Monitoreo de la Sequía Agrícola a nivel Mundial desde el Espacio

utilizando
el Sistema de Índice de Estrés Agrícola de FAO (ASIS)

Desarrollado por:

En colaboración con:

http://www.fao.org/climatechange/asis/en/

Objetivo

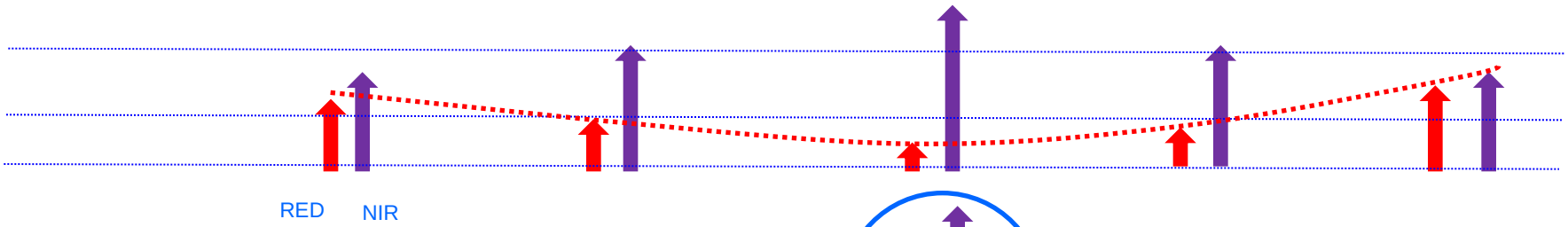
Limitación cuando se utilizan datos de estaciones meterológicas:

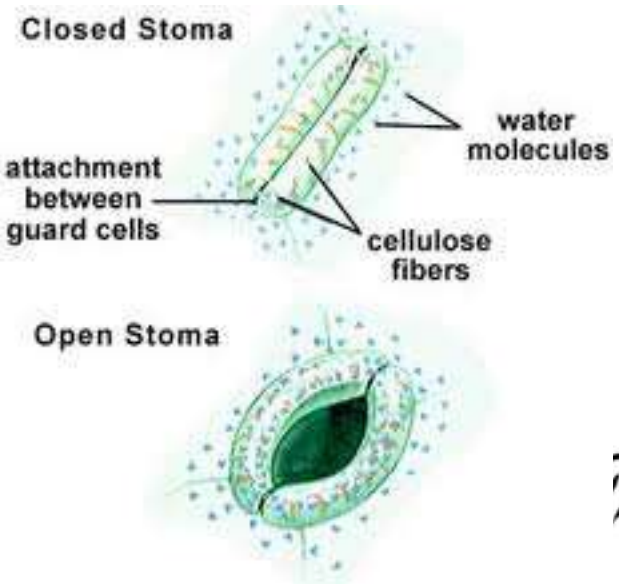
- Actualmente las estaciones meteorológicas son dispersas y proveen datos discontinuos
- Estimaciones de lluvia por satélite presentan errores y deben ser calibradas en cada país para ser utilizadas en forma operativa

Objetivo

- Desarrollar un sistema de monitoreo de sequía con base en observaciónes de satélite para simular el análisis que un experto en teledección haría y simplificar los resultados en mapas para los usuarios finales.

Energía Electromagnética registrada por el Sensor

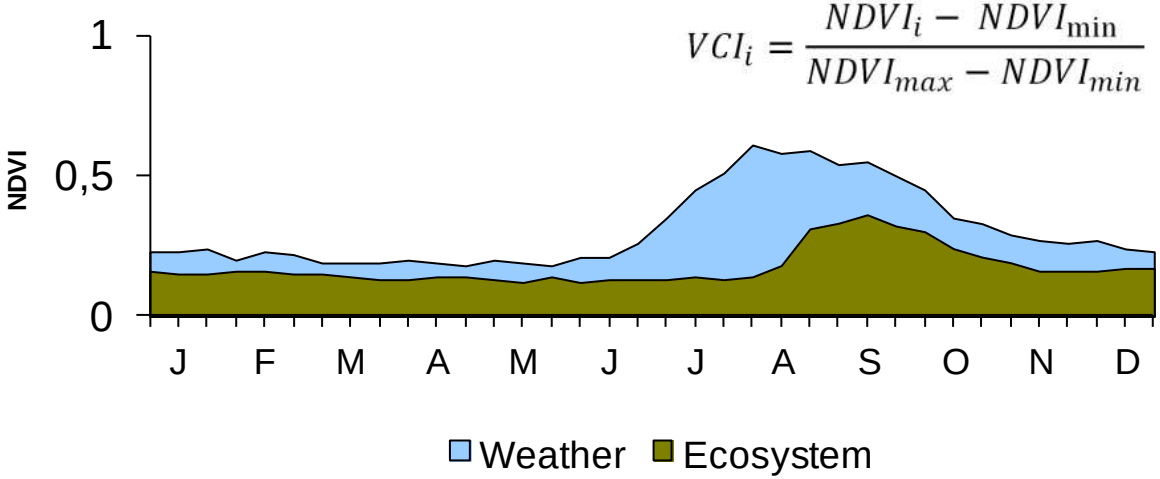




Emer-gence		Tassel	Silk		
Establishment (0)	Vegetative (1)	Flowering (2)		Yield Formation (3)	Ripening (4)
15-25 days	25-40 days	15-20 days		35-45 days	10-15 Days

Hodh El Gharbi, Mauritania

$$VCI_i = \frac{NDVI_i - NDVI_{\min}}{NDVI_{max} - NDVI_{min}}$$



***Source*:** Kogan, F. 1995. Droughts of the late 1980s in the United States as derived from NOAA polar-orbiting satellite data. Bulletin of the American Meteorological Society vol.76, No. 5 655-668 pp.

El Sistema del índice de stress agrícola basado en el Índice de Sanidad Vegetal (VHI) (Kogan et al. 1995)

Vegetation condition index (VCI)

$$VCI_i = \frac{NDVI_i - NDVI_{\min}}{NDVI_{max} - NDVI_{min}}$$

Temperature condition index (TCI)

$$TCI_i = \frac{BT_{max} - BT_{\mathrm{i}}}{BT_{max} - BT_{min}}$$

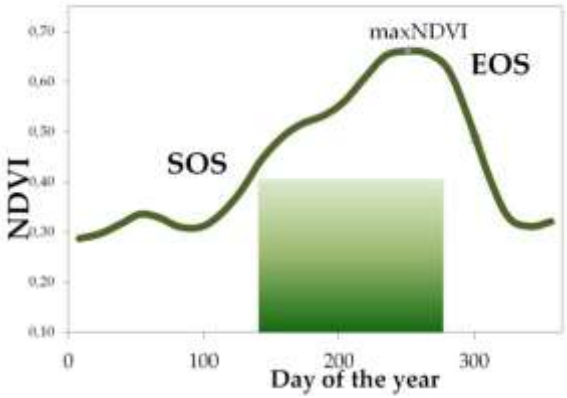
Vegetation Health Index (VHI)

VHI = a*VCI + (1-a)* TCI

low VHI

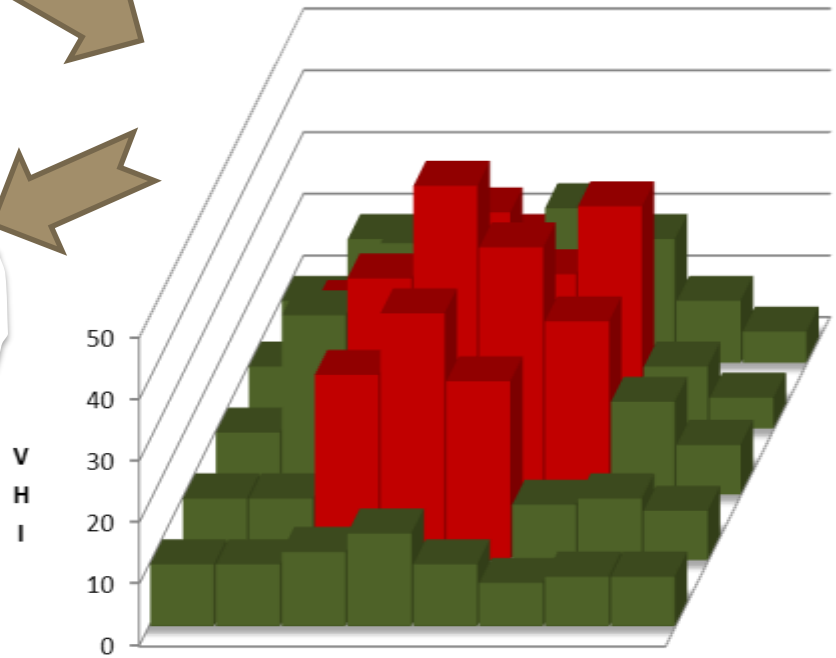
high VHI

ASIS evalúa la severidad (intensidad, duración y alcance espacial) de la sequía agrícola



% de área agrícola afectada por sequía (VHI <35)

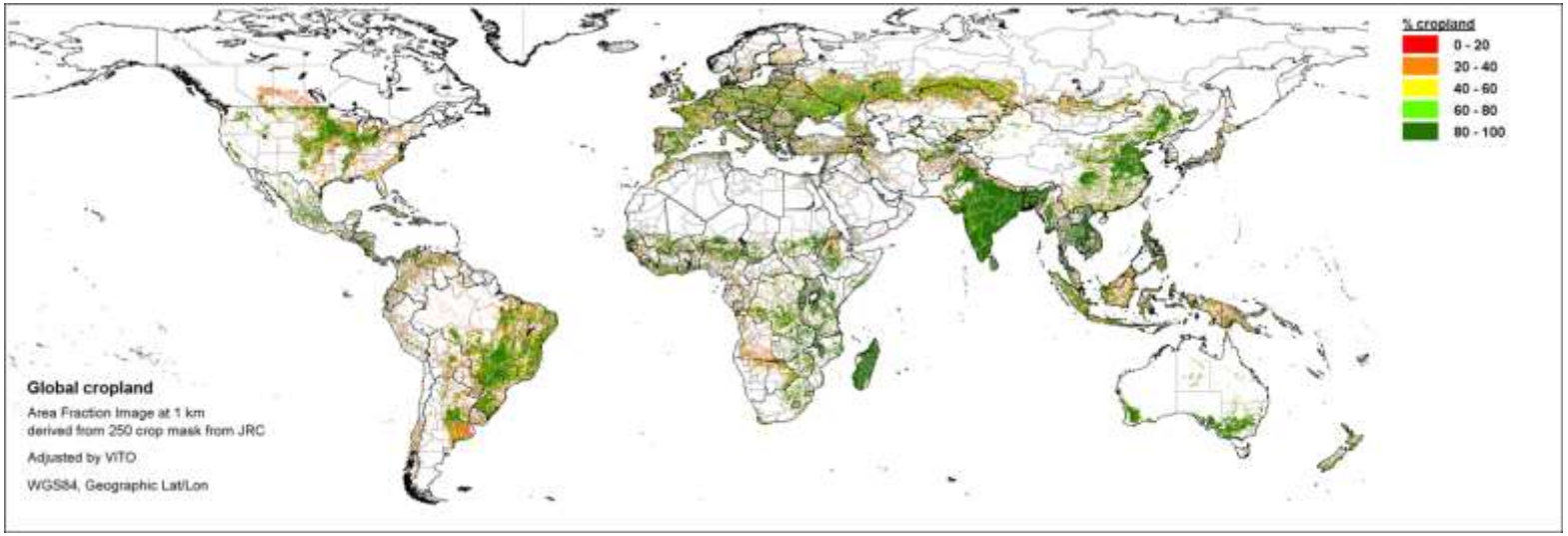
- 0 - 10
- 11 - 29
- 30 - 49
- 50 - 65
- 66 - 75
- 76 - 85
- 86 - 100

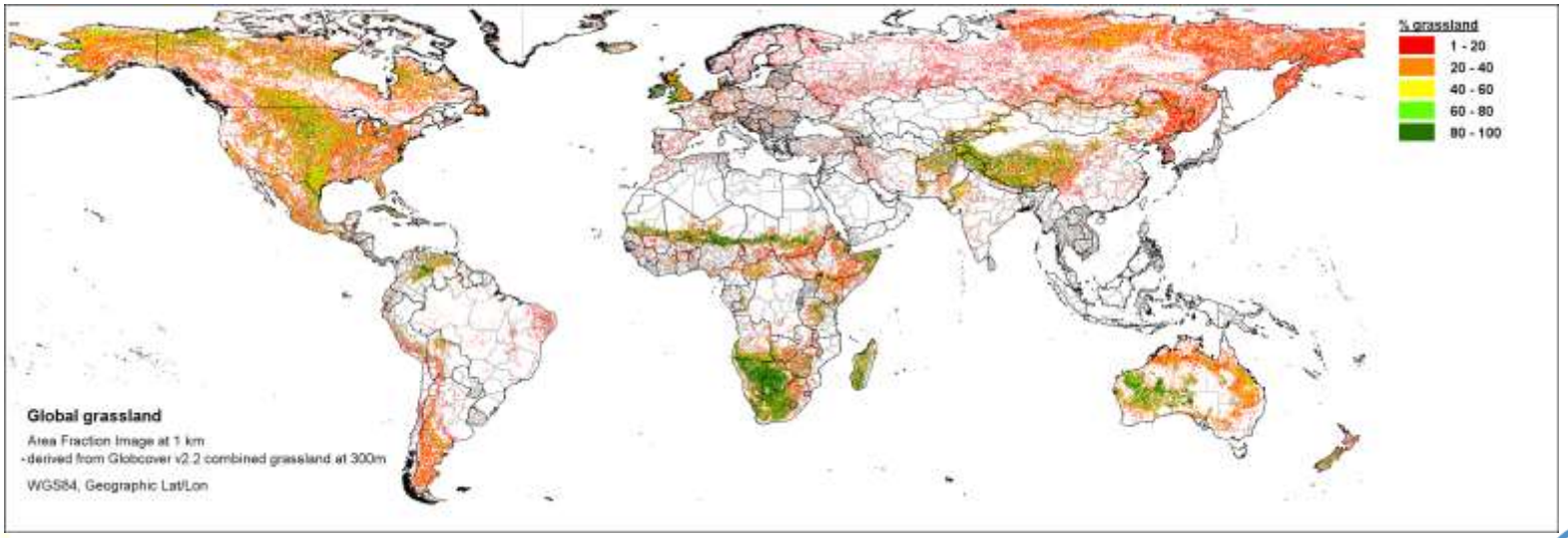


VHI temporal

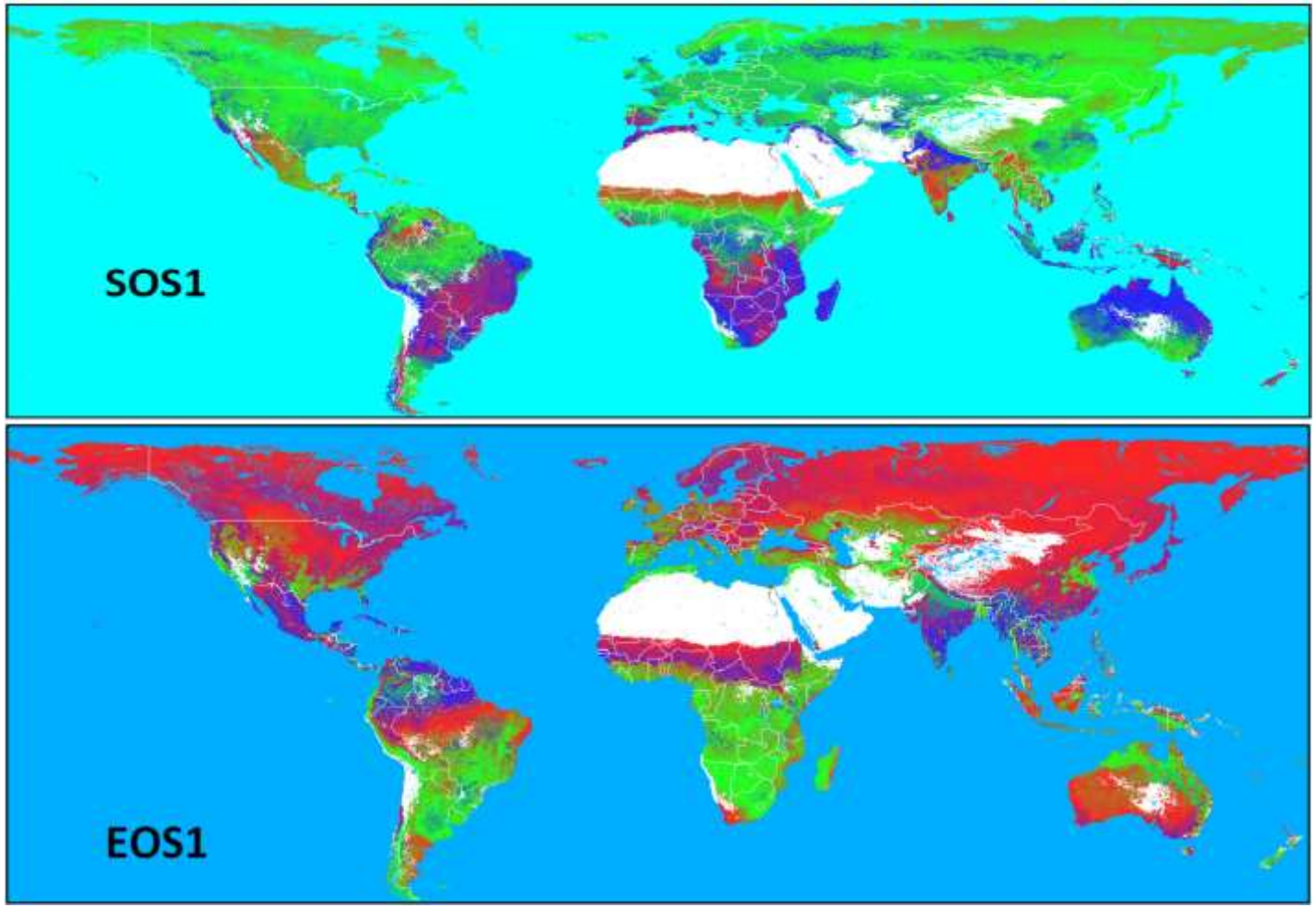
- 0- 10
- 10-20
- 20-25
- 25-35
- >35

Mapa Global del Uso de la Tierra

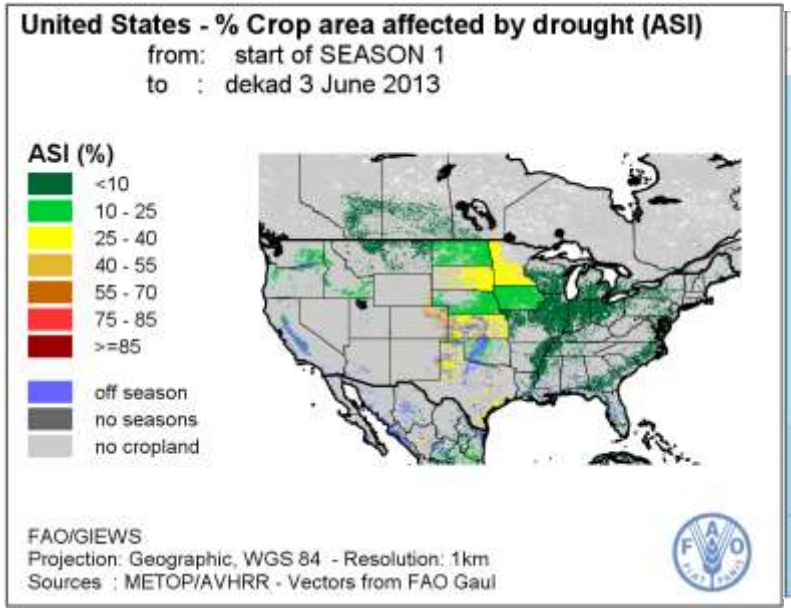


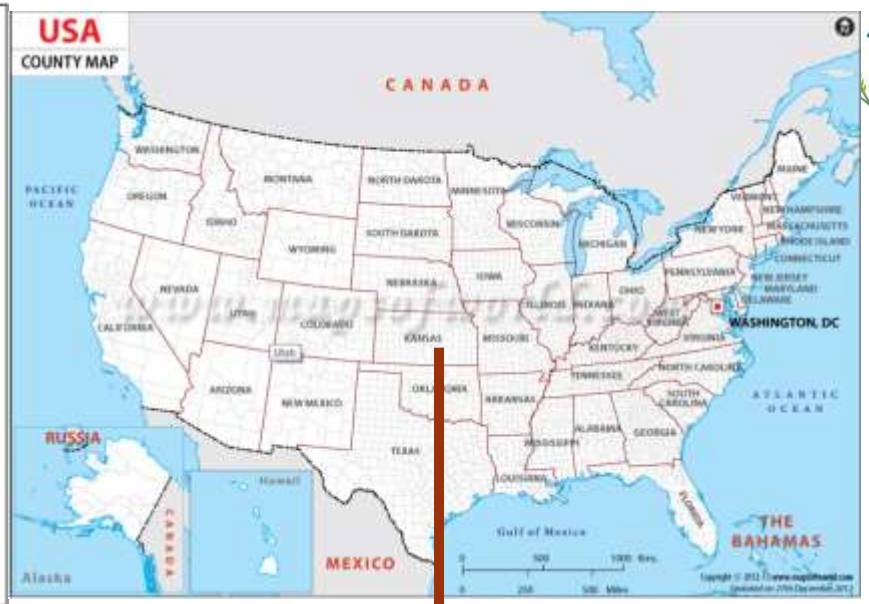


Agregación Temporal- definiendo SOS (start of growing season) & EOS (end of growing season)

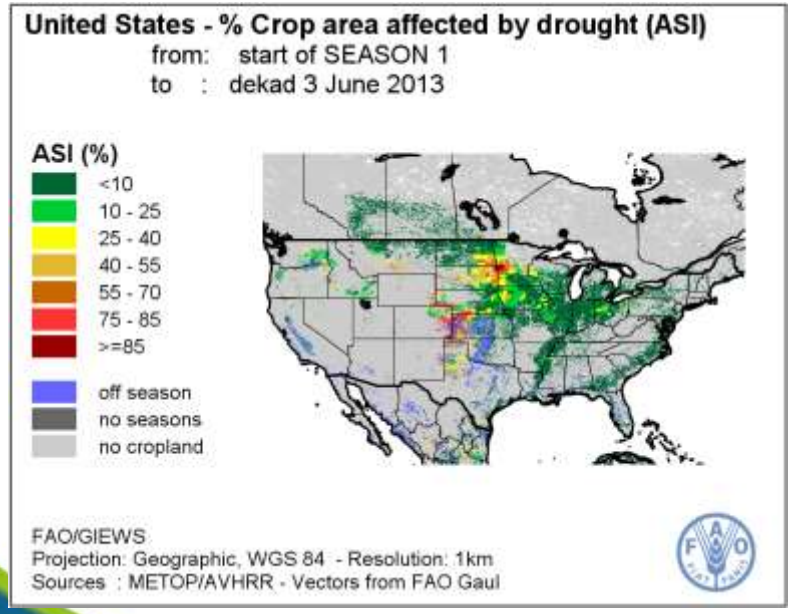


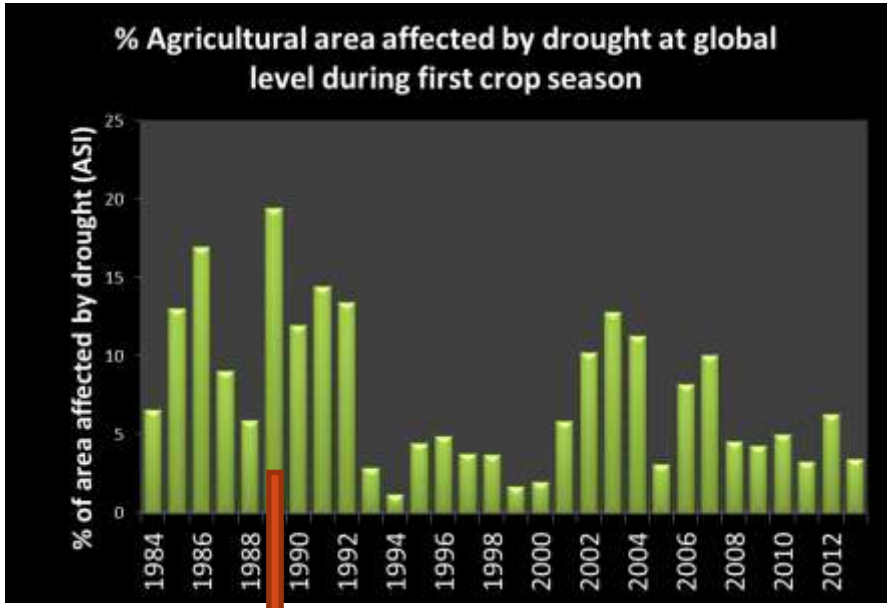
SOS and EOS of the first season, as derived from the long term NDVI averages of SPOT-VGT (roi GLD, 21 km resolution).

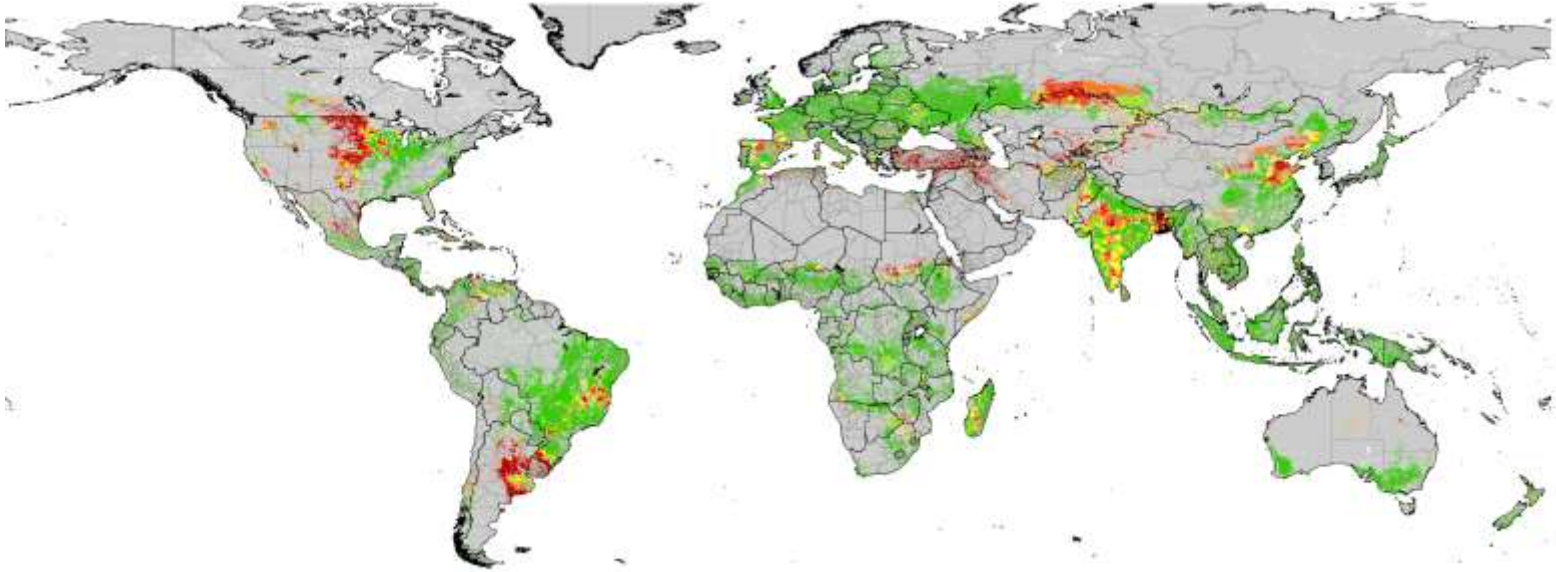




http://www.fao.org/eo/asis/index.jsp




% Agricultural area affected by drought at global level during first crop season
% of area affected by drought (ASI)
25
20
15
10
5
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012

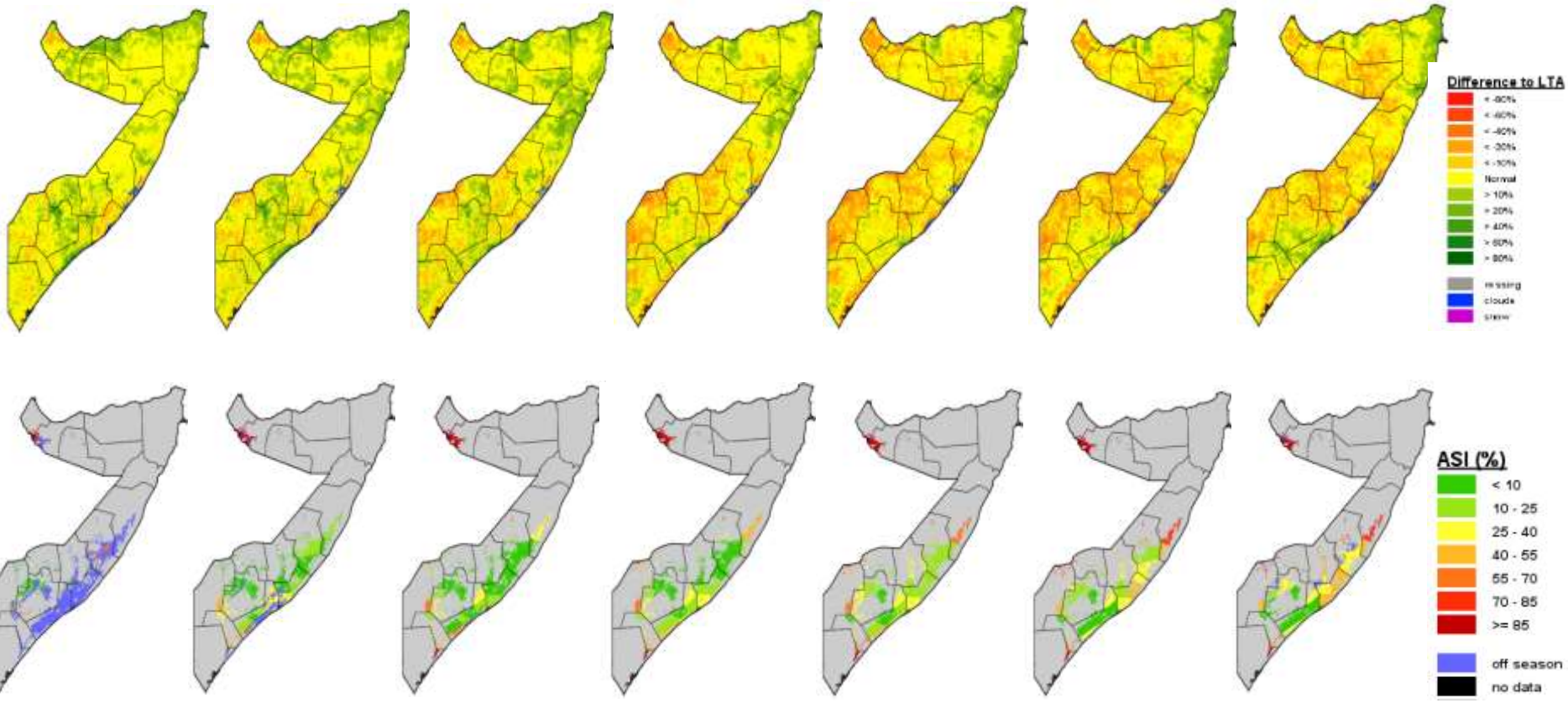


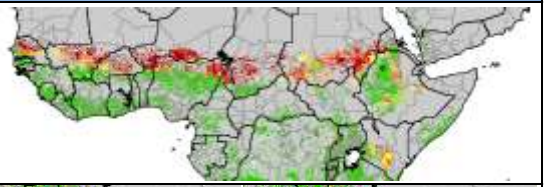
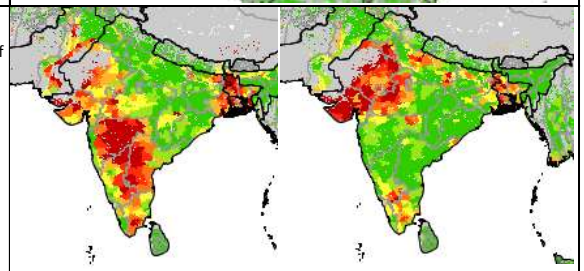
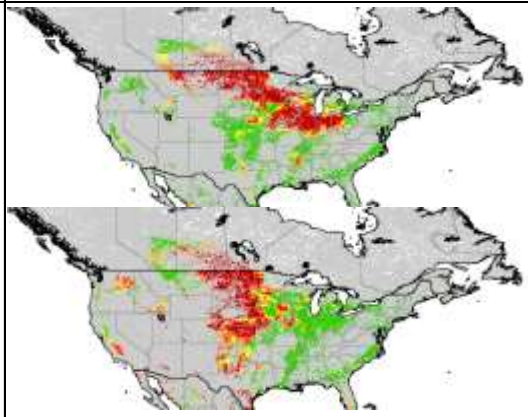
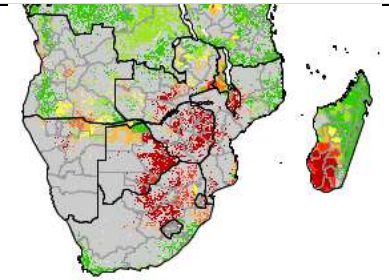
1989

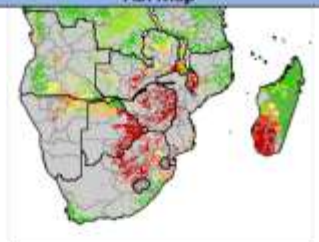
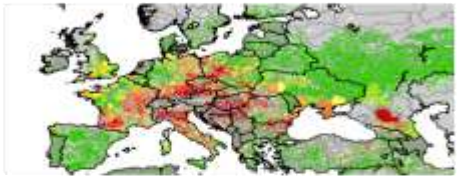
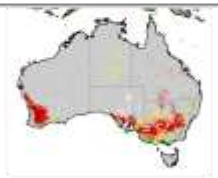
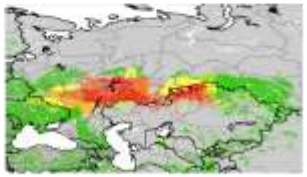
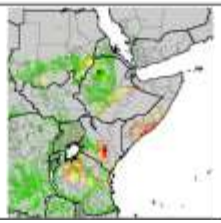
Somalia 2009

1st dekad April

1st dekad June

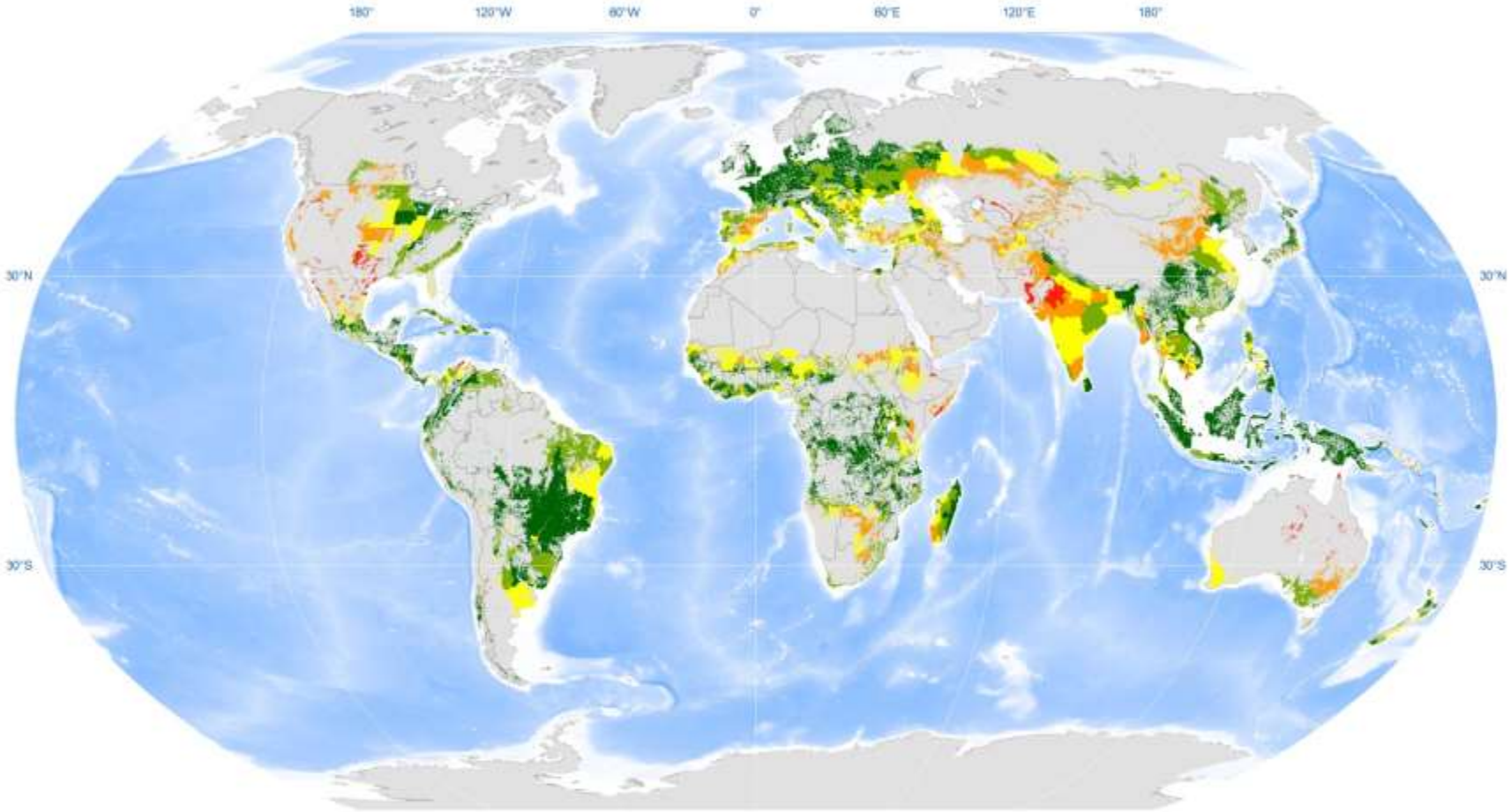


Year(s)	Country/region	Impact	ASI Map
1984	Sahel	During the crisis, an astounding 20 nations of Africa were under severe drought. Entire rivers and lakes completely dried up. Up to 20,000 people starved to death each month. Although the total number of people who perished is not completely known, it is estimated that over 1 million people died as a direct result of the drought. The worst drought in the Sahel during the early-mid 1980's occurred the year 1984 affecting most Sahel countries (Nicholson, 1985)	
1986 1987	India	In 1986 and 1987, India experienced severe drought (Nathan, 1994). During September and October 1986, the entire state of Haryana was hit by a drought. Crops like bajra, sugarcane, paddy, and pulses, worth a total of Rs. 100 crores, were damaged. In 1987, the drought situation was at its worst from June to August. Paddy sowing was done in only 40% of the area of Haryana. The 1987 drought affected 6,351 villages with a total population of more than 9 million, more than 1.4 million ha cropped area, and more than 5 million cattle. For drinking water alone, Rs. 3.70 crores assistance was given by the Indian government (Misra, 2003).	
1988 1989	United States	In the United States a severe droughts occurred during 1988 and 1989 (U.S. General Accounting Office, 1989). Following a milder drought in the Southeastern United States and California the year before, the 1988 drought spread from the Mid-Atlantic, Southeast, Midwest, Northern Great Plains and Western United States (U.S. Congress, 1988). This drought was widespread, unusually intense and accompanied by heat waves which killed around 4800 to 17000 people across the United States and also killed livestock across the United States. One particular reason that the Drought of 1988 became very damaging was farmers might have farmed on land which was marginally arable. Another reason was pumping groundwater near the depletion mark. The Drought of 1988 destroyed crops almost nationwide, residents' lawns went brown and water restrictions were declared many cities. This drought was very catastrophic for multiple reasons; it continued across the Upper Midwest States and North Plains States during 1989, not officially ending until 1990. The both droughts also affected Canada in certain divisions.	
1992	Southern Africa	The 1992 Southern African drought was the region's worst drought in living memory. Many wells and some perennial rivers dried. Well over a million cattle died: 1.03 million in Zimbabwe alone, more than 23% of the national herd (Tobaiwa, 1993). The drought affected around 86 million people in the 10 countries which then comprised SADC, of whom around 20 million people were estimated to be at 'serious risk' (SADC, 1993). Aggregate cereal production in the nine sverely affected countries (including South Africa) was 38% of the previous five-year mean, and only 22% in Zimbabwe, often an exporting country. Cereal imports into the 10 SADC countries and South Africa more than tripled during 1992/3, from 3.3 to 10.5 million tonnes (Clay, 1995).	

Year(s)	Country/region	Impact	ASI Map
1992	Southern Africa	The 1992 Southern African drought was the region's worst drought in living memory. Many wells and some perennial rivers dried. Well over a million cattle died: 1.03 million in Zimbabwe alone, more than 23% of the national herd (Tobaiwa, 1993). The drought affected around 86 million people in the 10 countries which then comprised SADC, of whom around 20 million people were estimated to be at 'serious risk' (SADC, 1993). Aggregate cereal production in the nine severely affected countries (including South Africa) was 38% of the previous five-year mean, and only 22% in Zimbabwe, often an exporting country. Cereal imports into the 10 SADC countries and South Africa more than tripled during 1992/3, from 3.3 to 10.5 million tonnes (Clay, 1995).	
2003	Europe	Europe experienced a particularly extreme climate event during the summer of 2003, with temperatures up to 6°C above long-term means, and precipitation deficits up to 300 mm (Trenberth et al., 2007). A record drop in crop yield of 36% occurred in Italy for maize grown in the Po valley, where extremely high temperatures prevailed (Ciais et al., 2005). In France, compared to 2002, the maize grain crop was reduced by 30% and fruit harvests declined by 25%. Winter crops (wheat) had nearly achieved maturity by the time of the heatwave and therefore suffered less yield reduction (21% decline in France) than summer crops (e.g., maize, fruit trees and vines) undergoing maximum foliar development (Ciais et al., 2005). Forage production was reduced on average by 30% in France and hay and silage stocks for winter were partly used during the summer (COPA COGECA, 2003b). Wine production in Europe was the lowest in 10 years (COPA COGECA, 2003a). The (uninsured) economic losses for the agriculture sector in the European Union were estimated at ≈13 billion, with largest losses in France (≈4 billion) (Sénat, 2004).	
2006	Australia	2006 was an exceptionally dry year in many parts of the south-eastern quarter of Australia, extending north to southern Queensland, as well as in the south-est of Western Australia. The affected areas included the bulk of Australia's population, and most of its cropping areas. The annual rainfall in 2006 was 40-60% below normal over most of the country south of the Tropic of Capricorn and eastwards from central South Australia (Australian Bureau of Statistics, 2008) http://www.abs.gov.au/ausstats/abs@.nsf/0/CCC8EAD27928C3C7CA2573D200106BDE?opendocument	
2010	Russia	Russia's worst drought in at least 50 years, drove wheat prices to the biggest jump since 1973. This is the first time in 50 years that the Hydrometeorological Center of Russia register the combination of such a long period of abnormal heat and both atmospheric and soil drought. Russia's Grain Union has said the drought is the worst since record-keeping started 130 years ago. http://www.bloomberg.com/news/articles/2010-08-03/worst-russian-drought-in-50-years-threatens-more-crops-grain-sowing-plans#news/articles/2010-08-03/worst-russian-drought-in-50-years-threatens-more-crops-grain-sowing-plans	
2011	Horn of Africa	Between July 2011 and mid-2012, a severe drought affected the entire East Africa region (OCHA, 2011). Said to be "the worst in 60 years", the drought caused a severe food crisis across Somalia, Djibouti, Ethiopia and Kenya that threatened the livelihood of 9.5 million people (Wooldridge, 2011). Many refugees from southern Somalia fled to neighboring Kenya and Ethiopia, where crowded, unsanitary conditions together with severe malnutrition led to a large number of deaths. Other countries in East Africa, including Sudan, South Sudan and parts of Uganda, were also affected by a food crisis (Wooldridge, 2011; Gordts, 2011; FEWSNET, 2011).	

Agriculture Stress Index Frequency

with > 10 % of cropping areas affected by drought



Agricultural Drought Frequency Index (%)

0 100

SOURCE:
El Niño data http://ggweather.com/enso/oni.htm
ASIS data http://www.fao.org/giews/earthobservation
GAUL www.fao.org/geonetwork

Analysis and Mapping:
Oscar Rojas (NRC), Yanyun Li (EST), Renato Cumani (NRL)

FAO, Rome, Italy, September 2014

GIEWS Earth Observation Website

Thanks

http://www.fao.org/giews/earthobservation/

Standalone ASIS development

funded by:

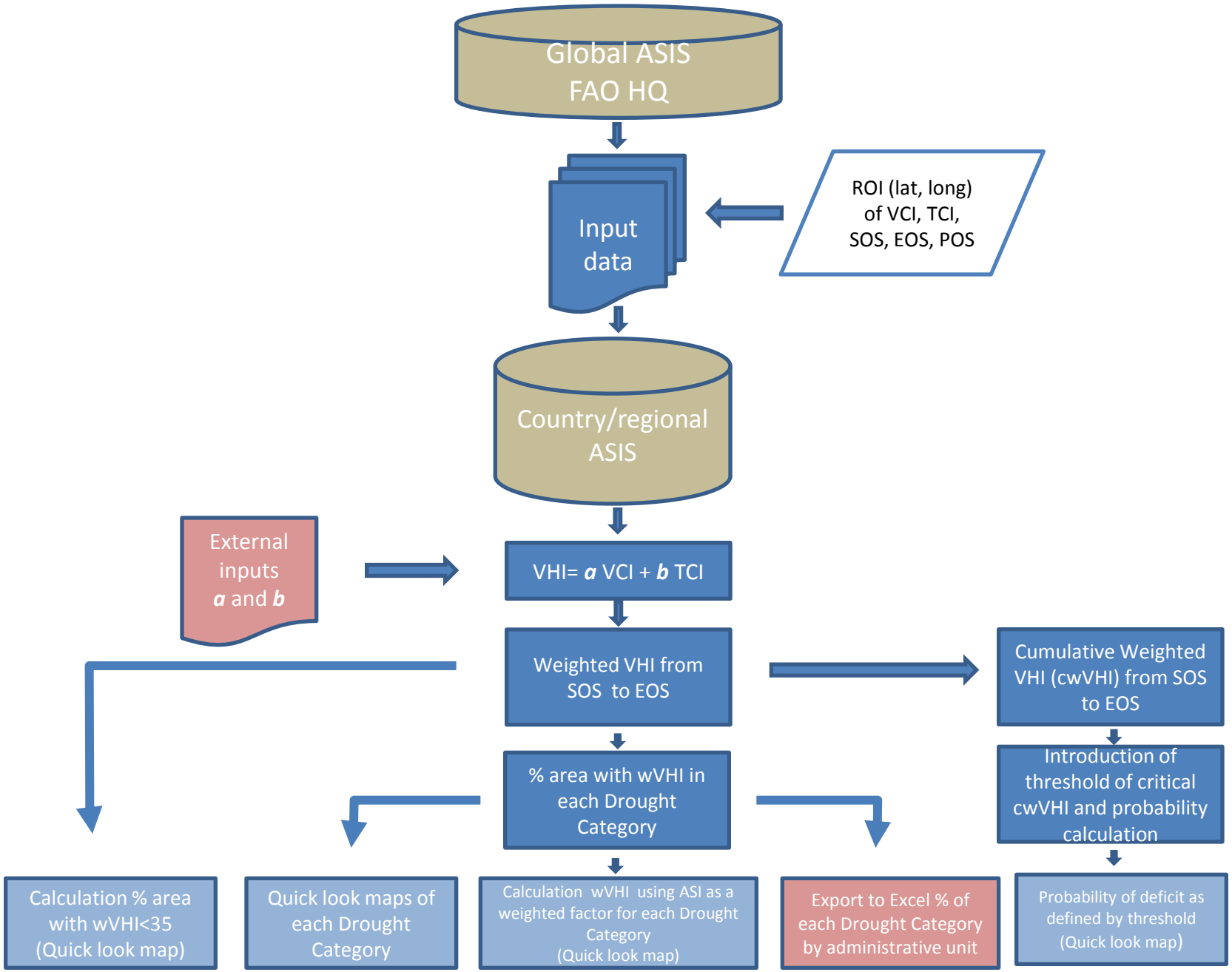
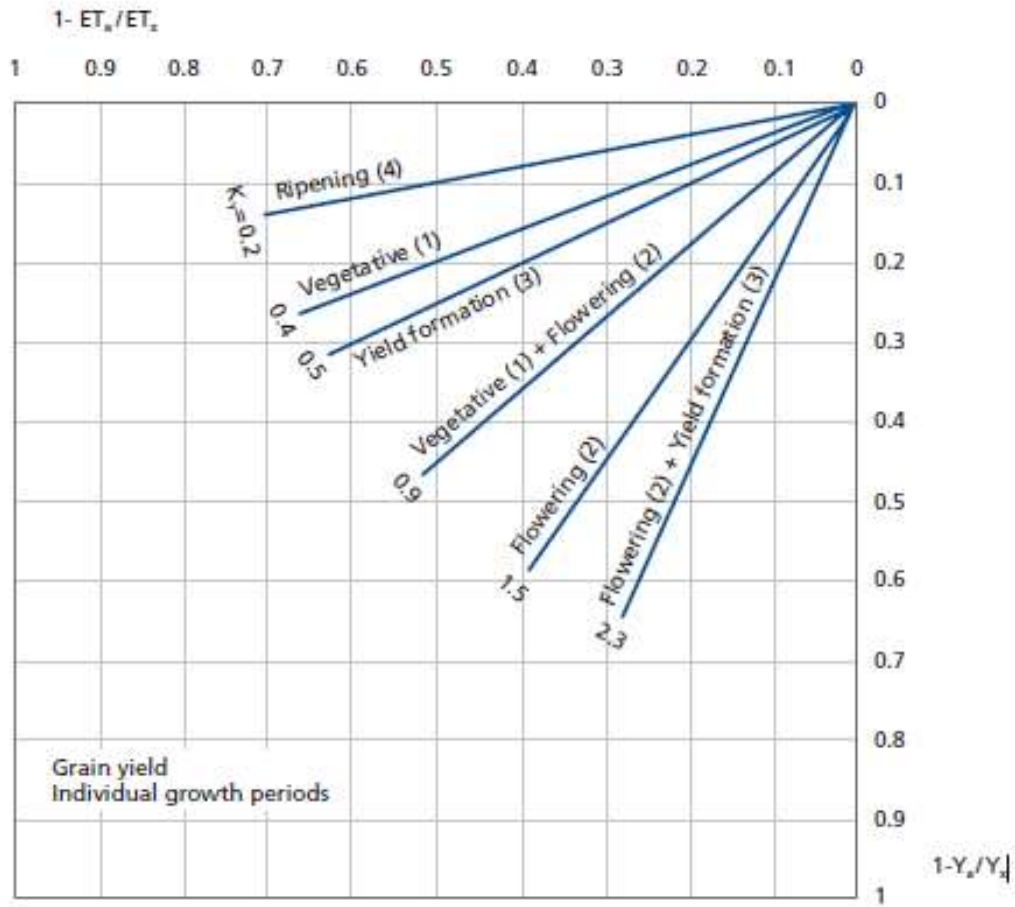
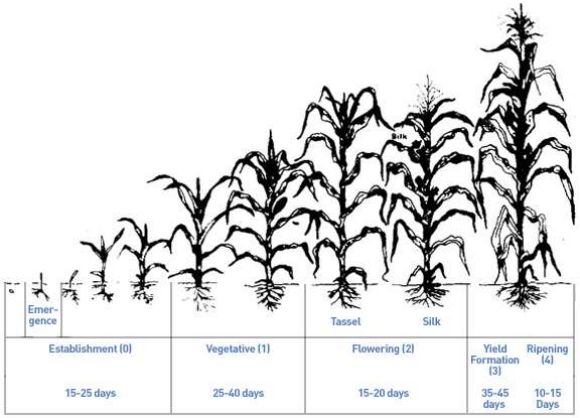
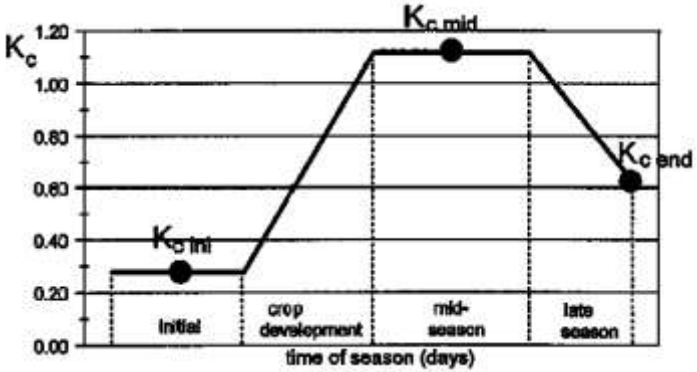

Global ASIS
FAO HQ
Input data
ROI (lat, long) of VCI, TCI, SOS, EOS, POS
Country/regional ASIS
External inputs *a* and *b*
VHI= *a* VCI + *b* TCI
Weighted VHI from SOS to EOS
Cumulative Weighted VHI (cwVHI) from SOS to EOS
% area with wVHI in each Drought Category
Introduction of threshold of critical cwVHI and probability calculation
Calculation % area with wVHI<35 (Quick look map)
Quick look maps of each Drought Category
Calculation wVHI using ASI as a weighted factor for each Drought Category (Quick look map)
Export to Excel % of each Drought Category by administrative unit
Probability of deficit as defined by threshold (Quick look map)

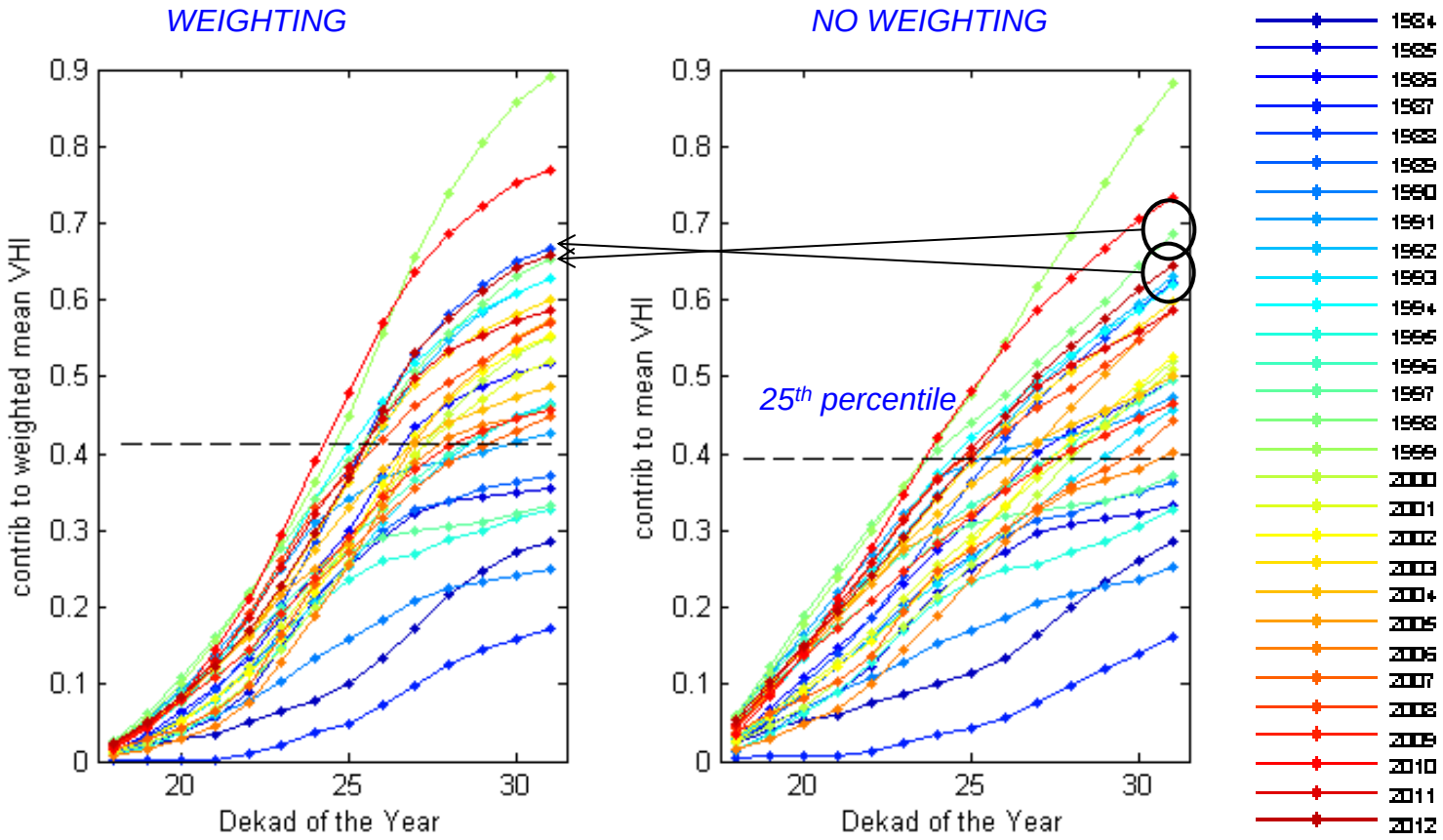
FIGURE 1 Linear water production functions for maize subjected to water deficits occurring during the vegetative, flowering, yield formation and ripening periods. The steeper the slope (i.e. the higher the K_y value), the greater the reduction of yield for a given reduction in ET because of water deficits in the specific period.



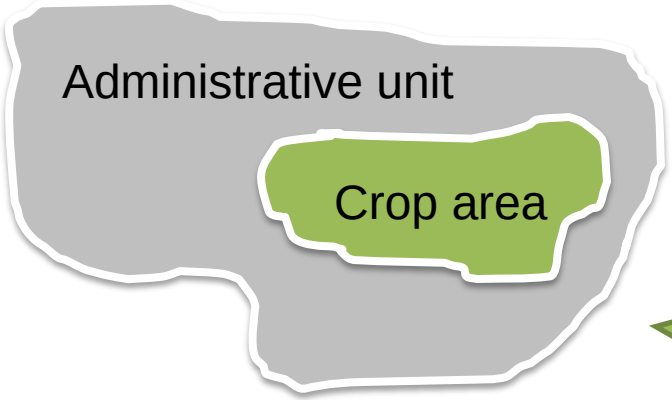


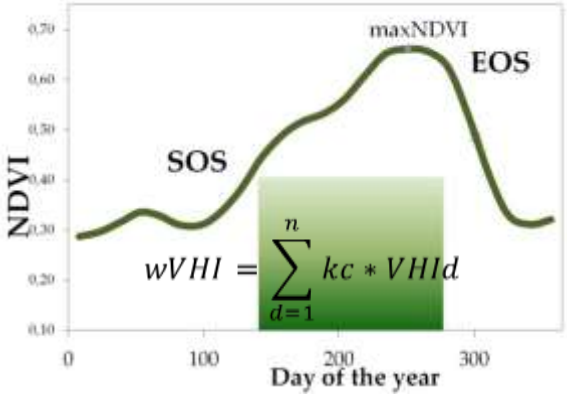


Efecto de Ponderación, de cVHI a wcVHI
(Pix 2, Niger)



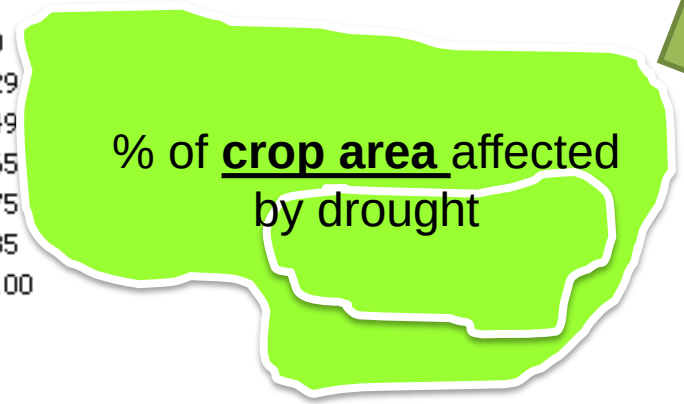
ASIS evalúa la severidad (intensidad, duración y alcance espacial) de la sequía agrícola

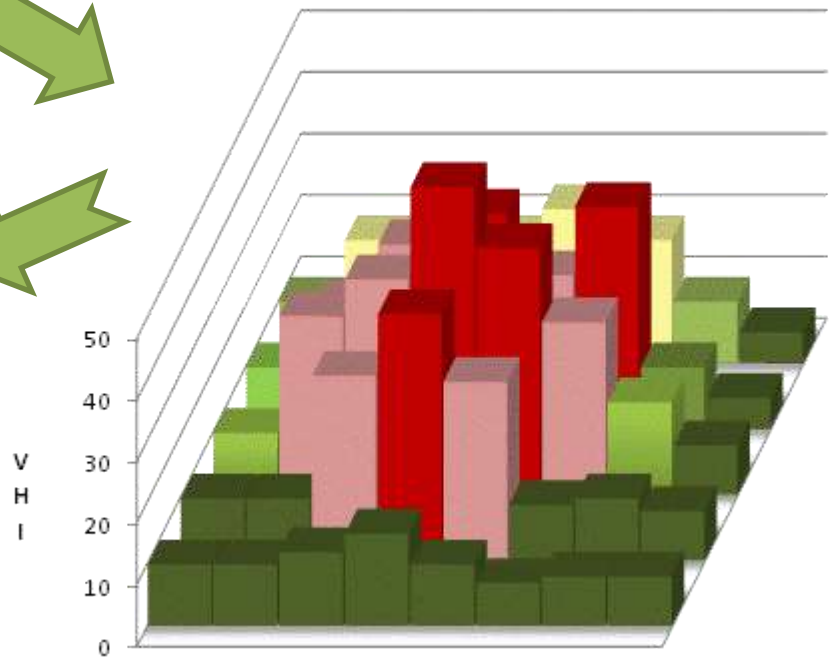




Percentage of the agriculture areas with VHI below 35

- 0 - 10
- 11 - 29
- 30 - 49
- 50 - 65
- 66 - 75
- 76 - 85
- 86 - 100

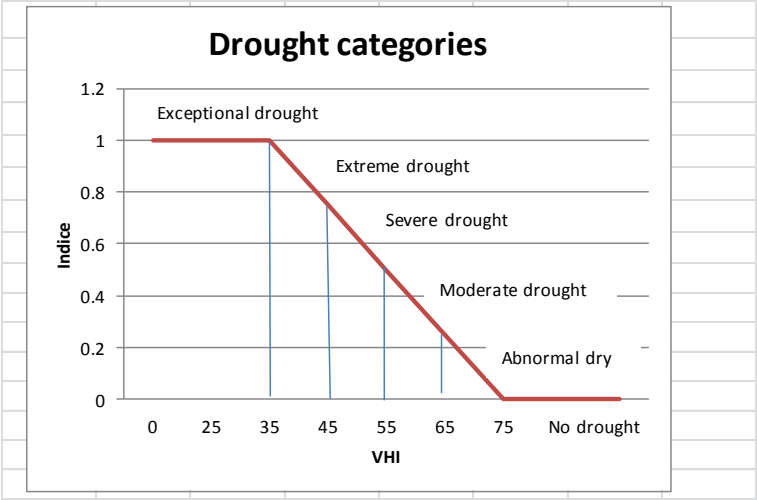




VHI temporal average value

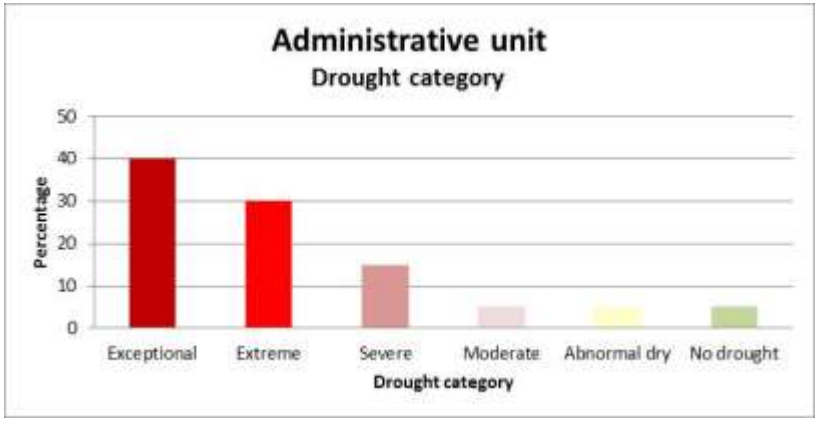
- 0- 10
- 10-20
- 20-25
- 25-35
- >35

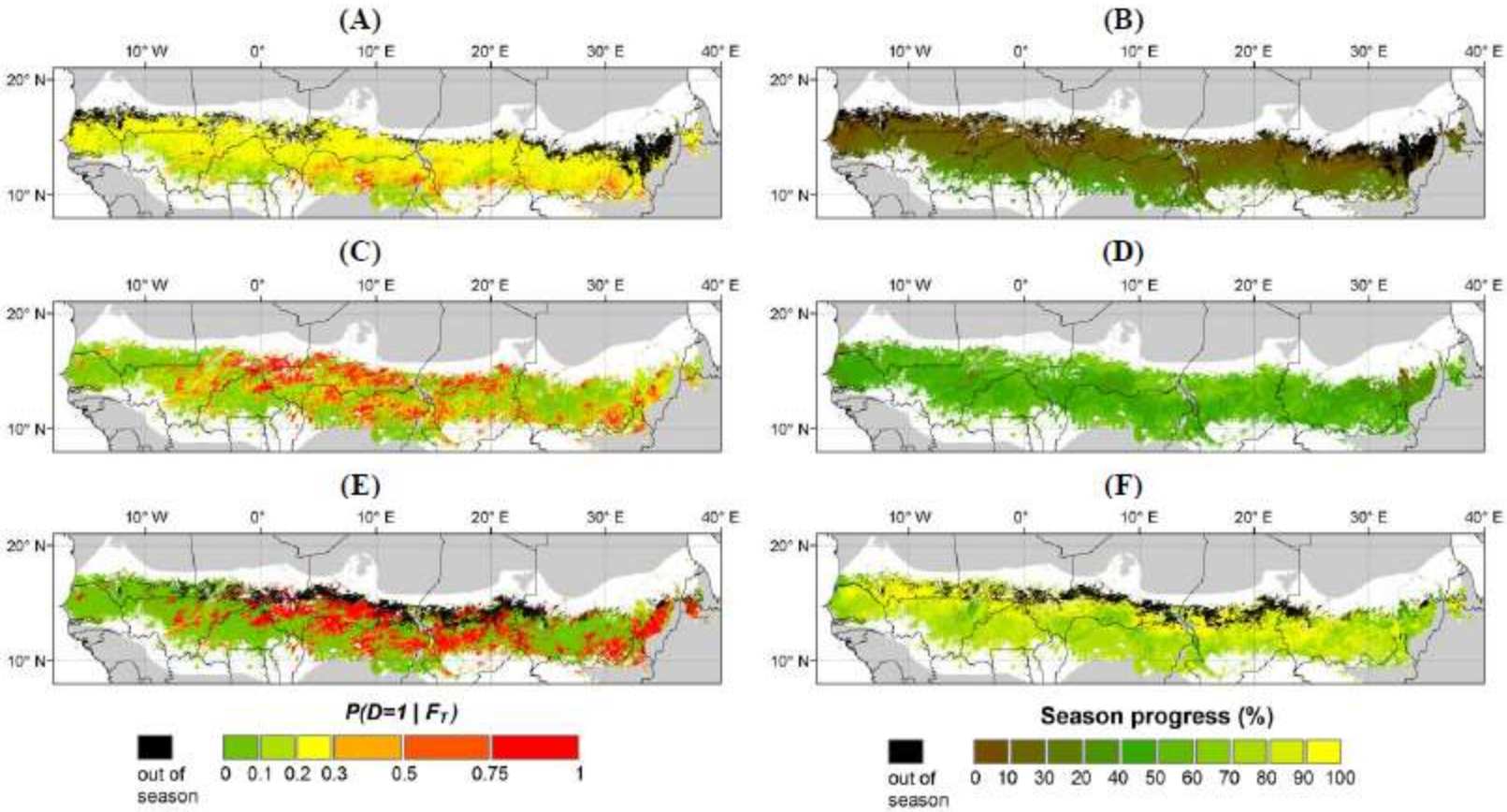
Categorías de Sequía



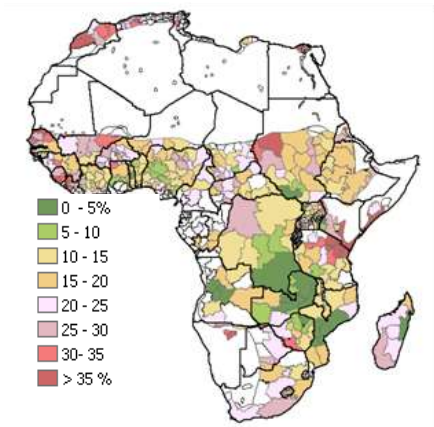
Indicator	Drought category	VHI pixel	ASI*
1	Exceptional Drought	<35	%
0.75-0.99	Extreme Drought	36-45	%
0.50-0.74	Severe Drought	46-55	%
0.25-0.49	Moderate Drought	56-65	%
0.01-0.24	Abnormal dry	66-75	%
0	No Drought	>75	%

* Percentage of pixels in each drought categoy

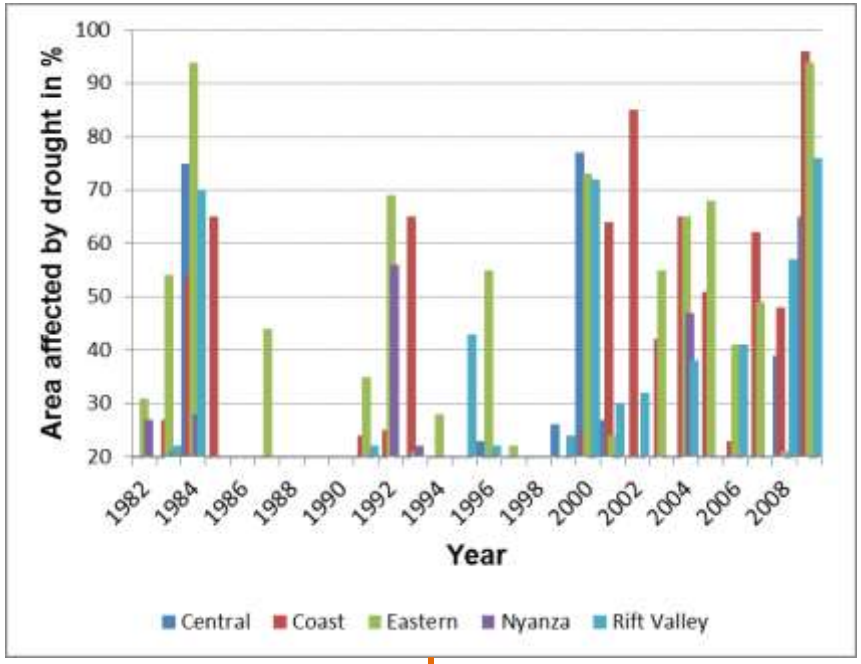


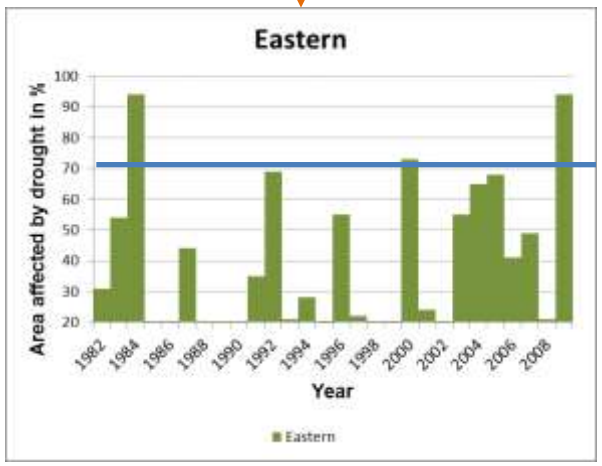

(A)
(B)
(C)
(D)
(E)
(F)
10° W
0°
10° E
20° E
30° E
40° E
20° N
10° N
P(D=1 | F_T)
out of season
0 0.1 0.2 0.3 0.5 0.75 1
Season progress (%)
out of season
0 10 30 20 40 50 60 70 80 90 100

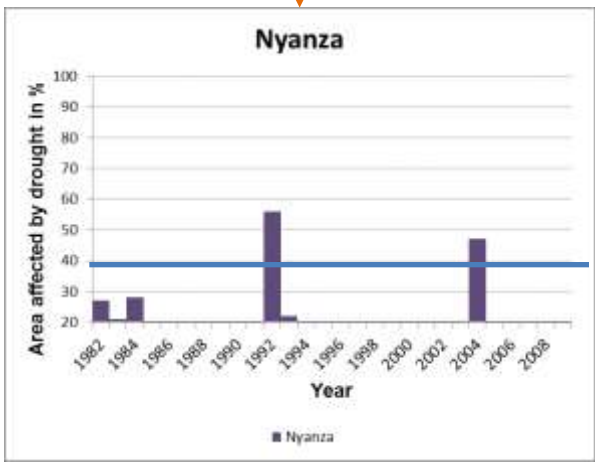
Seguro de Cosecha Indexado con base en Sensores Remotos



Probability by administrative unit of having more than 30% of the agricultural area affected by drought during the first crop season.







Hypothetical case of payoff at province level, using the line of 70 and 40% of agricultural area affected by drought in Kenya (1982-2010).

Syria

Crop yield model based on ASI

Figure 1: Wheat yield model in which ASI explains 87% of the yield variation

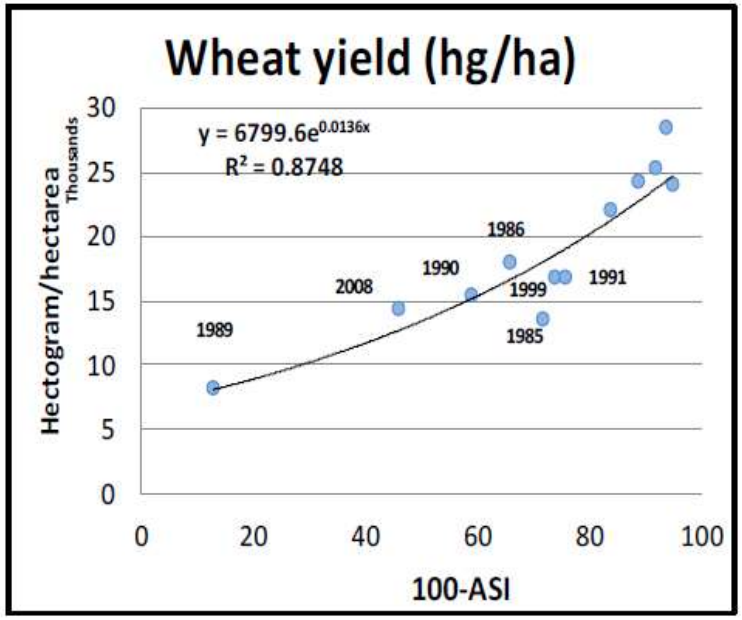


Figure 2: Barley yield model in which ASI explains 74% of the yield variation

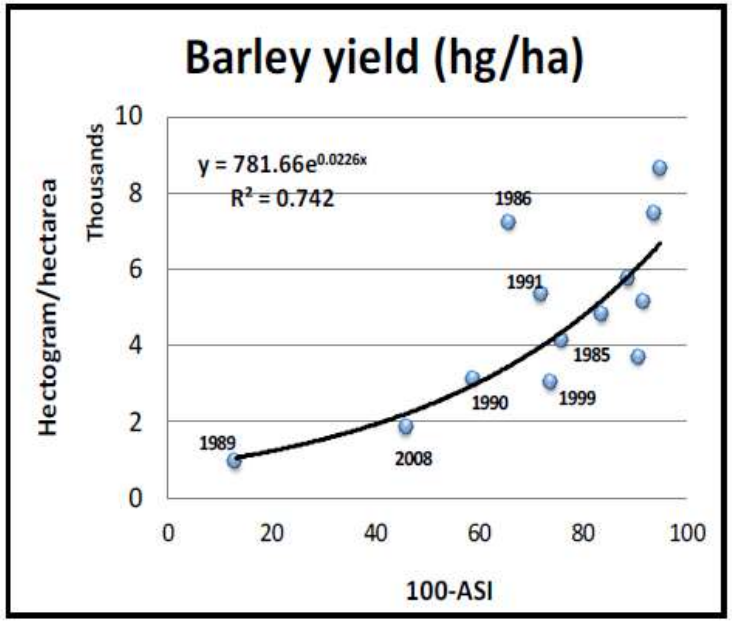


Figure 4A: Wheat and barley yield estimates based on ASI
Figure 4B: Maps of ASI value for 1989, 2008 and partial value up to 2nd dekad of April 2014

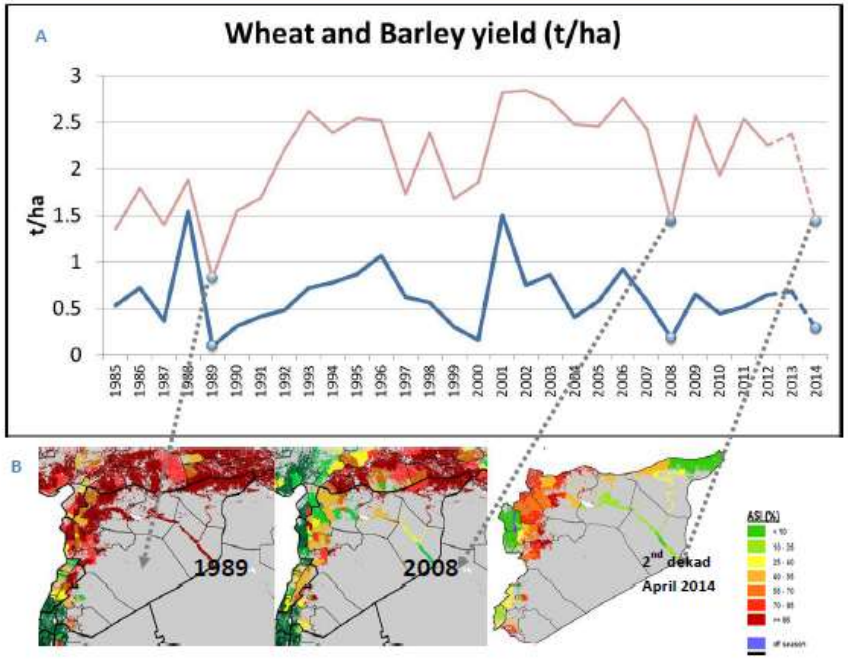
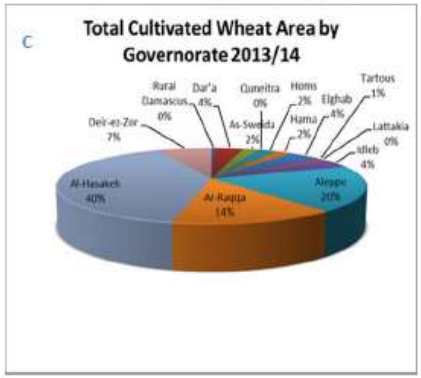


Figure 4C: Total cultivated wheat area by governorate
Figure 4D: Progress of season expressed in percentage



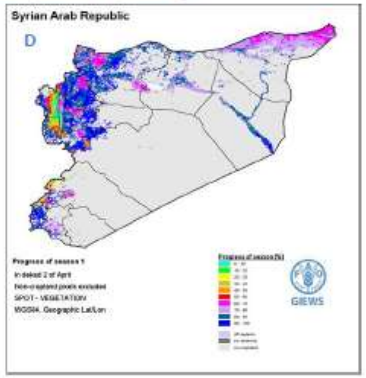
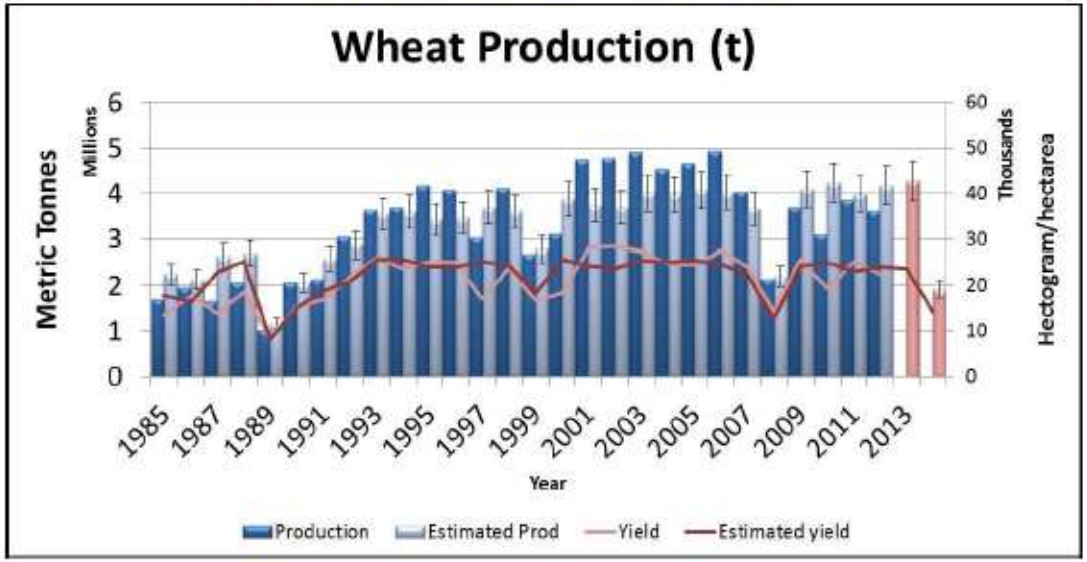


Table 1. Estimation of Syrian wheat production using remote sensing observations

Scenarios	Wheat					
2014	Yield (t/ha)	Standard Error of Estimation (SEE)	Area (ha)	Production (t)	Variation % Avg (03-12)	Variation % (2012)
Scenario 1: Area cultivated estimated by Ministry of Agriculture	1.50	±0.32	1312535	1968803	-51	-48
Scenario 2: 2008-2012 Average Area Harvested	1.50	±0.32	1529248	2293872	-43	-39
Reference data						
2003-2012 Average	2.40		1663205	3991691		
2012	2.34		1602814	3750585		
2008	1.44		1485900	2139696		

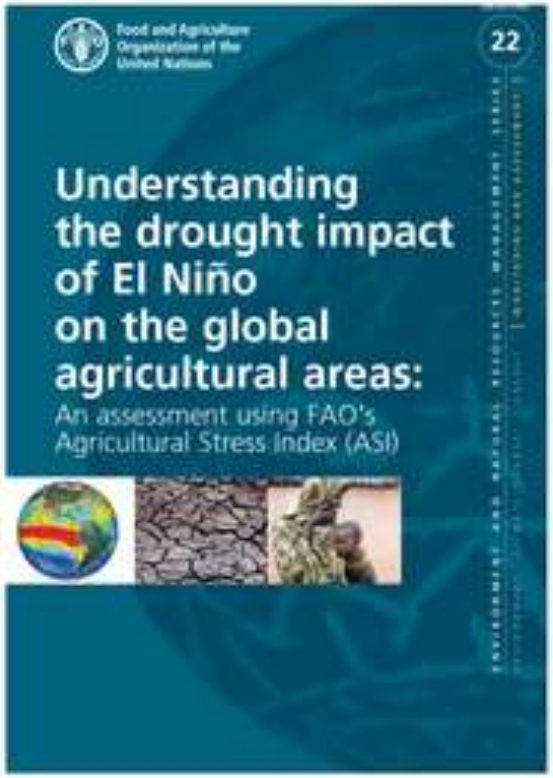
Figure 3: Model estimates of wheat production and yield

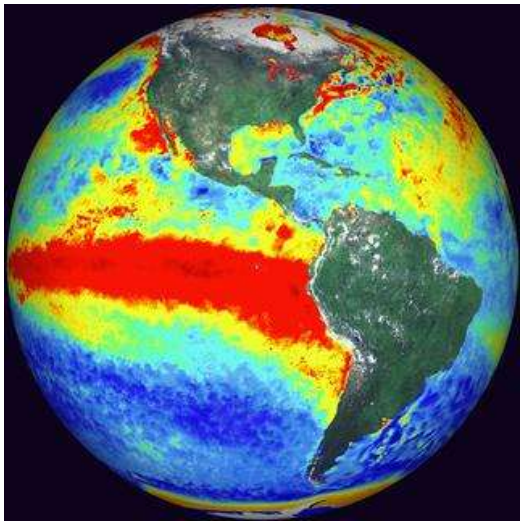


Estimates are based on the FAO-model and area estimated by MAAR. Production estimates show the 10 percent error bar.

Understanding the drought impact of El Niño on the global agricultural areas

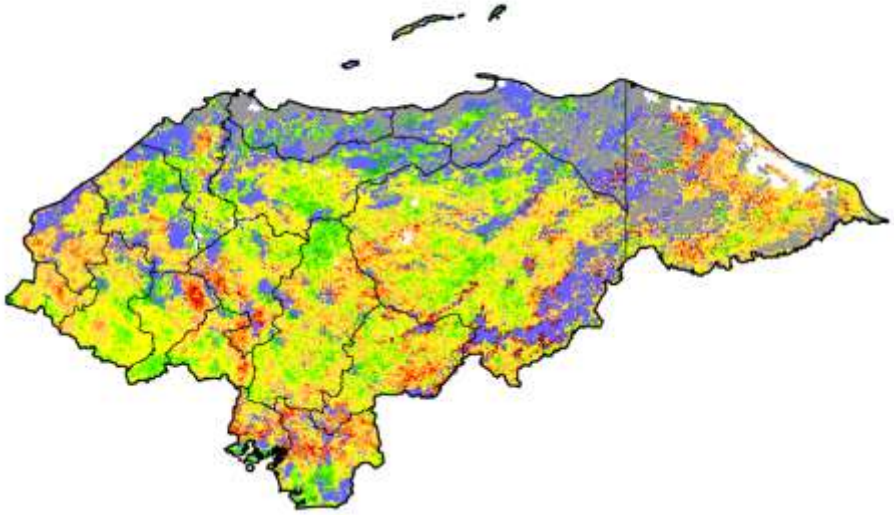
An assessment using FAO's Agricultural Stress Index (ASI)

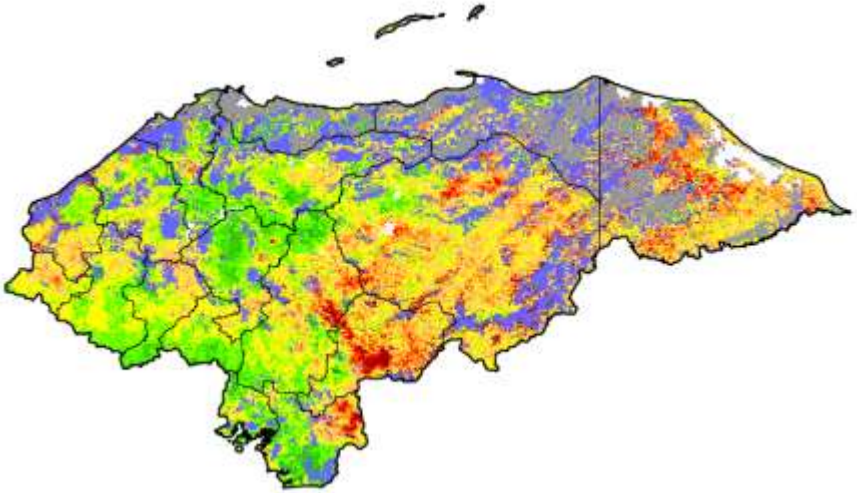




El Niño observed from sattelite. The red areas of the tropical coasts of South America indicate the pool of warm water. Source: NOAA

Honduras





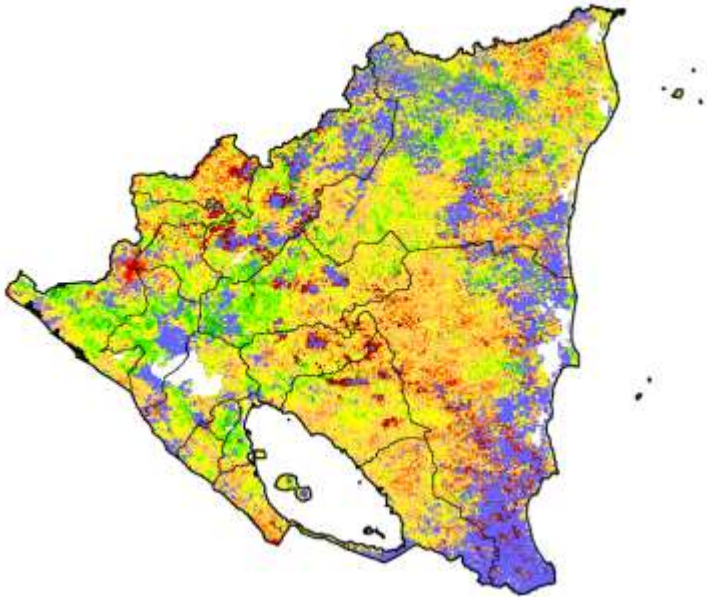
Mean VHI

- < 0.15
- 0.15 - 0.25
- 0.25 - 0.35
- 0.35 - 0.45
- 0.45 - 0.55
- 0.55 - 0.65
- 0.65 - 0.75
- 0.75 - 0.85
- >= 0.85
- off season
- no data
- no seasons

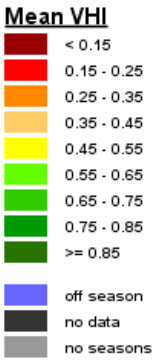
1 década
Agosto 2015

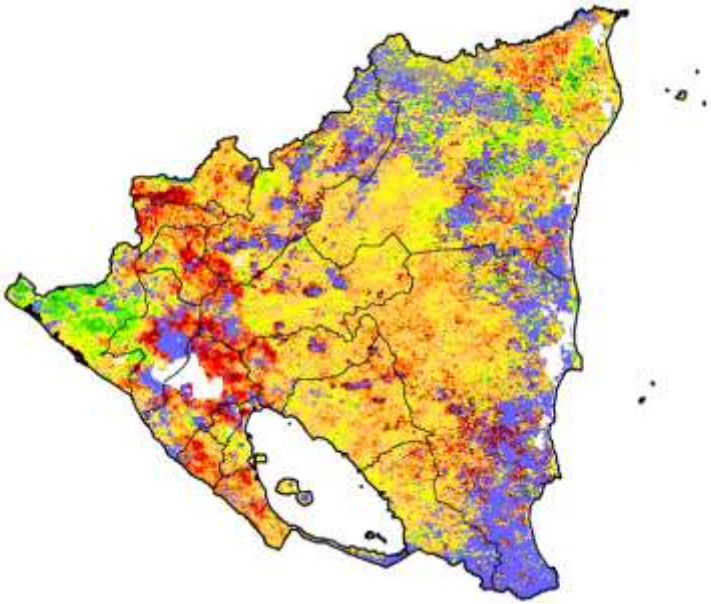
1 década
Agosto 2014

Nicaragua



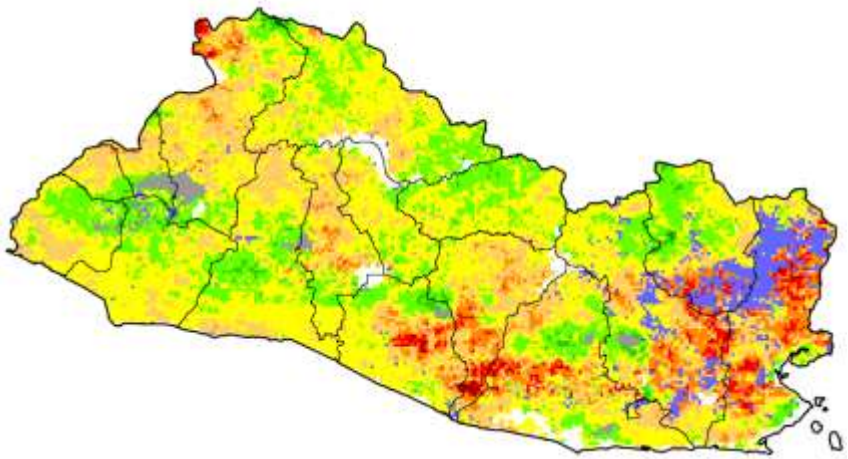
1 década
Agosto 2015



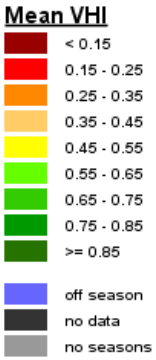


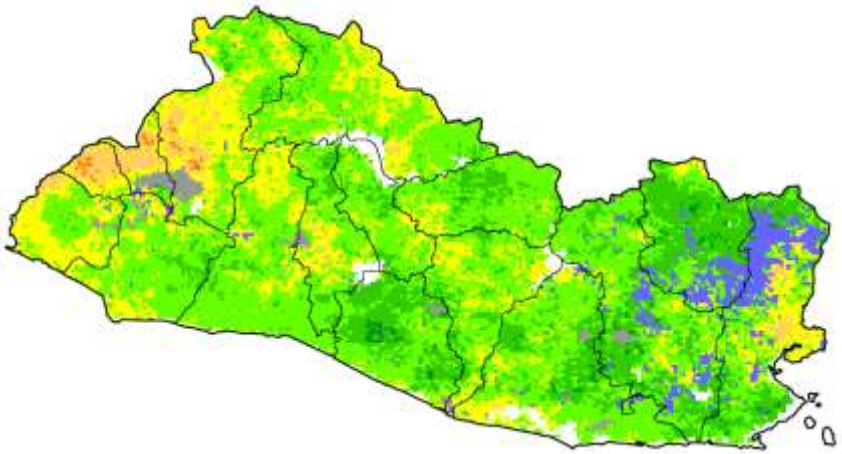
1 década
Agosto 2014

El Salvador



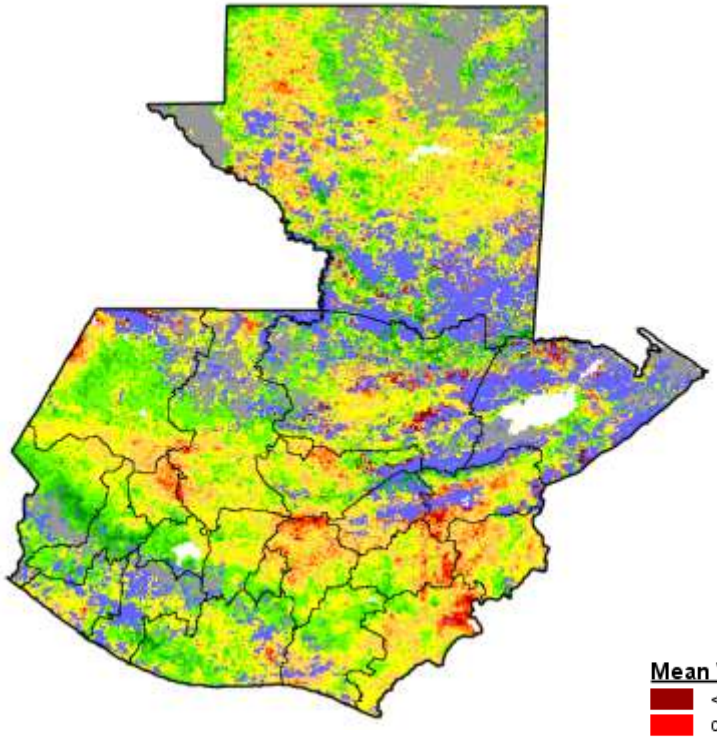
1 década
Agosto 2015



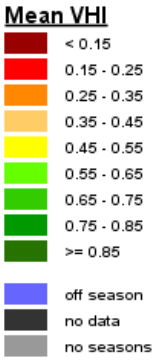


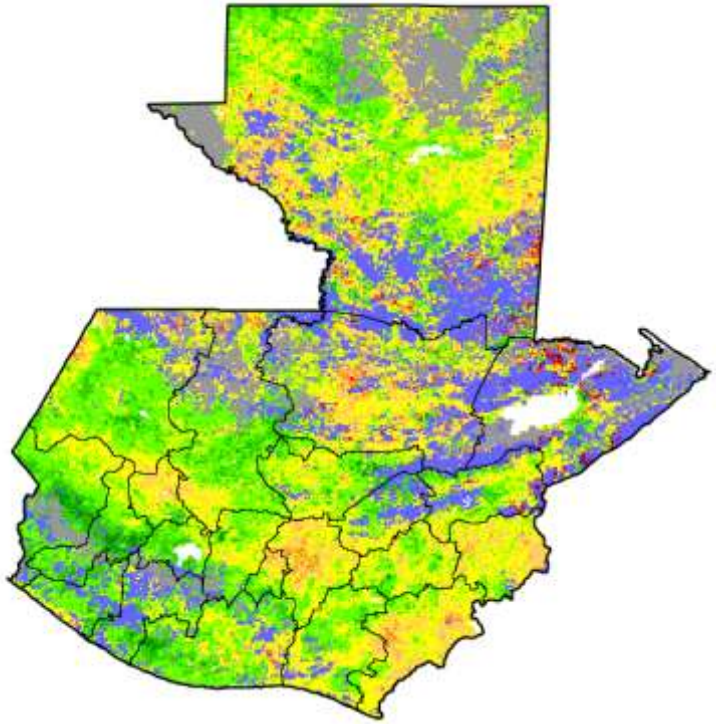
1 década
Agosto 2014

Guatemala



1 década
Agosto 2015





1 década
Agosto 2014

Índice de Salud Vegetación(VHI) Durante época de Postrera 2015