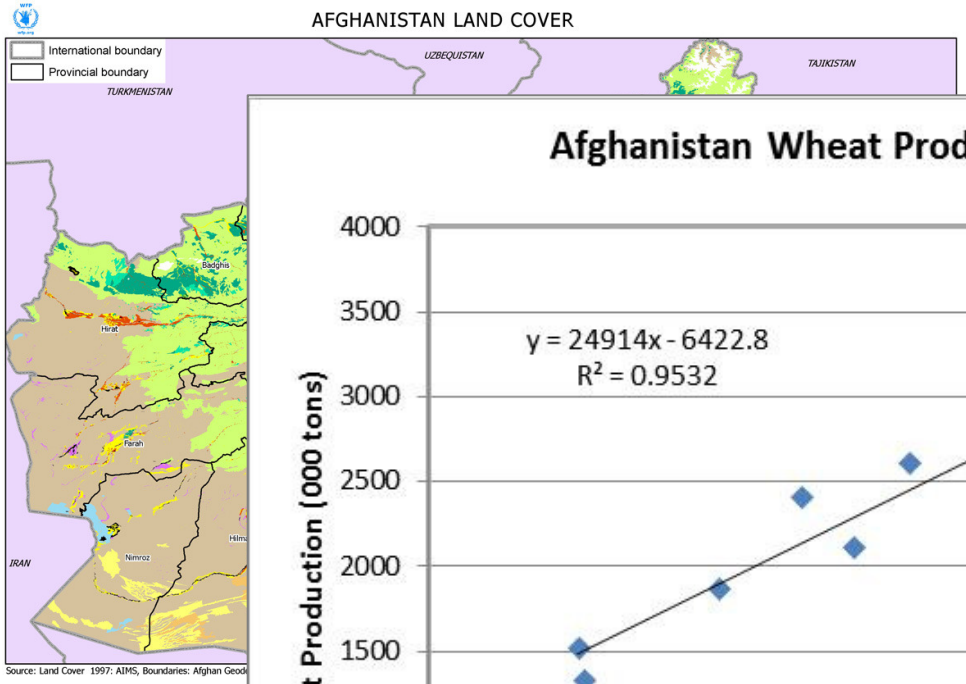
Afghanistan NDVI profiles over Cultivated Areas

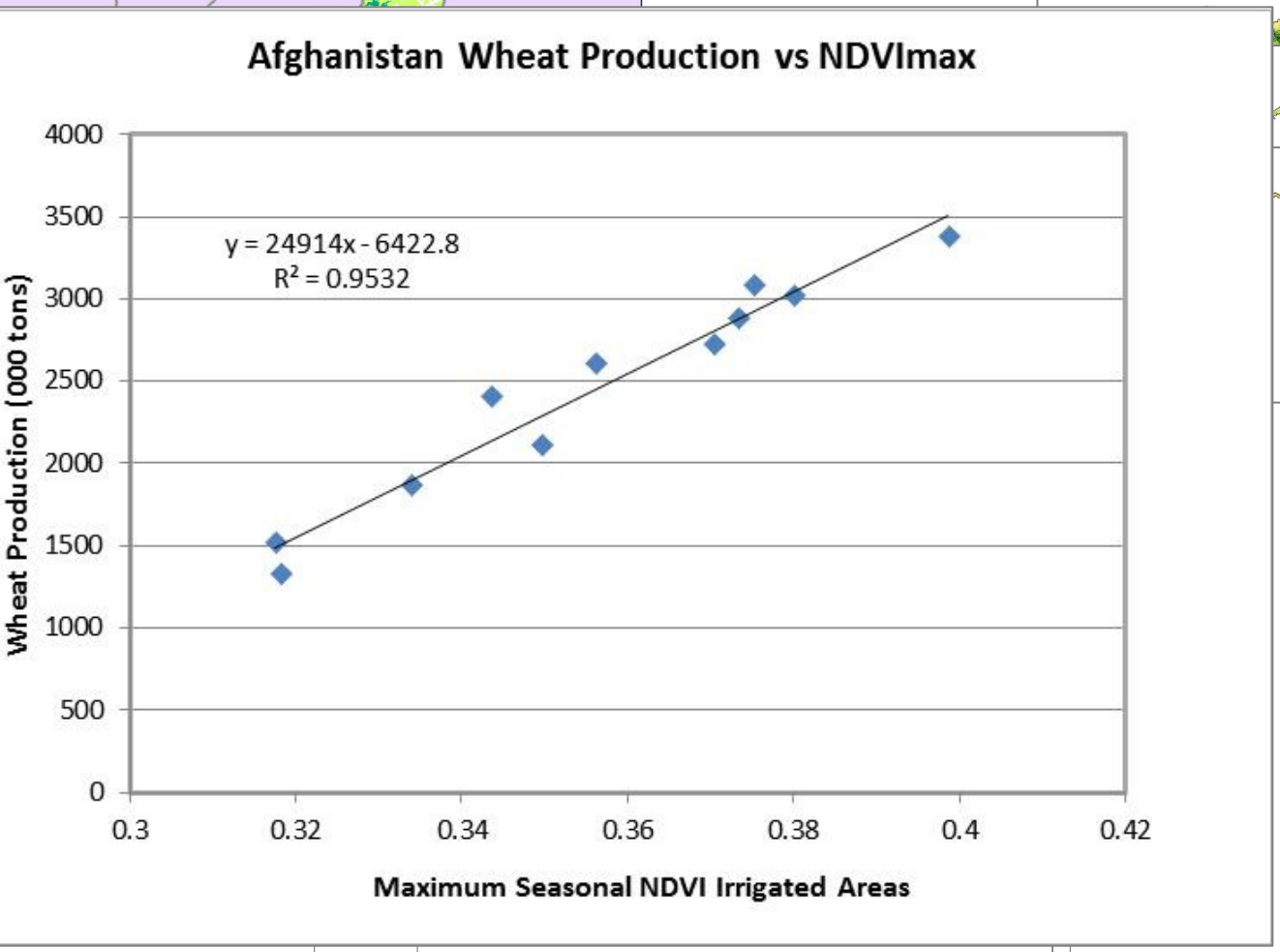


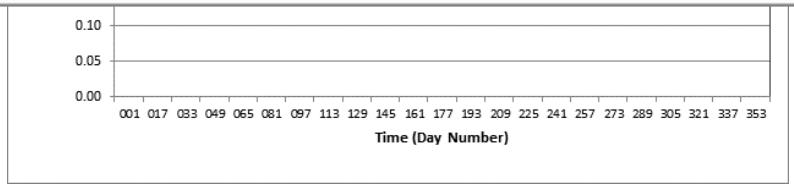




Afghanistan Winter Wheat Production Estimates







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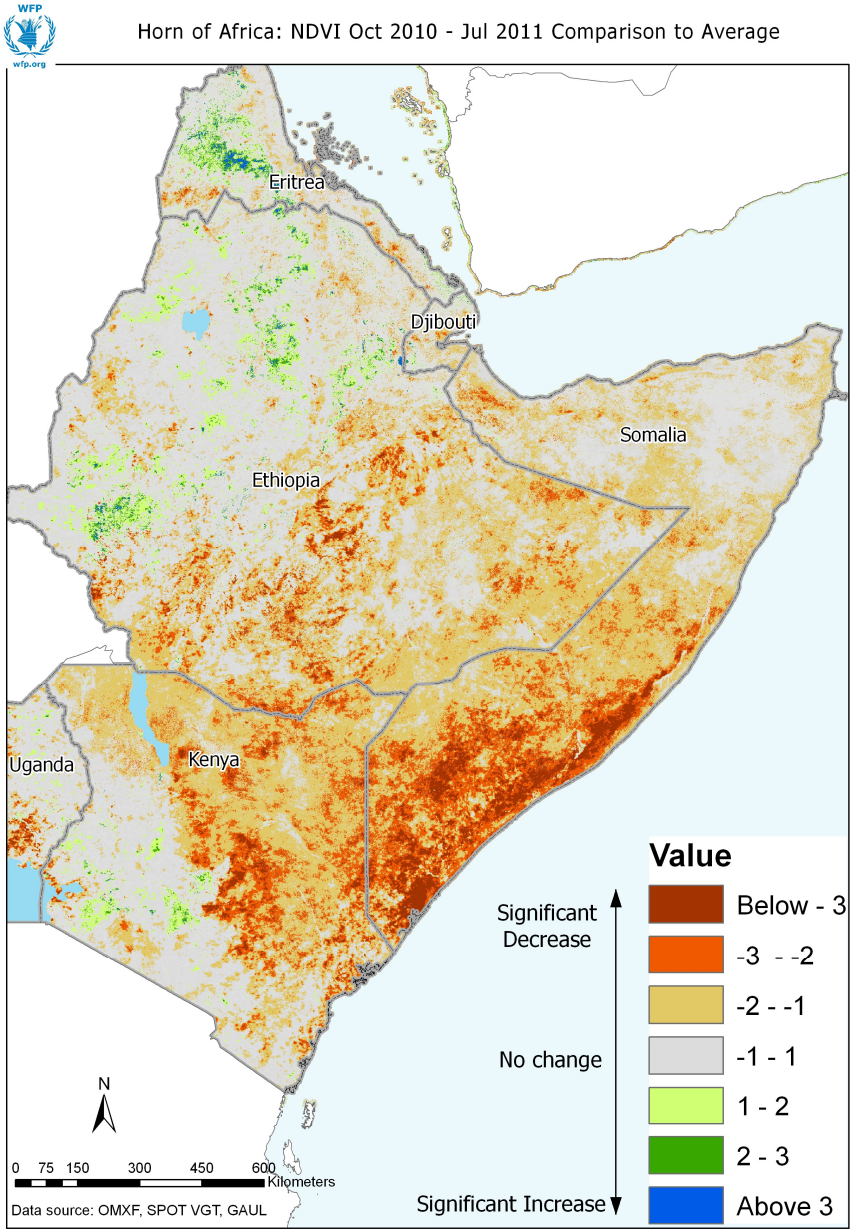
The Temporal Context: a long term view of the Horn



How does the recent drought event compare with the historical record? How exceptional? Part of a trend or just natural variability?

Experiment: Combine NDVI datasets with slightly different characteristics, covering different time spans

Inter-calibrate

GIMMS NDVI 1981-2008

SPOT-VGT 1998-present

to obtain a tentative synthetic dataset 1981-present

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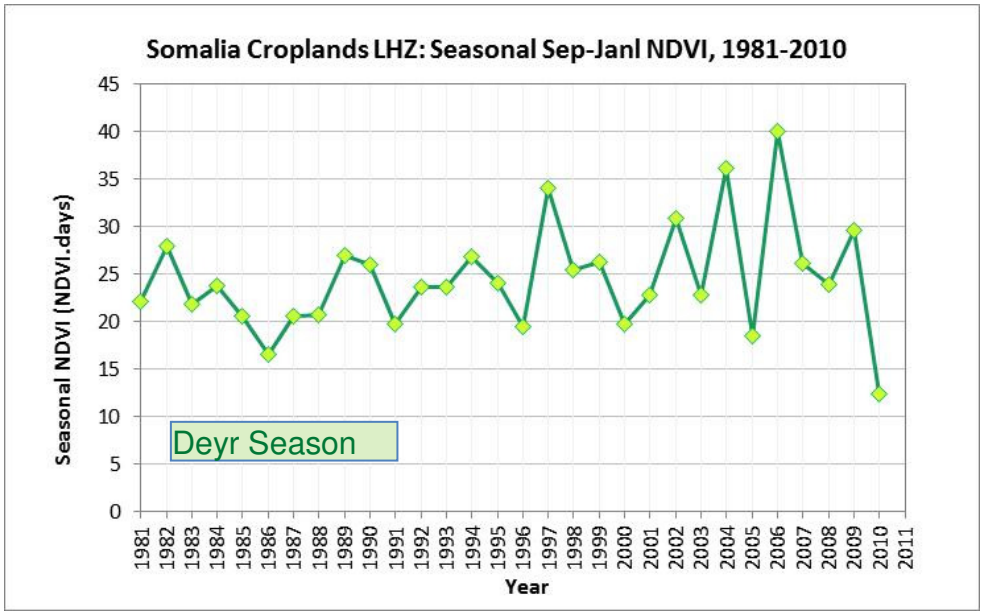
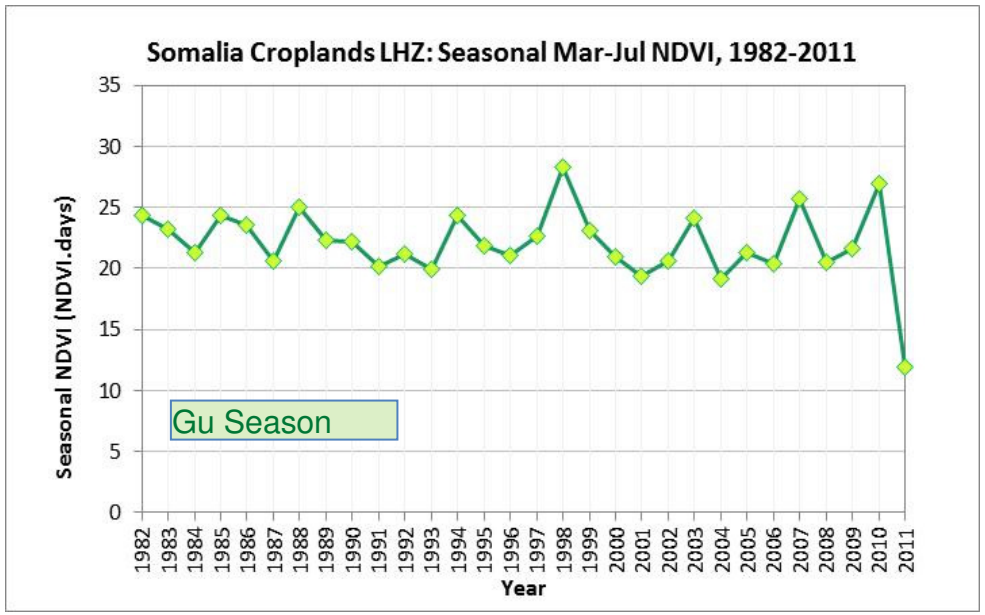
Temporal Context – Somalia Croplands





Agricultural livelihood areas :
Deyr season (Oct-Dec, short rains) much more variable than Gu season (Apr-Jun, long rains)

2010-2011 event exceptional in the 30 year timeframe

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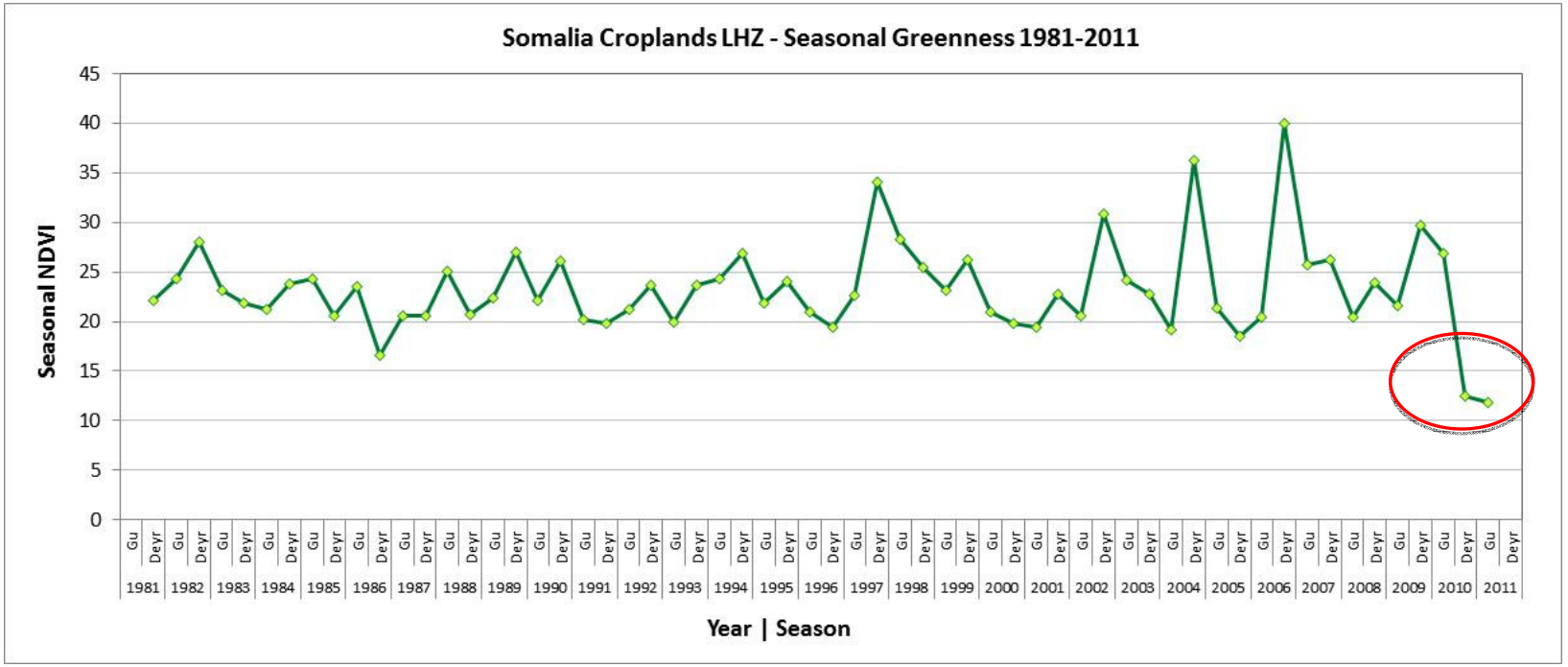
Temporal Context – Somalia Croplands



Agricultural livelihood areas :

No apparent trend, but increasing variability?
2010-2011 event : two consecutive exceptional failures in the 30 year record

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Wrap up

EO data products increasingly visible and used with higher demand fuelled by greater awareness of their potential.

- Increasing availability and wider variety of datasets
- Standard approach
- Usage of land cover/livelihood information
- Need to integrate with household/livelihood information and crop/farming calendars.
- Information in long-medium term data sets

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Analysis for the Horn of Africa

Integrated view over two seasons:

Z anomaly for aggregated NDVI October 2010 – July 2011

Classify each season Z image into severe (or worse), moderate, normal, cross tabulate and re-group into key groups :

- **Severe impact in both seasons**
- **Severe impact in one season, moderate in other**
- **Moderate impact on both seasons**
- **Severe impact in one season, normal in other**
- **Moderate impact in one season, normal in other**

Rough, but allows quick identification of areas with consecutive significant impact (relative to past behaviour)

Descriptive legend convenient for non technical readers

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Analysis for the Horn of Africa

Rationale :

Past variation in NDVI assumed to contain the range of variation in seasonal resources that the household has had to cope with.

•Z btn [-1 to +1]: ***normal*** season to season variation

•Z btn [-1 to -2]: ***moderate*** variation assumed to enclose the limits of the usual coping capacities of agricultural households.

•Z btn [-2 to -3]: ***severe*** variation, stretching coping capacity beyond what many households could achieve. Significant impacts.

•Z < -3: ***extreme*** variation, well outside the coping capacity if not the experience / living memory of households. Extreme impacts, once in a generation events (?)

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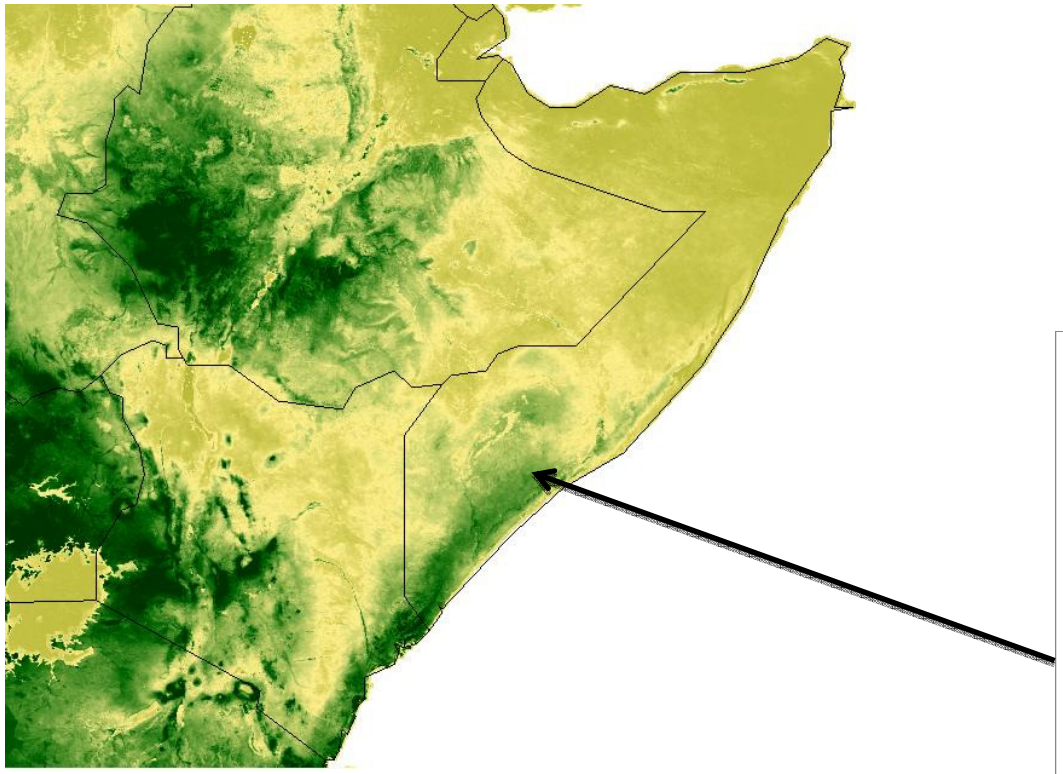
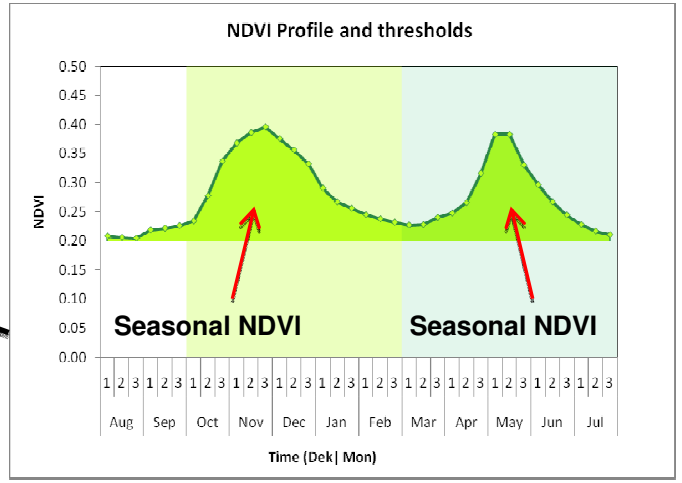
Image © 2012 DigitalGlobe
© 2012 Cnes/Spot Image
lat 36.667973° lon 66.906944° elev 395 m
Balkh, Afghanistan
Google earth

Evaluate Seasonality





Bimodal Regime (2 seasons)
Seasonal NDVI within each individual growing period

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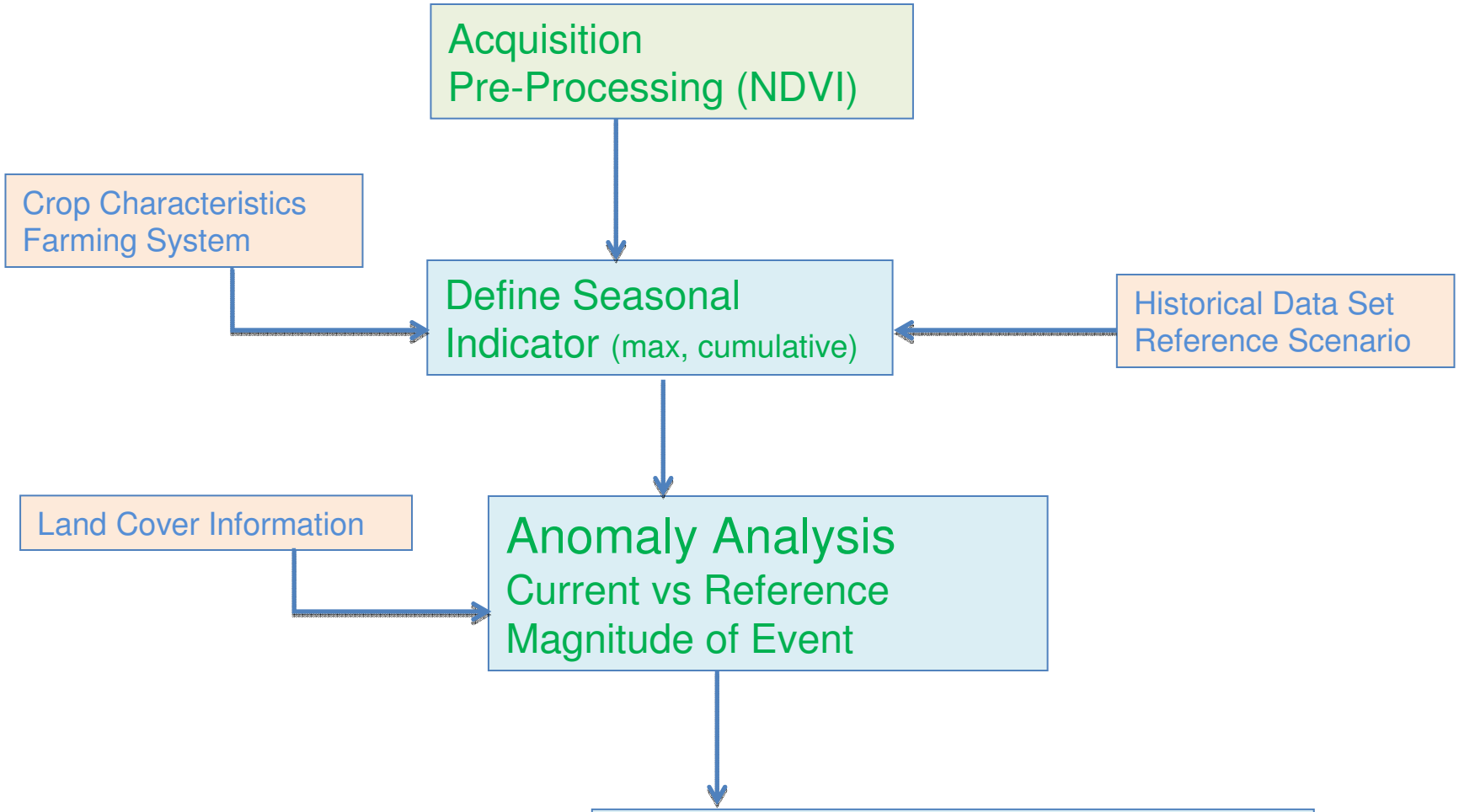
Analysis Framework



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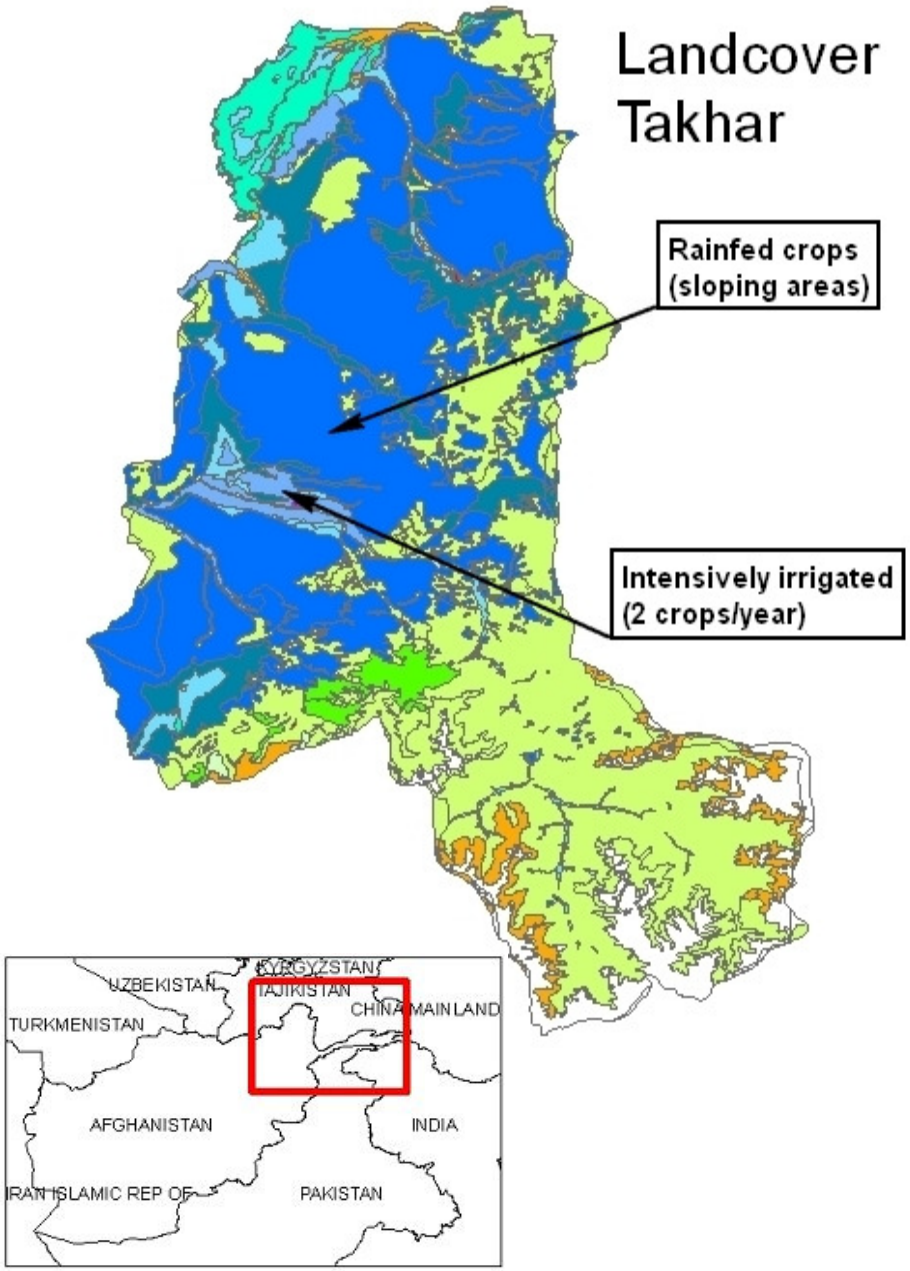
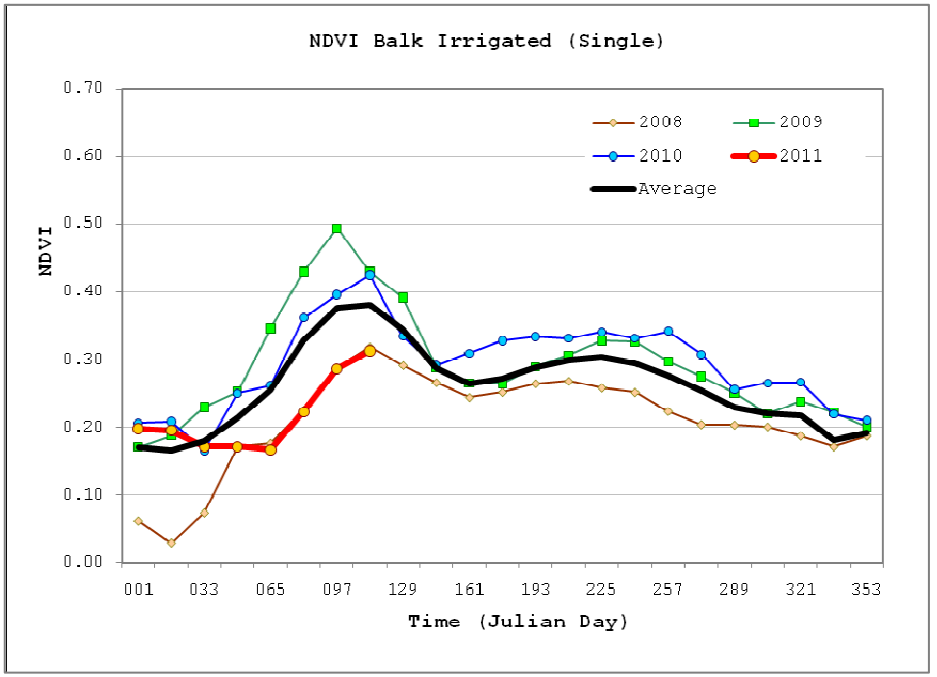
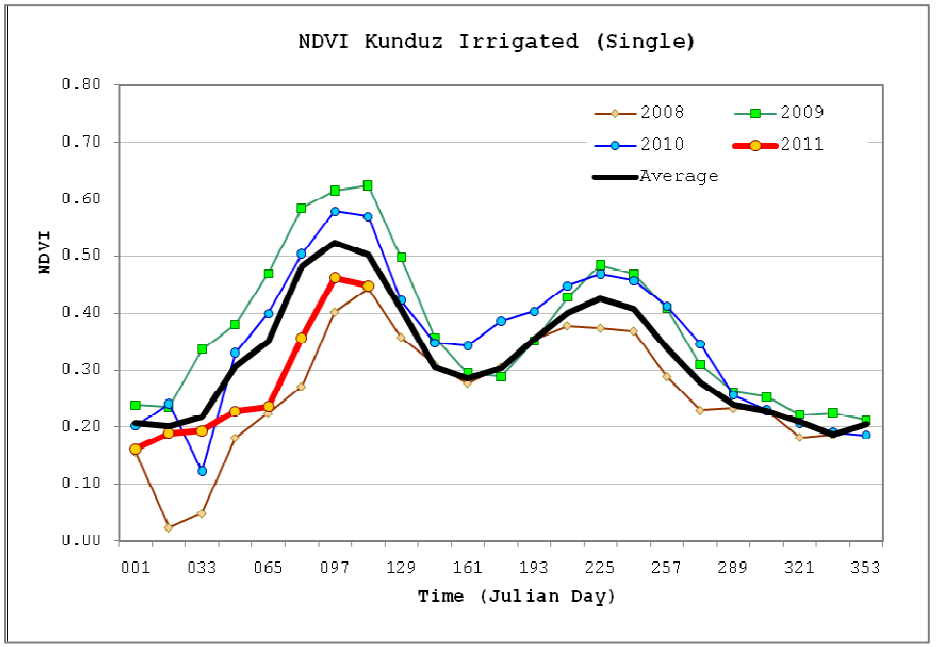
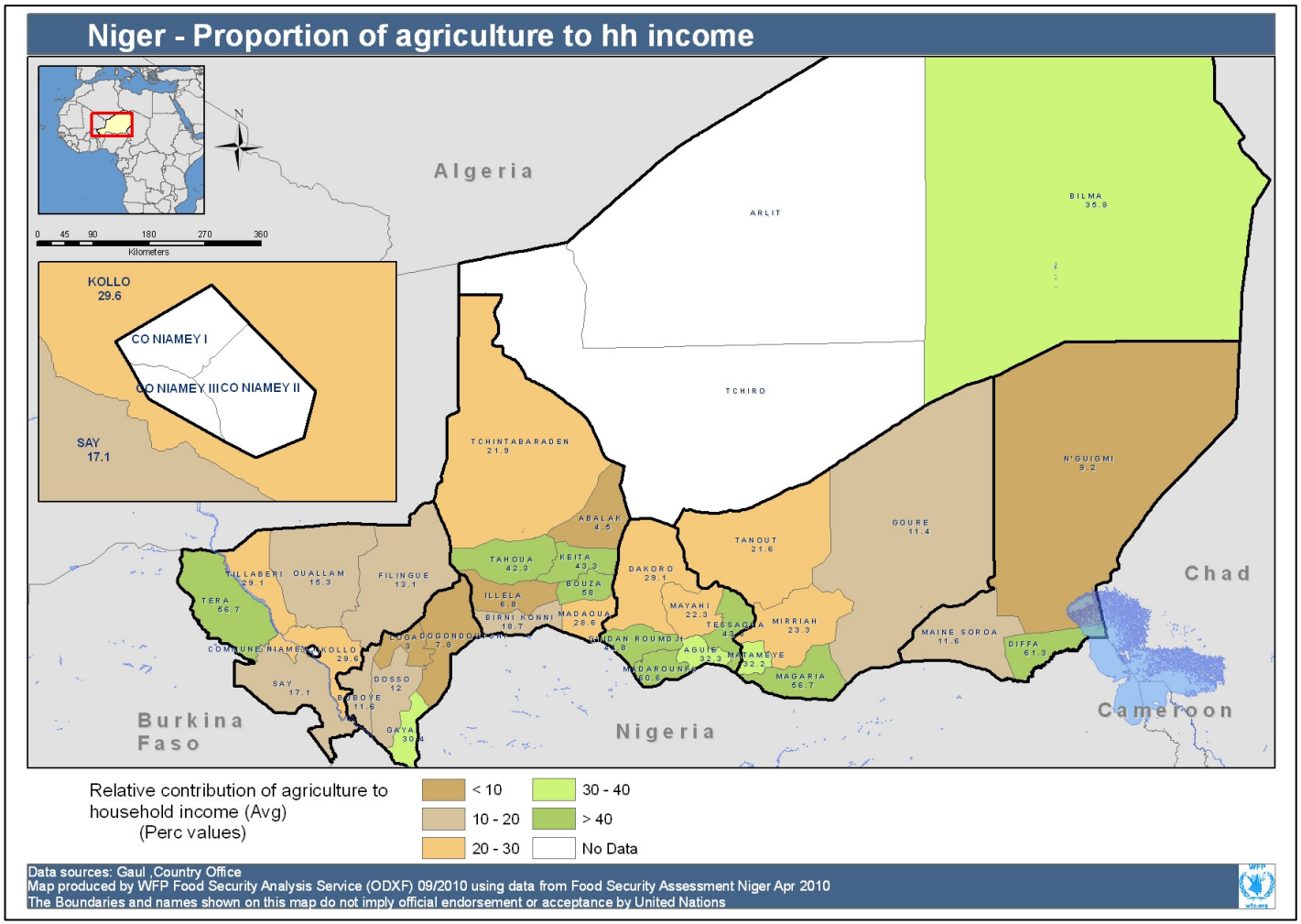
Afghanistan NDVI profiles over Cultivated Areas









Key information to evaluate impacts of fluctuations in crop production

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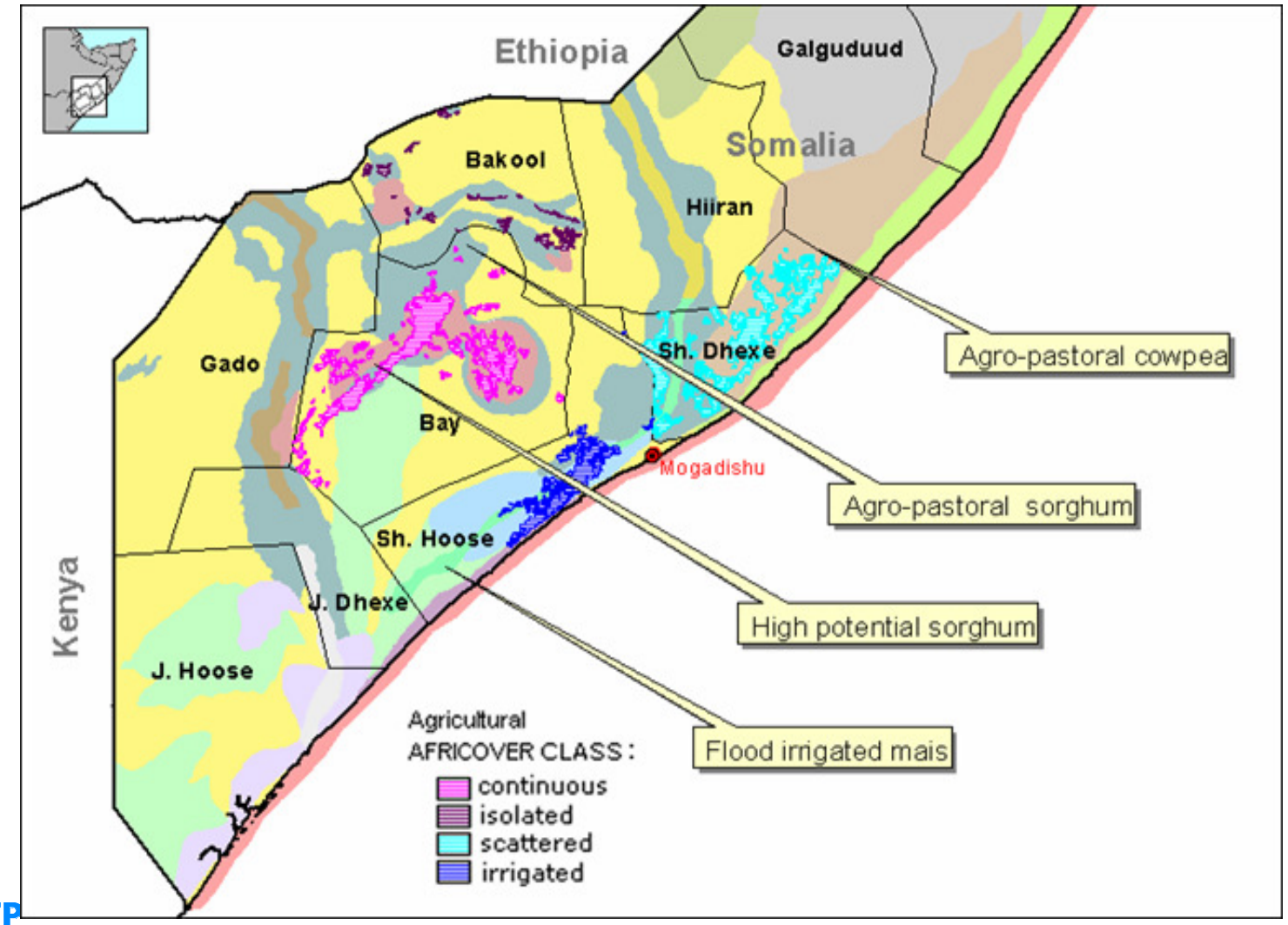

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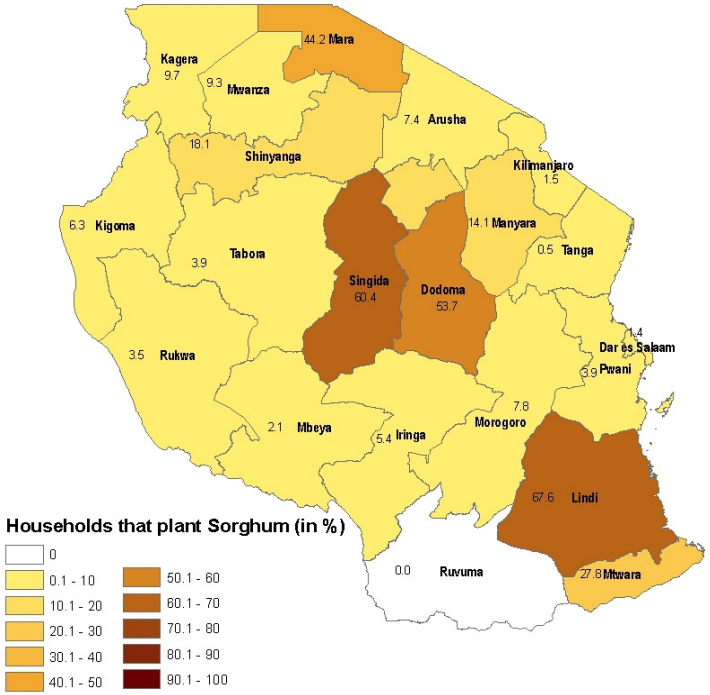
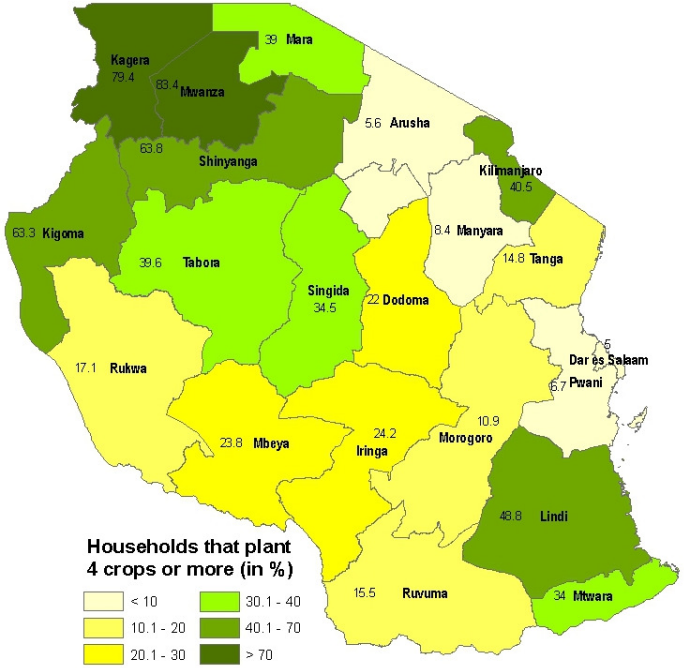
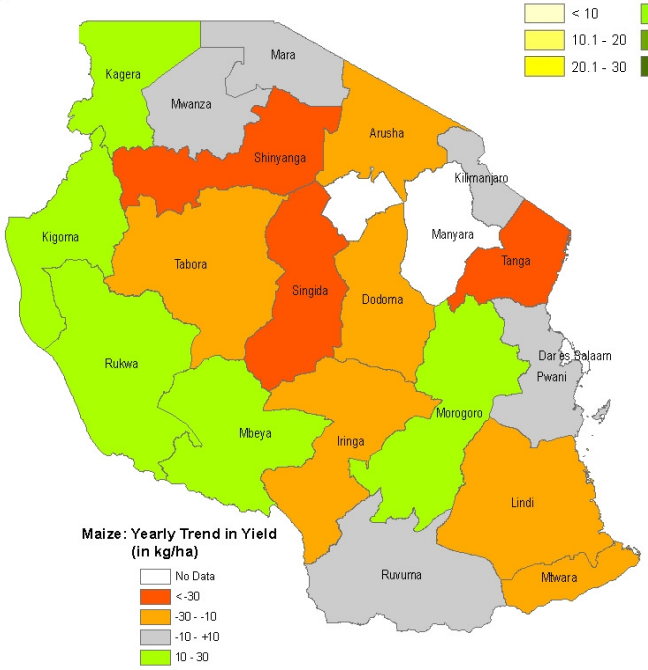
Agricultural Characterization







Tanzania

Crop Prevalence
HH Crop Diversity
Trend in Crop Yield

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Analytical Framework

Anomaly analysis, i.e. comparison of current vs reference scenario

Reference scenario – Long Term Average.

- Identify affected areas and intensity of impact
- Describe their characteristics
- Place in temporal context
- Input/context to market and trade analysis

NDVI (SPOT-VGT) based

- Proxy for household resources (crop and pasture)
- Reasonably long records
- Fine resolution, performance over irrigated areas

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Analysis for the Horn of Africa

A look at the situation post-event. Objective can be described as establishing a drought baseline.

- Identify affected areas and intensity of impact
- Describe their characteristics
- Place in temporal context
- Input/context to market and trade analysis

NDVI (SPOT-VGT) based

- Proxy for household resources (crop and pasture)
- Reasonably long records
- Fine resolution, performance over irrigated areas

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Conclusions

EO data products increasingly visible and used with higher demand fuelled by greater awareness of their potential.

- Long-medium term data series vs new products
- Usage of land cover/livelihood information
- Integration of monitoring outputs with Food Security and Market information

Linkages with local providers of monitoring information

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Analysis for the Horn of Africa

Requirement : spatial extent and magnitude of impacts in a single map

Common problem – derive a single seasonal summary from the growing season NDVI profile

Maximum. Cumulative/integrated NDVI. Others?

Approach : **Seasonal NDVI** - Cumulative NDVI above a dry season threshold (preceding minimum up to 0.2).

Separate calculation for each season and joint:

October-February / March-July / October-July

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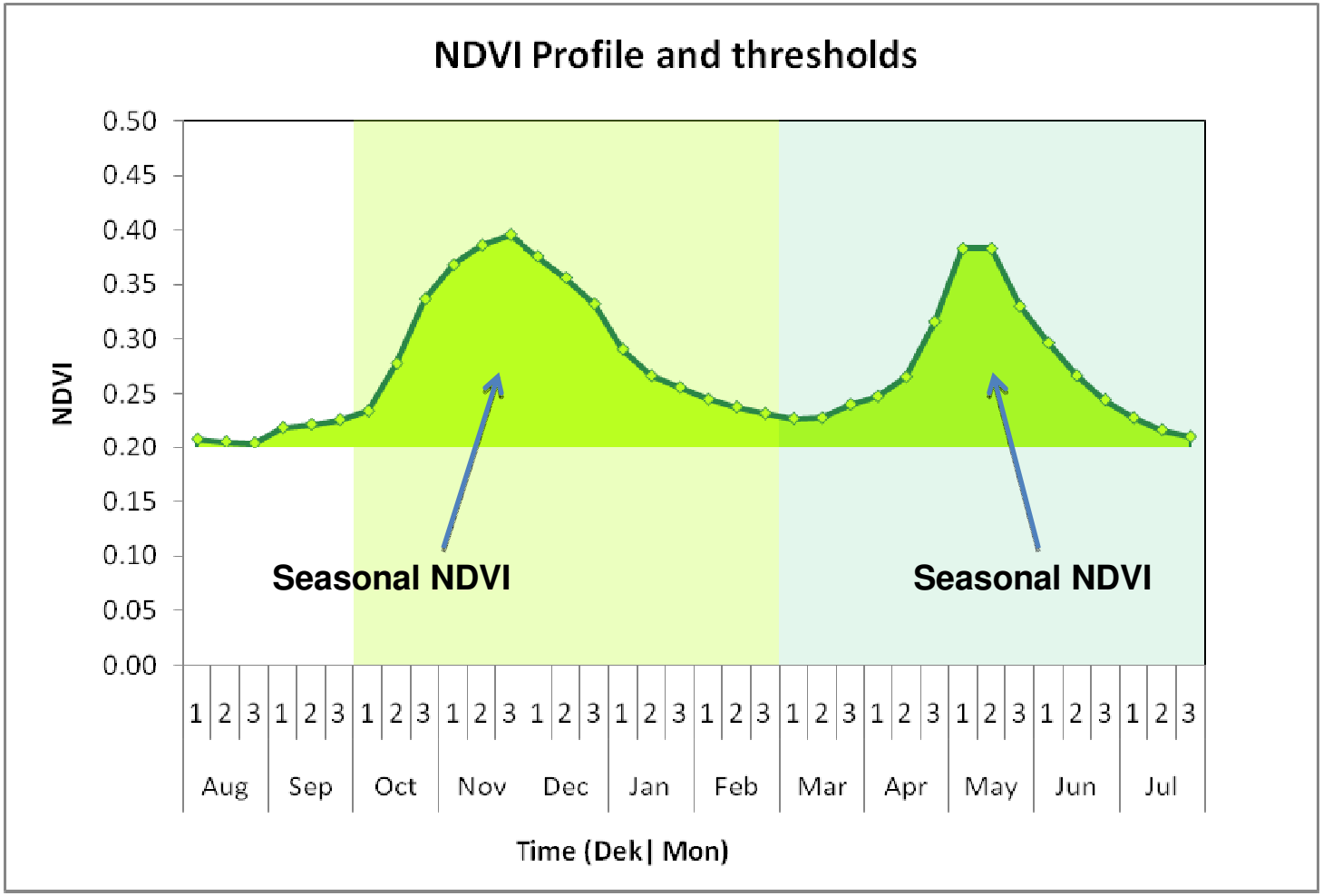

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Analysis for the Horn of Africa

Once seasonal parameter defined, how do you evaluate the 2010-2011 seasons?

NDVI Anomalies: Difference, Ratio

Approach : Standardized Anomaly

$$Z_{NDVI} = \frac{NDVI_i - \overline{NDVI}}{\sigma_{NDVI}}$$

Current season behaviour scaled by past variability (variation from average as number of std deviations).
Same Difference or Ratio may correspond to very different Z values, depending on past variation

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Rationale :

Past variation in NDVI assumed to contain the range of variation in seasonal resources that the household has had to cope with.

•Z btn [-1 to +1]: ***normal*** season to season variation

•Z btn [-1 to -2]: ***moderate*** variation assumed to enclose the limits of the usual coping capacities of agricultural households.

•Z btn [-2 to -3]: ***severe*** variation, stretching coping capacity beyond what many households could achieve. Significant impacts.

•Z < -3: ***extreme*** variation, well outside the coping capacity if not the experience / living memory of households. Extreme impacts, once in a generation events (?)

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Analysis for the Horn of Africa

Results:

•The impacts were very strong (extremely strong in places), were spatially very widespread and extended over two consecutive growing seasons which is in itself quite unusual.

•The area most affected both in terms of spatial extent and magnitude of the event was by far Southern Somalia, where both seasons registered extremely poor performance.

•Other impacted areas were central and north-eastern Kenya and areas of Southern Ethiopia but to a lesser degree, as impacts during the late 2010 growing season were much less marked than for Southern Somalia.

•All livelihood zones in Somalia were affected given the extent of the drought impact. In some areas, in particular agricultural areas of the Shabelle, Bay and Juba regions, the values of the standardized anomaly reached below -5 – the simplest way to translate this is that in these regions there would have been no one old enough to remember an event of such magnitude.

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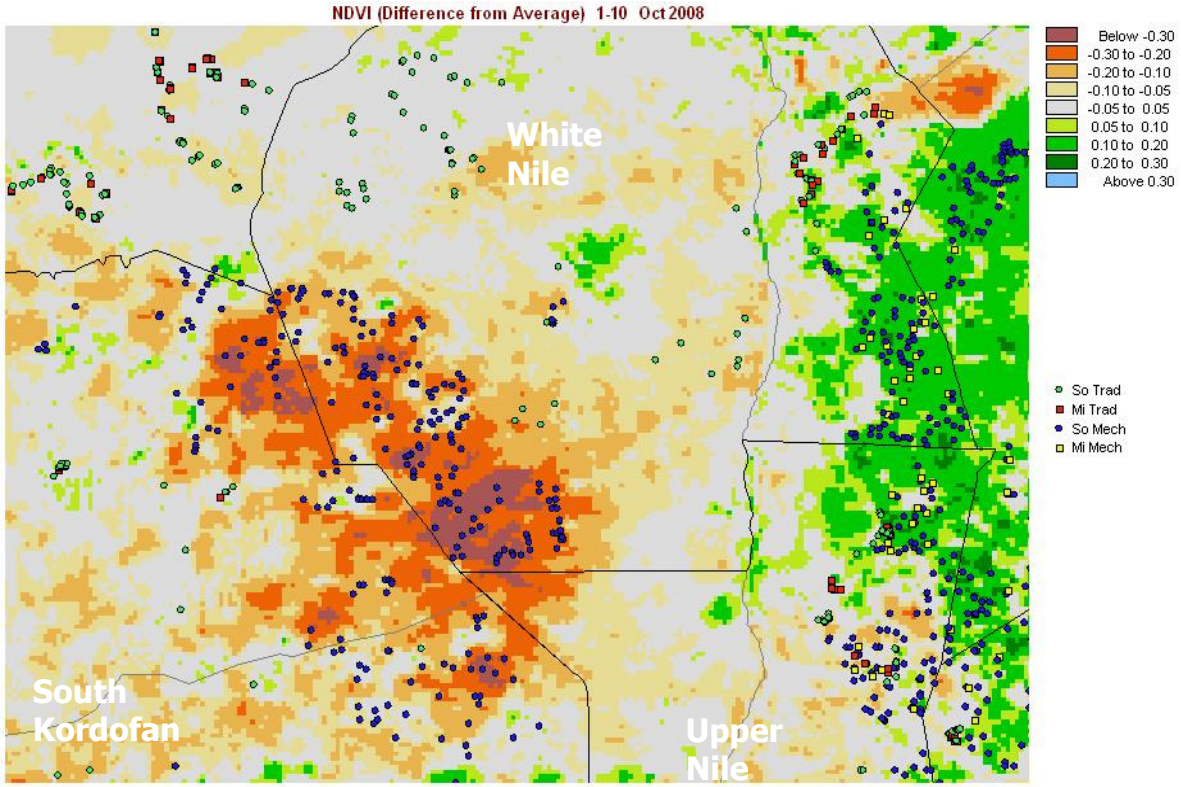
Central Sudan NDVI anomaly, semi-mechanized areas



Central Sudan NDVI anomaly – land cover information defines this as a semi-mechanized agriculture region.

Impact of crop failure on the rural subsistence households of the region is not through impacts on their own production but through the loss of labour income.

Magnitude of impact is evaluated against household income profile

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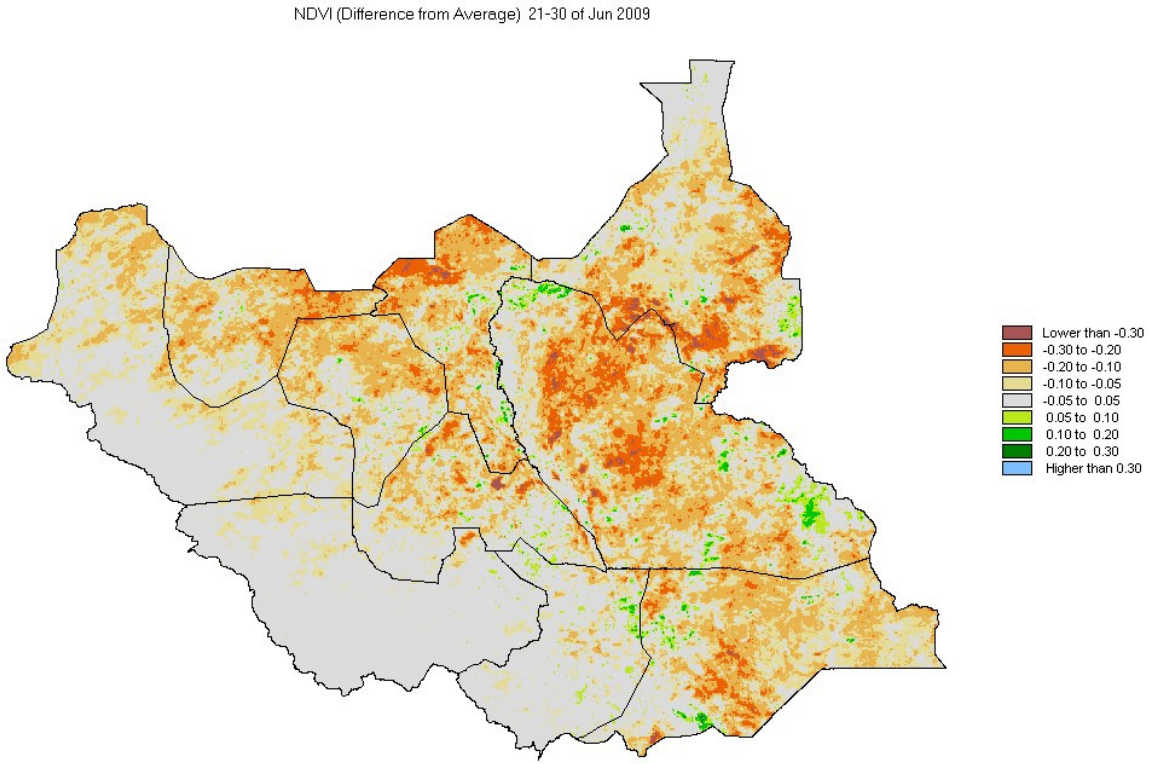
South Sudan early season RFE/NDVI anomaly



How is this translated into information of value for WFP? Know-how of farming systems and crop calendars :

Short maturing sorghum is planted early so as to yield the first grain harvest of the season.

The NDVI anomaly translates into a “hunger gap” longer by 4 to 6 weeks.

Impact of this has to be judged against status of household stocks, itself mostly a function of previous season’s production

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Application of Remote Sensing Data

- Monitoring and assessment of agricultural season performance in priority areas/countries [early warning, impact assessment]
- Analysis of past events – frequency, magnitude and spatial distribution.
- COs frequently initiate a request (cf. Niger, Yemen). Mostly analysis carried out at HQ.
- Frequently rely on good relationships with in-country partners (FEWS-Net) and inter-institutional FS fora.
- WFP-VAM and ODEP (Emergency Preparedness) coordination

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Usage of Remote Sensing Data at WFP

Food Security :

- Availability
- Access
- Utilization
- Stability

Relevance of Remote Sensing :

- Availability dimension

Some initial steps on commodity price analysis

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