



Organización de las Naciones Unidas  
para la Alimentación y la Agricultura

# From the Global Agriculture Drought Monitoring to Country Level using Geospatial Information

In collaboration with:



UNIVERSITY OF TWENTE.

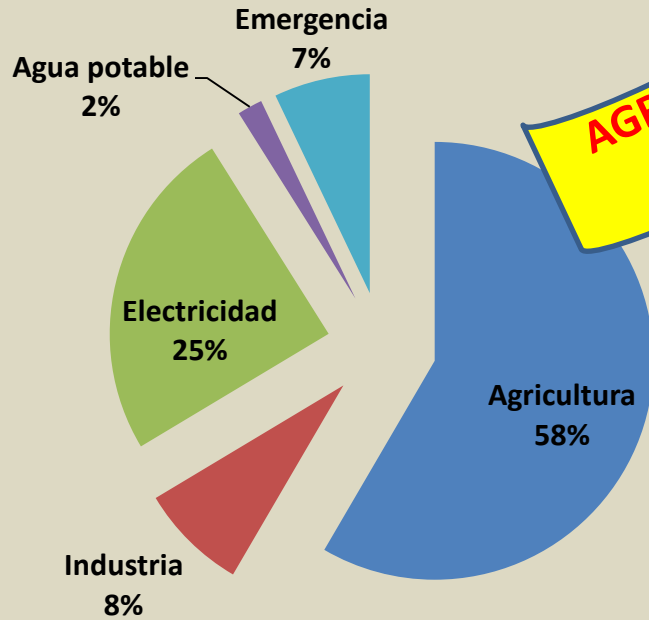


# ASIS

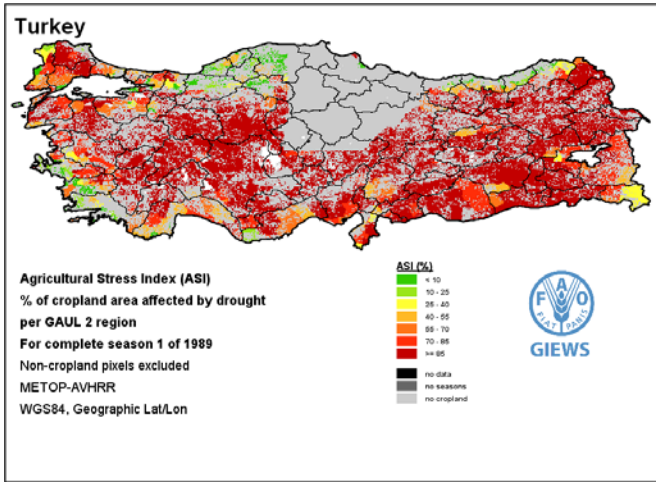
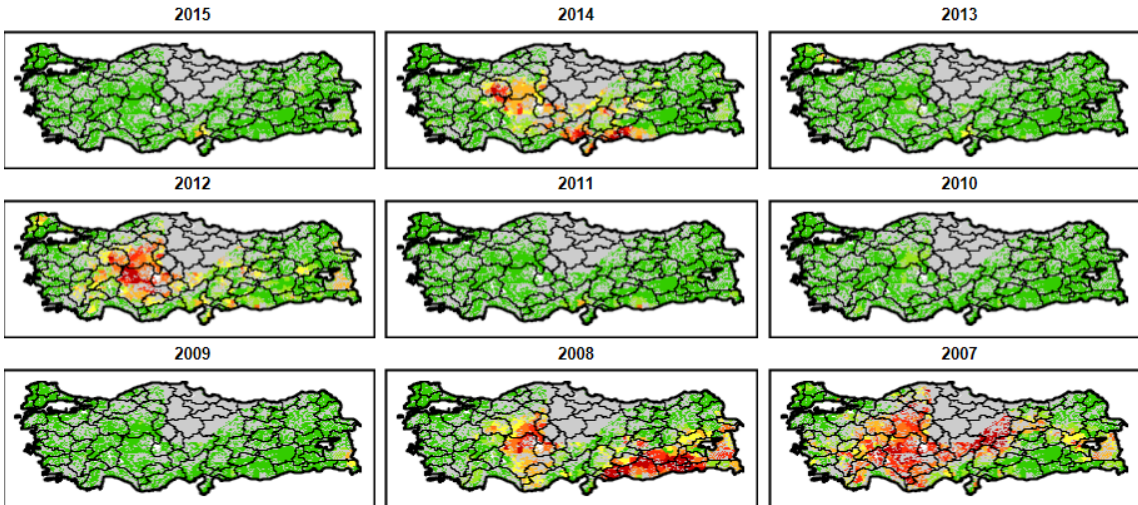
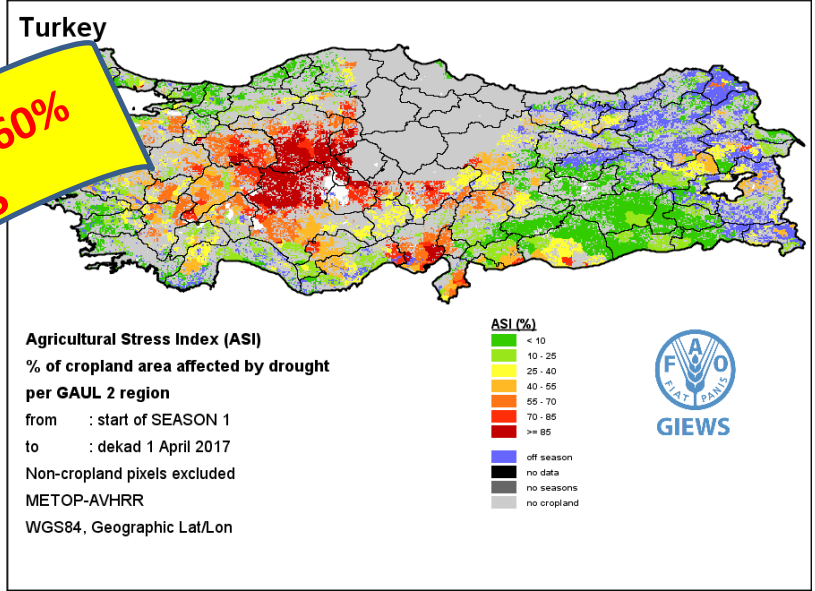
<http://www.fao.org/climatechange/asis/en/>

# PERDIDAS POR SEQUÍA SE CONCENTRAN EN EL SECTOR AGROPECUARIO (58%)

## CENTROAMÉRICA: PERDIDAS OCASIONADAS POR LA SEQUÍA 2001



**AGRO RONDA EL 60% EN SEQUÍAS**





# Objective

## Limitation using rainfall data:

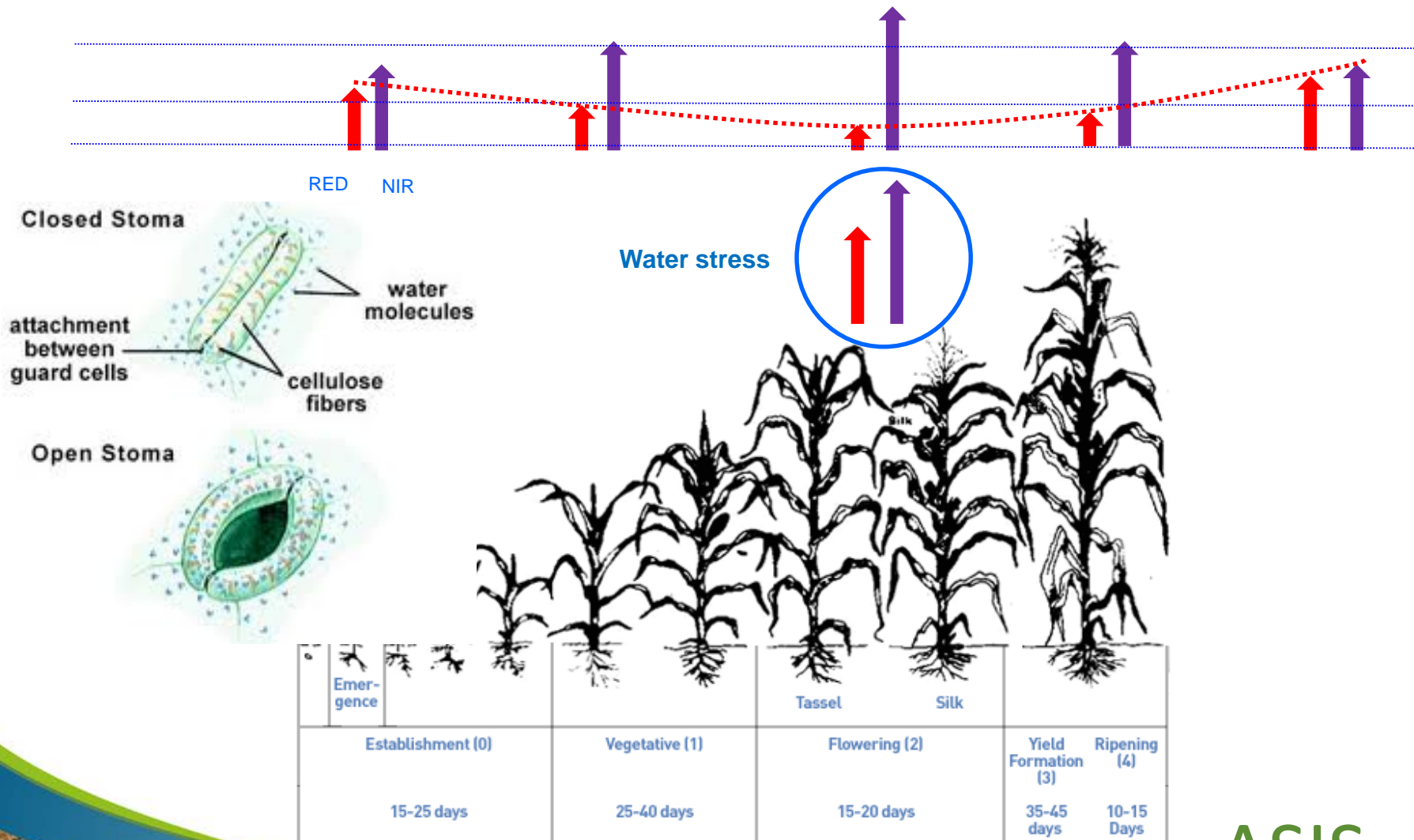
- Currently weather stations are sparse and provide discontinuous data
- Rainfall estimates have a bias and show deviations in different regions of Africa (Dinku et al. 2007, Lim and Ho 2000).

## What ASIS is?

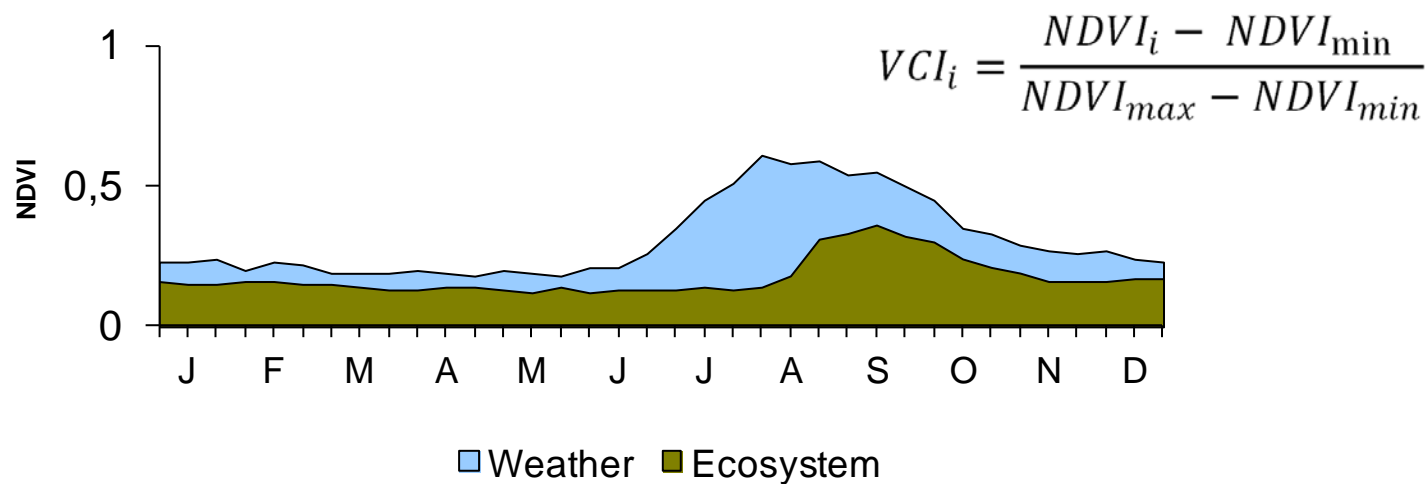
- Is a expert system for agricultural drought monitoring based on 10-day satellite data of vegetation and land surface temperature from METOP-AVHRR sensor at 1 km.

ASIS

# Electromagnetic energy recorded by the sensor



### Hodh El Gharbi, Mauritania



**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.

# Agricultural Stress Index System is based on the Vegetation Health Index (VHI) (Kogan et al. 1995)

Vegetation condition index (VCI)

Temperature condition index (TCI)

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

$$TCI_i = \frac{BT_{max} - BT_i}{BT_{max} - BT_{min}}$$

Vegetation Health Index (VHI)

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

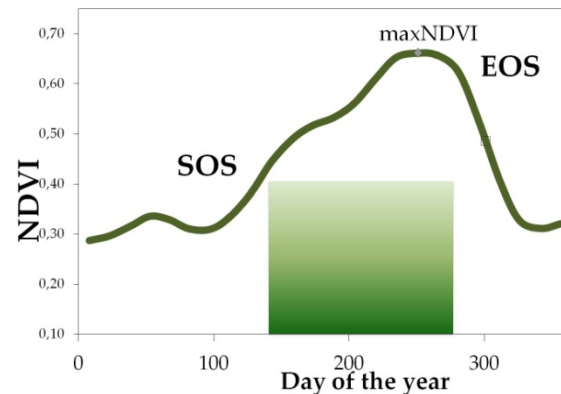
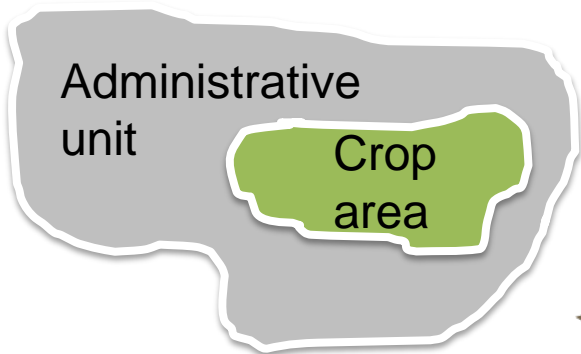
low VHI



high VHI

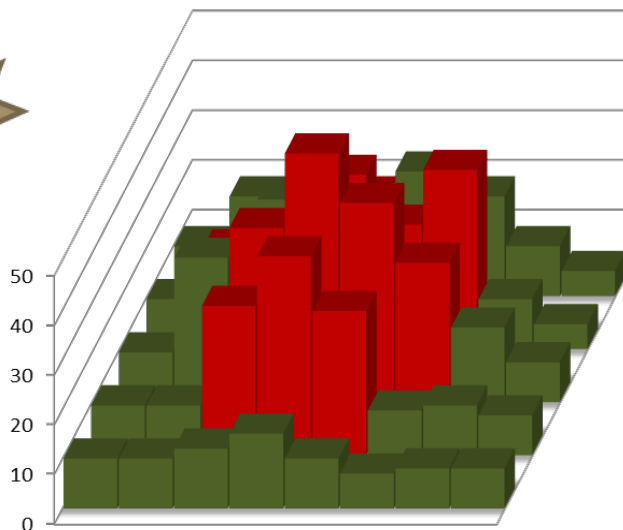
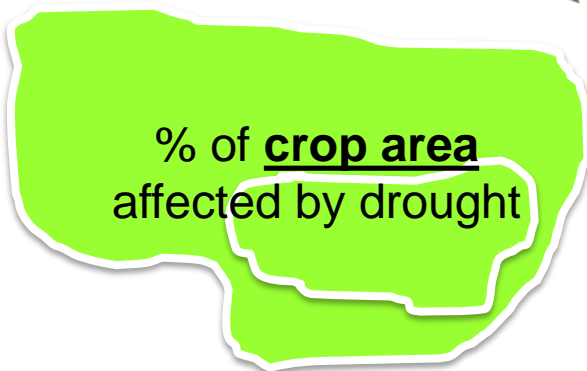


# ASIS assess the severity (intensity, duration and spatial extent) of the agricultural drought



Percentage of the agriculture areas with VHI below 35

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



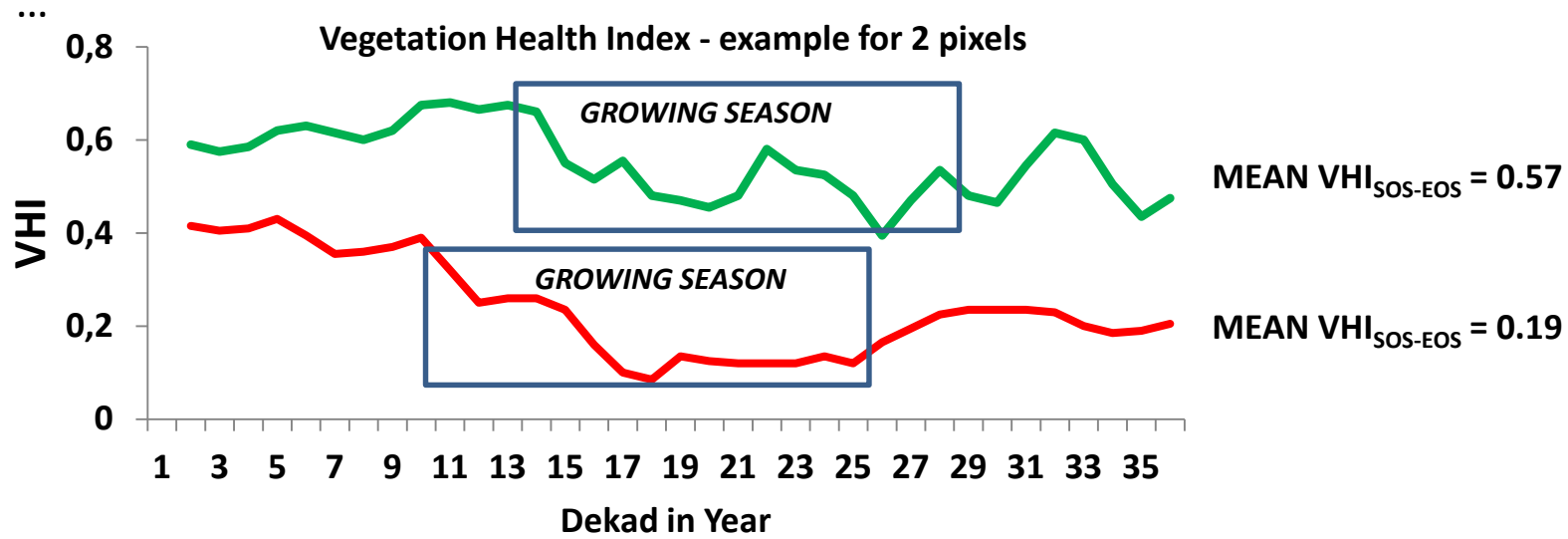
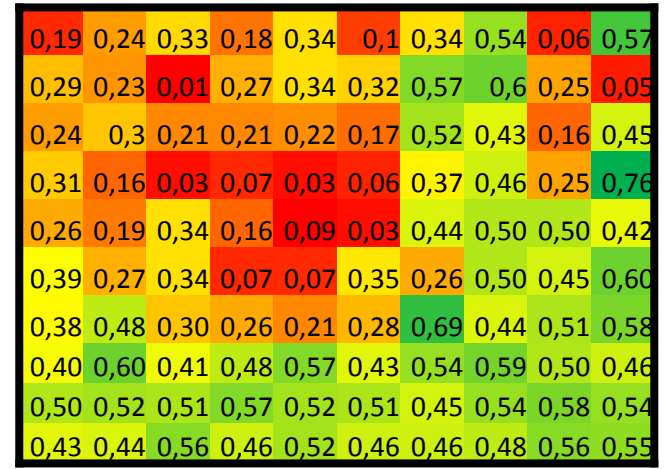
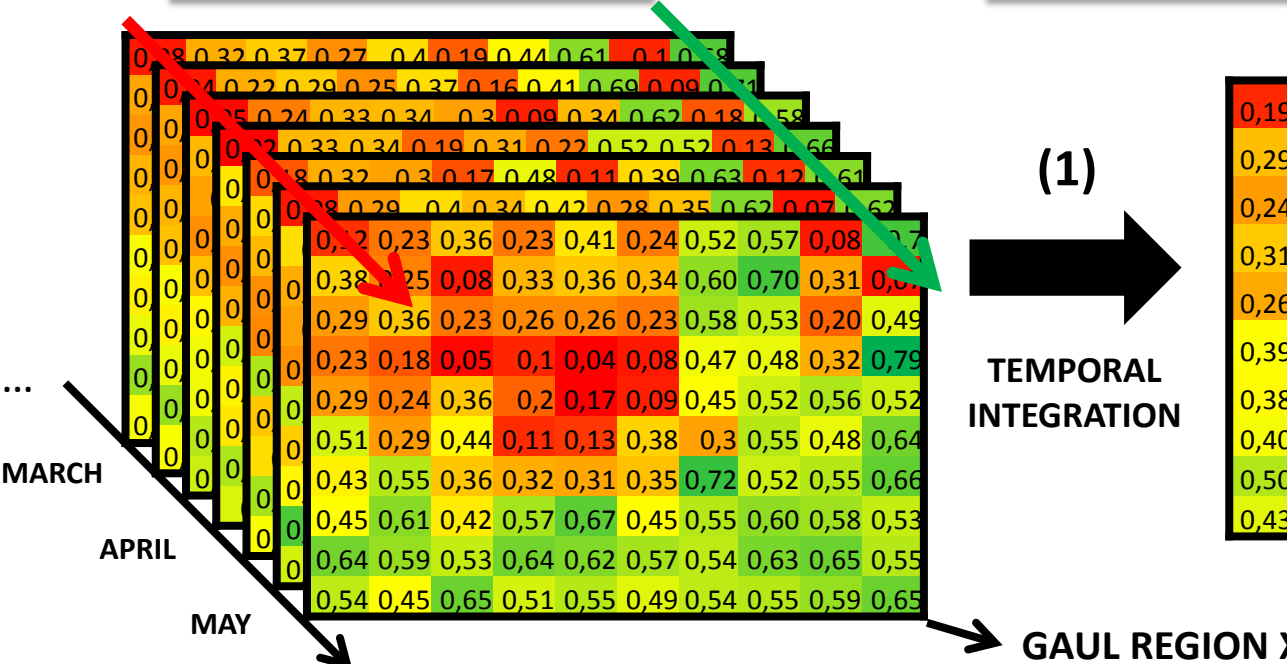
VHI temporal average value

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

# "Agriculture Stress Index"

Dekadal VHI images

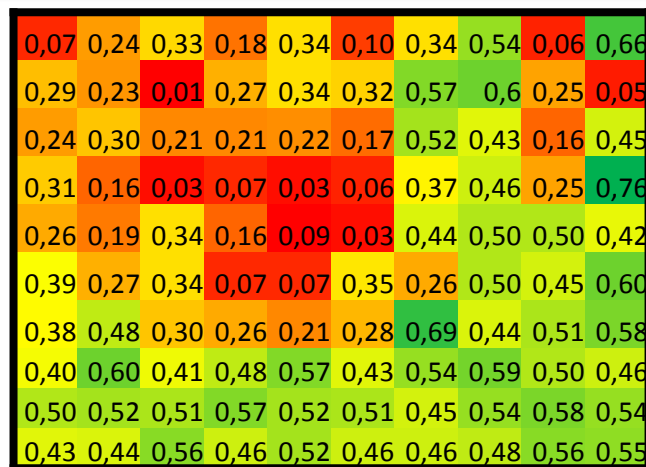
Mean VHI image over the crop season



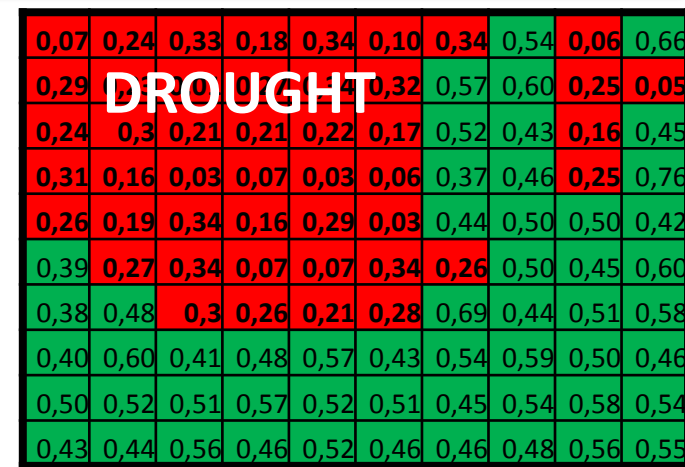


# "Agriculture Stress Index"

Mean VHI image over the crop season

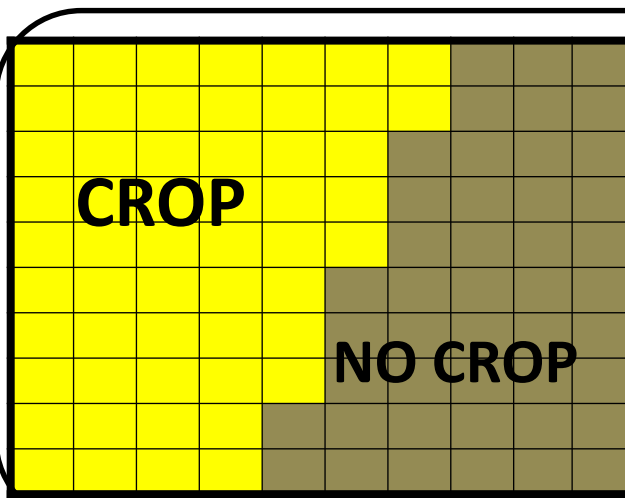


PIXELS with MEAN VHI < 35%

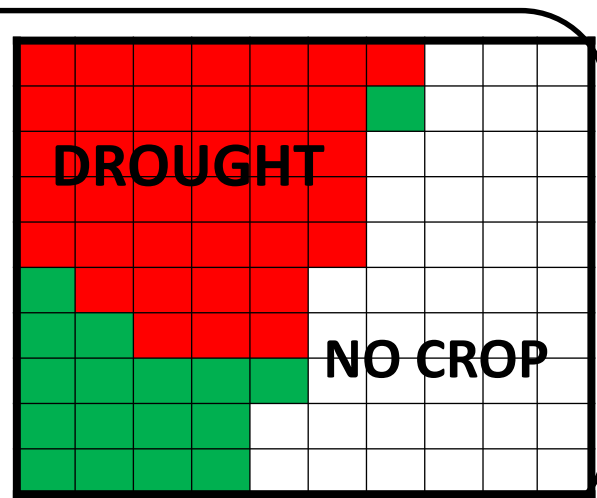


(2)  
THRESHOLD

(3) ONLY CROP AREA



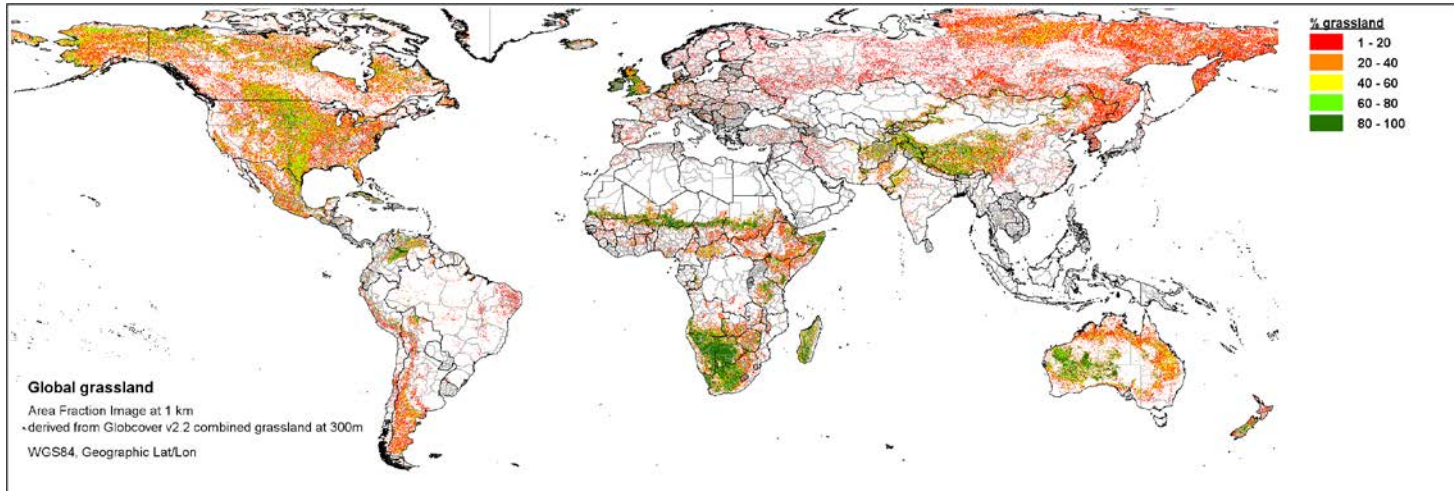
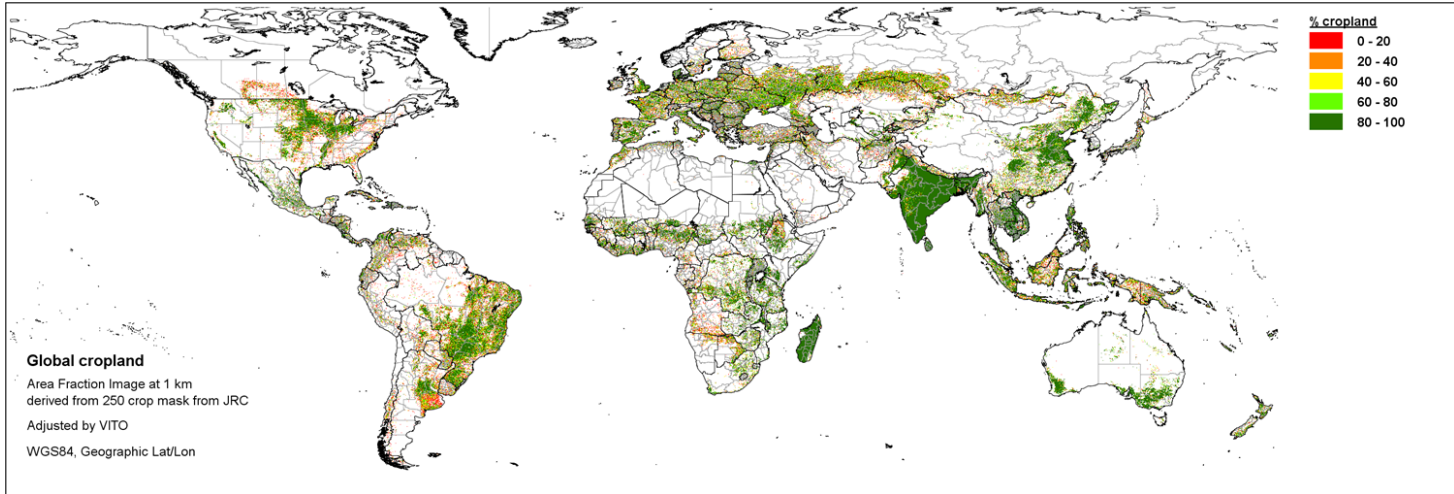
(4) PIXEL COUNTING



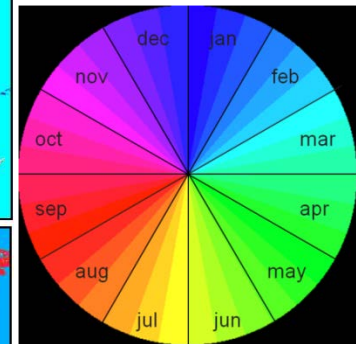
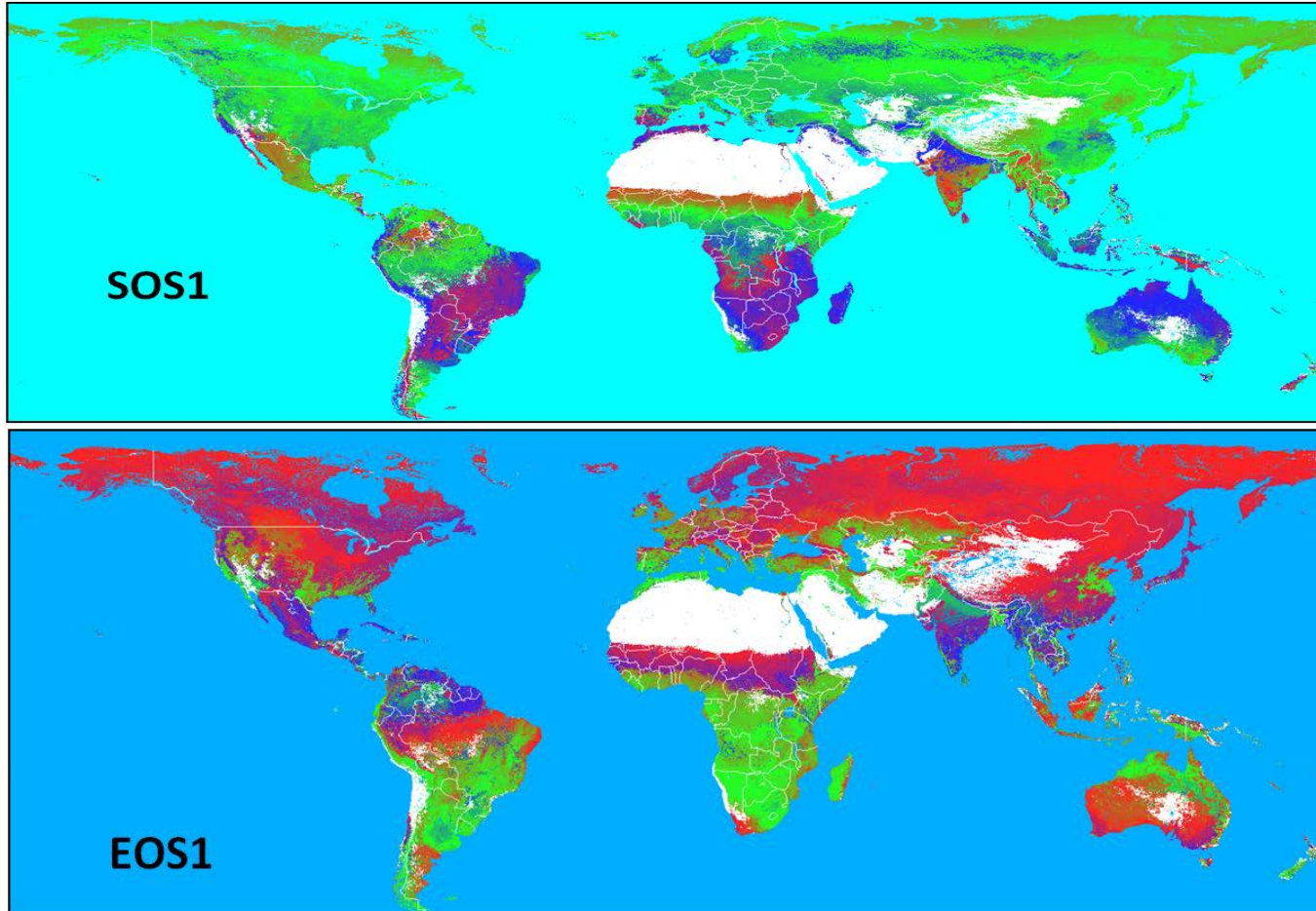
Agricultural Stress Index  
ASI  
70%

$$\frac{\text{\#drought pixels (38)}}{\text{\#total crop pixels (55)}} = \pm 70\% \text{ of crop area affected by drought}$$

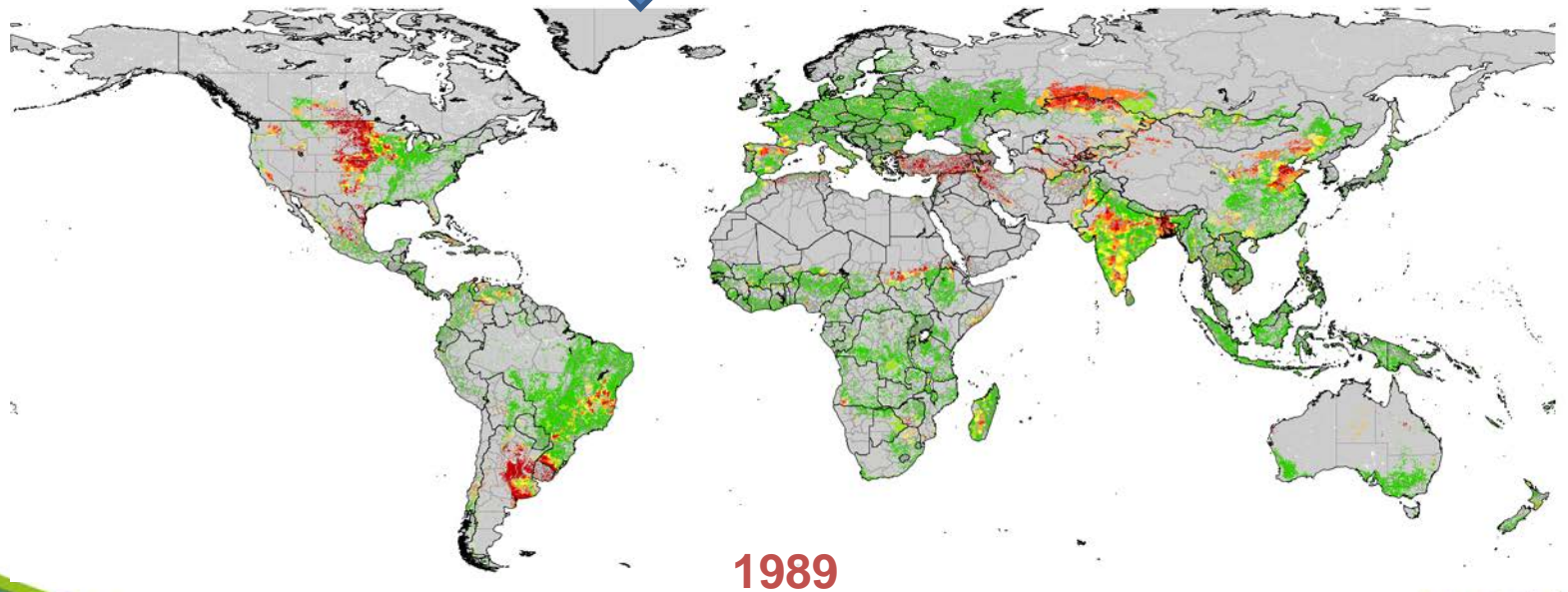
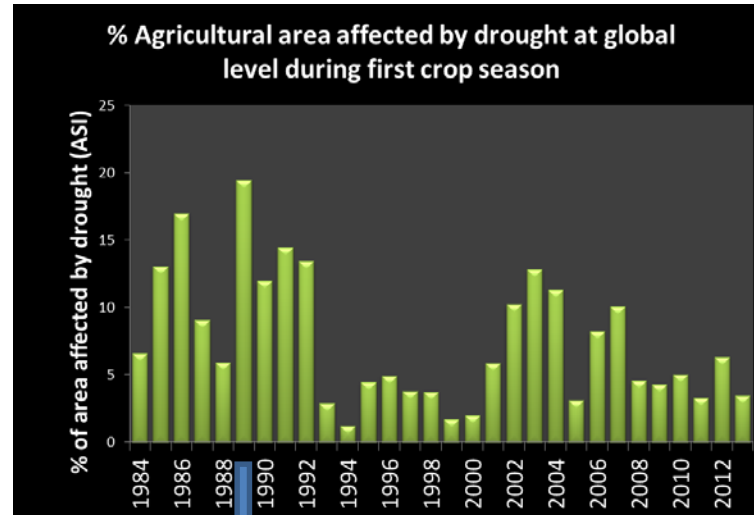
# Global cropland mask



## Temporal aggregation - defining 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).*



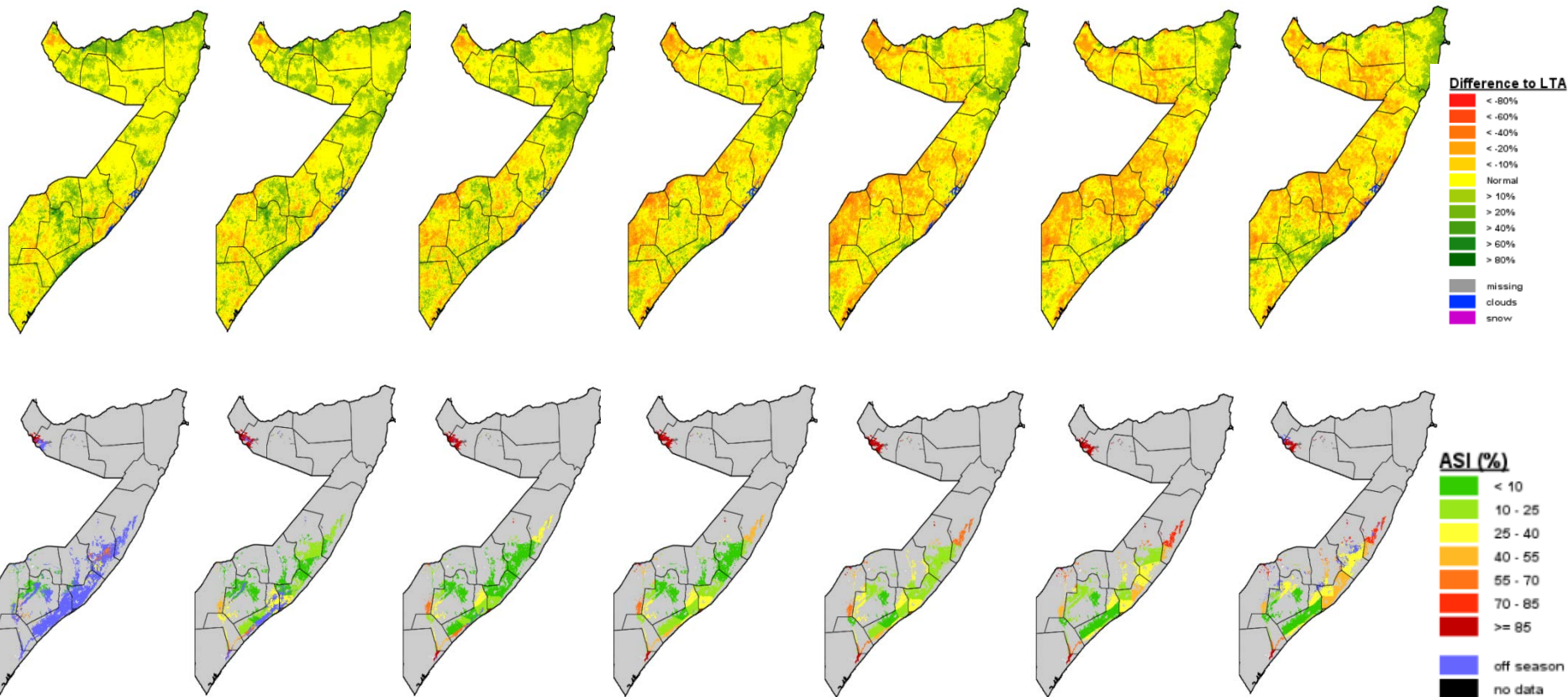


# Classical analysis compared with ASIS

## Somalia 2009

1<sup>st</sup> dekad April

1<sup>st</sup> 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 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).	



# GIEWS Earth Observation Website

Thanks

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



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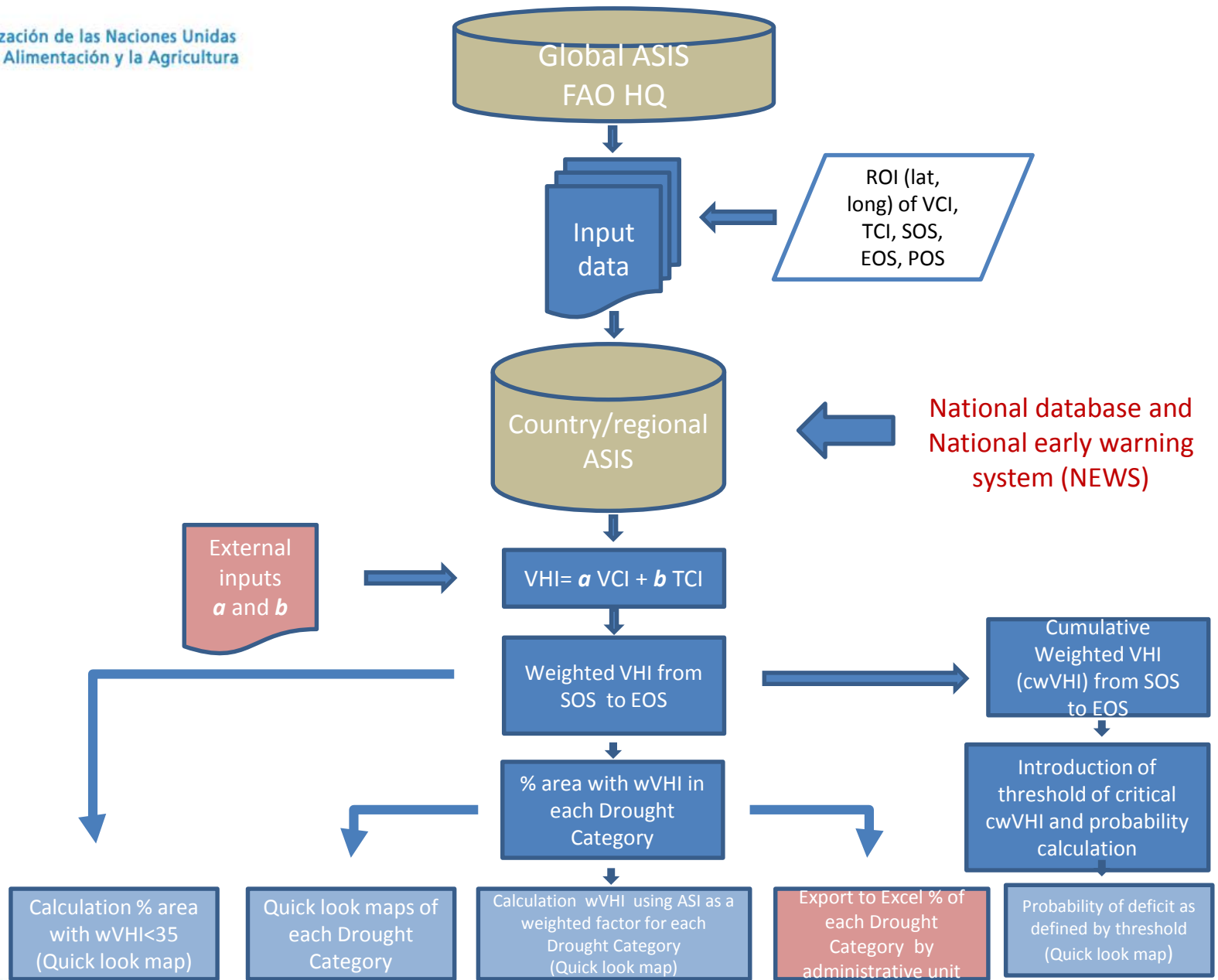
# Standalone ASIS

funded by:

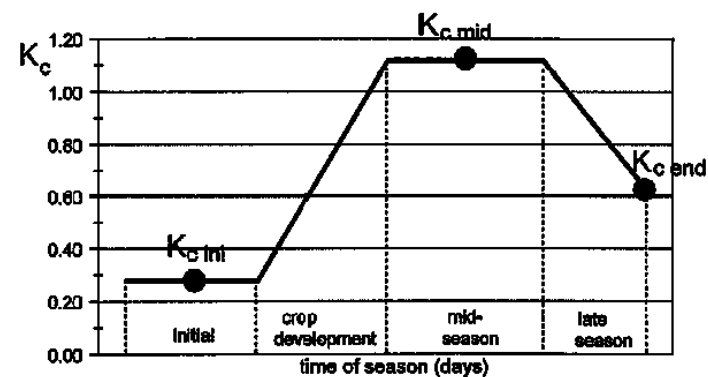
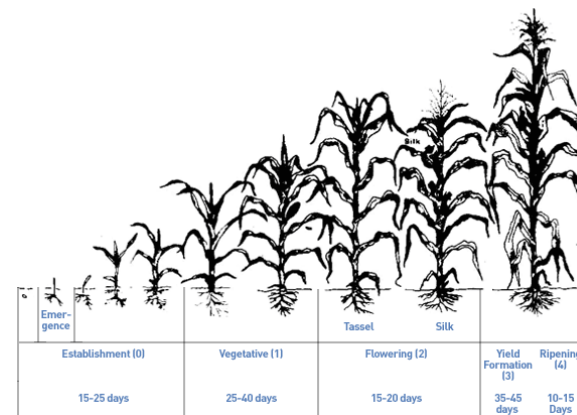
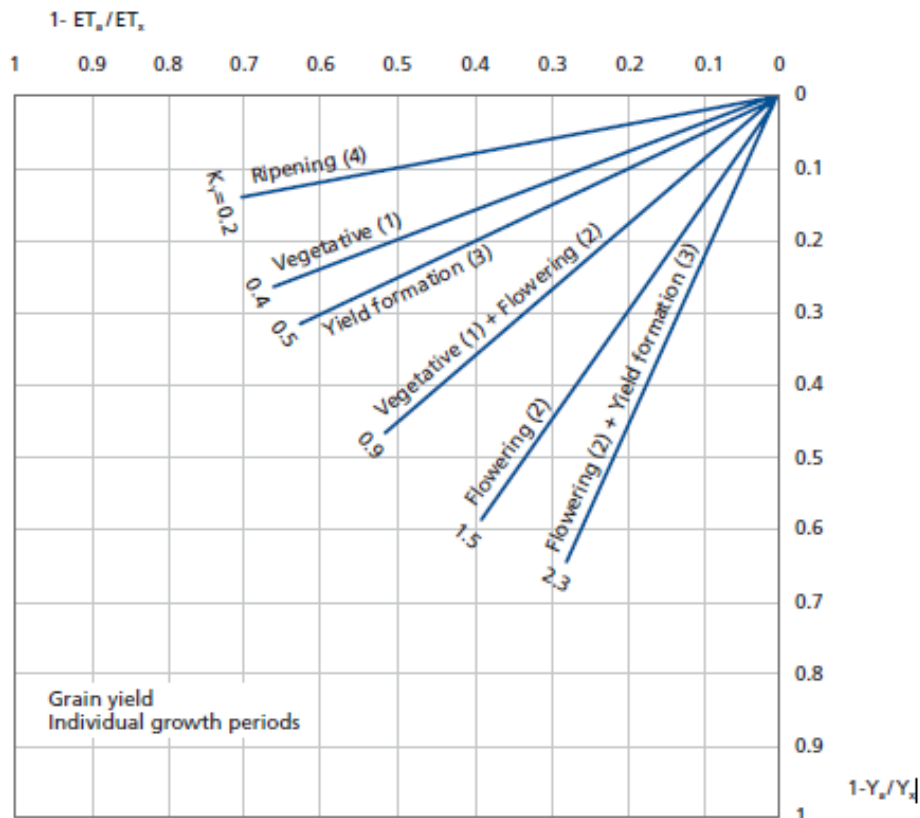


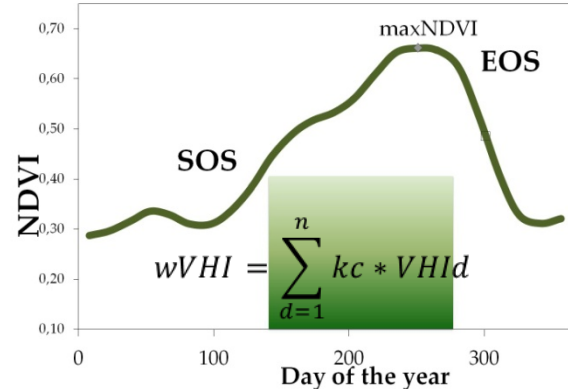
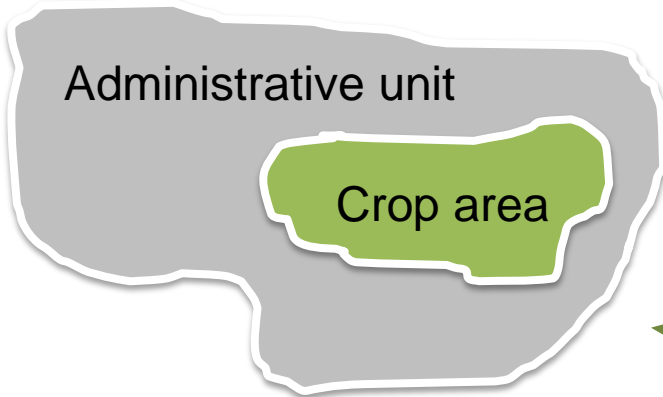
**ASIS**





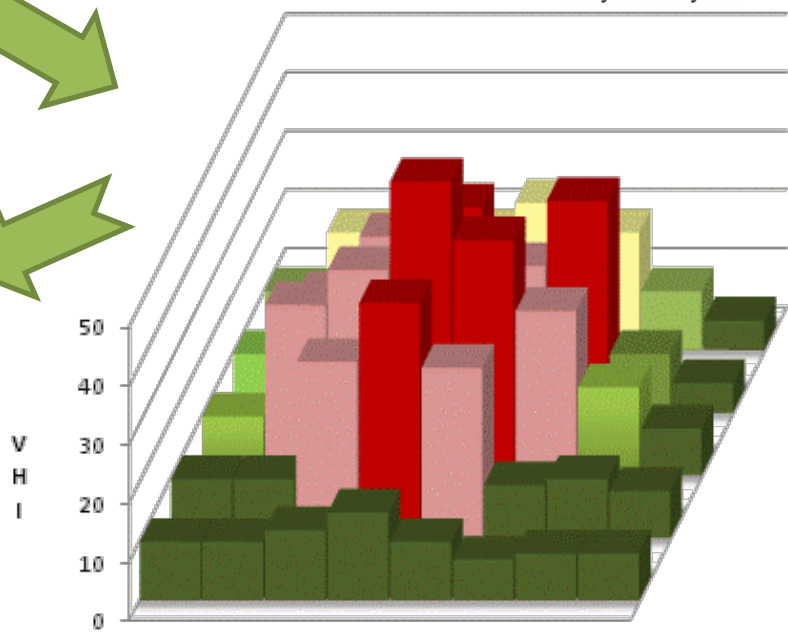
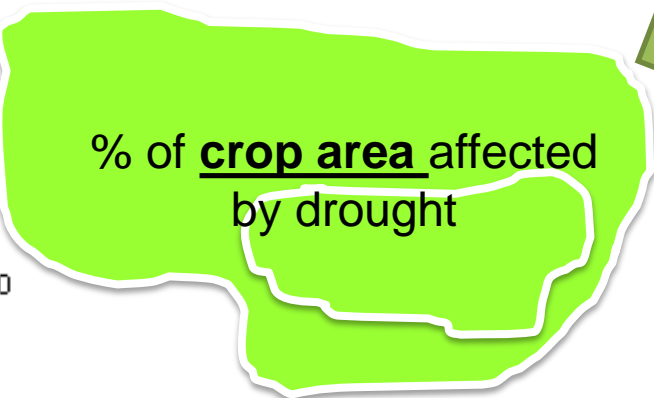
**FIGURE 1** Linear water production functions for maize subjected to water deficits occurring during the vegetative, flowering, yield formation and ripening periods. The steeper the slope (i.e. the higher the  $K_y$  value), the greater the reduction of yield for a given reduction in ET because of water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





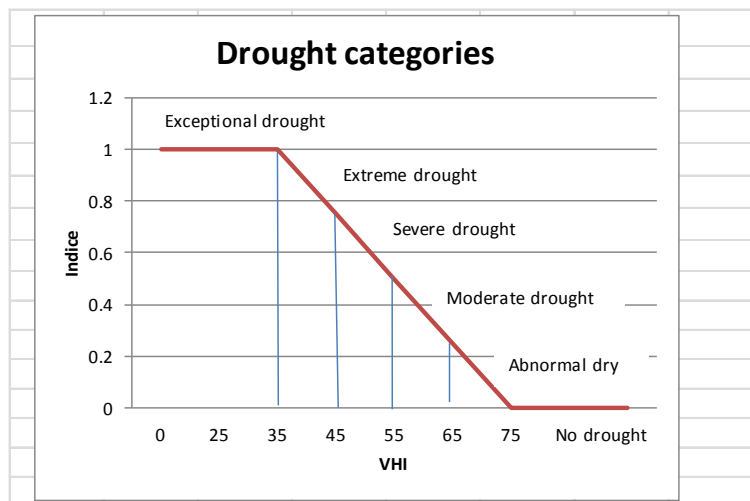
Percentage of the agriculture areas with VHI below 35

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- 11 - 29
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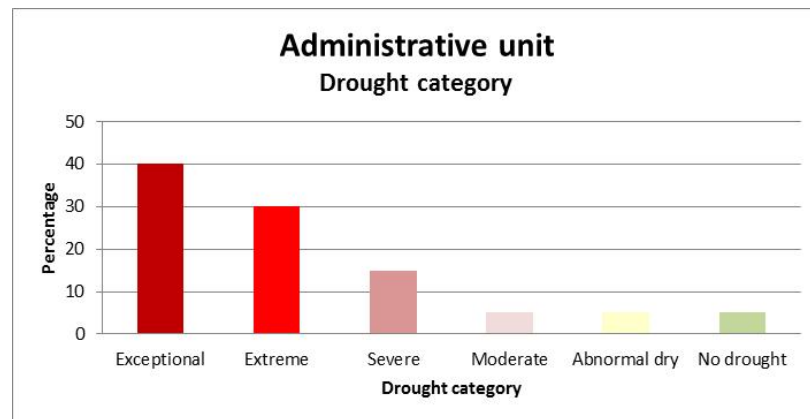
- VHI temporal average value
- 0- 10
  - 10-20
  - 20-25
  - 25-35
  - >35

# Drought categories

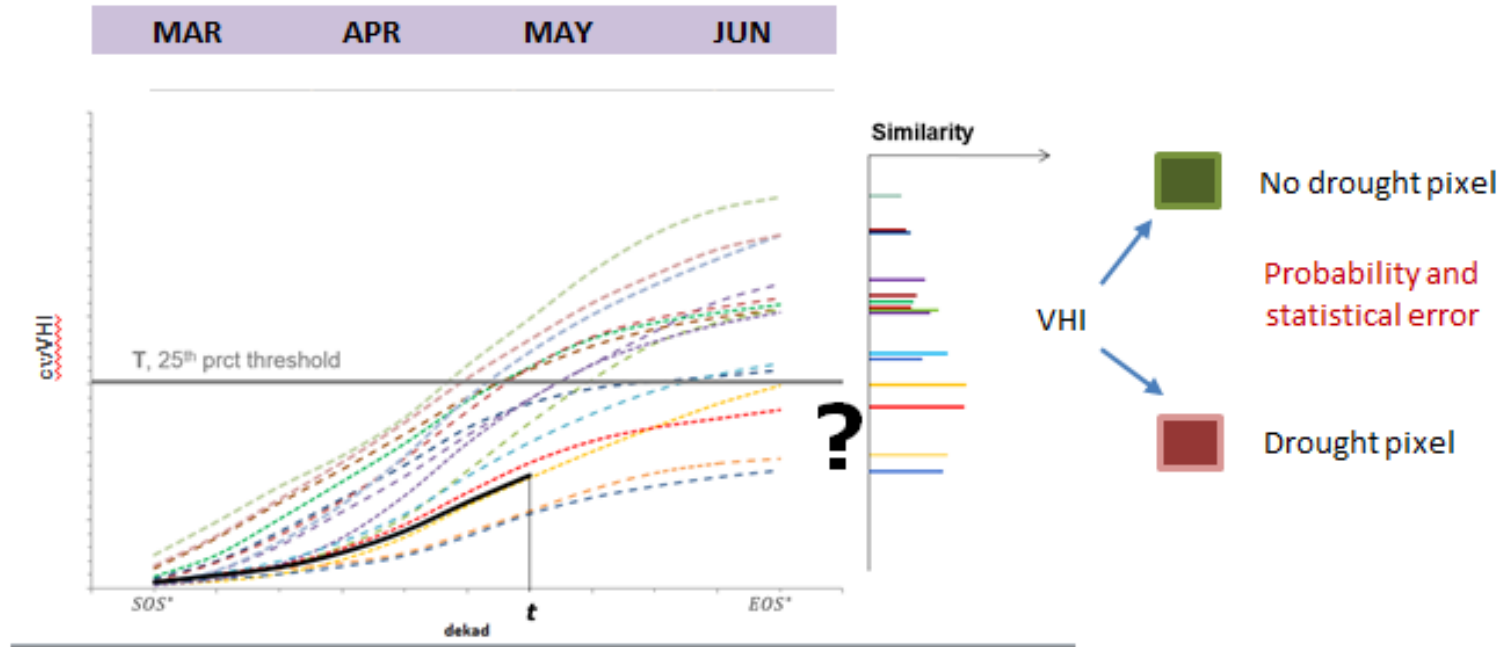


Indicator	Drought category	VHI pixel	ASI*
1	Exceptional Drought	<35	%
0.75-0.99	Extreme Drought	36-45	%
0.50-0.74	Severe Drought	46-55	%
0.25-0.49	Moderate Drought	56-65	%
0.01-0.24	Abnormal dry	66-75	%
0	No Drought	>75	%

\* Percentage of pixels in each drought category



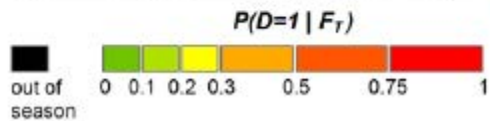
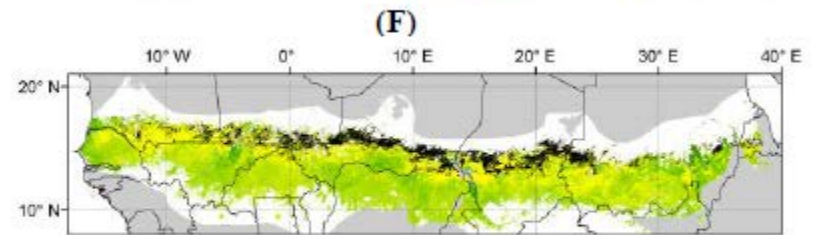
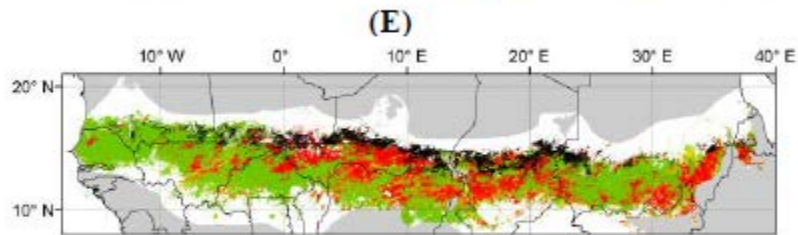
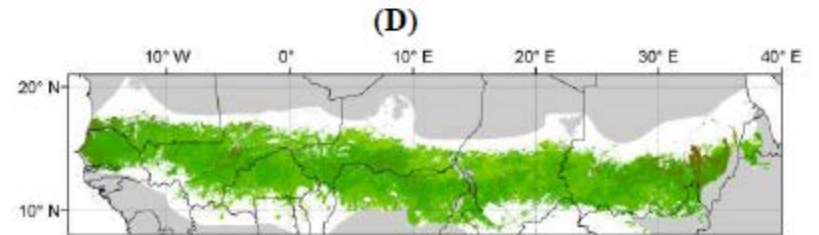
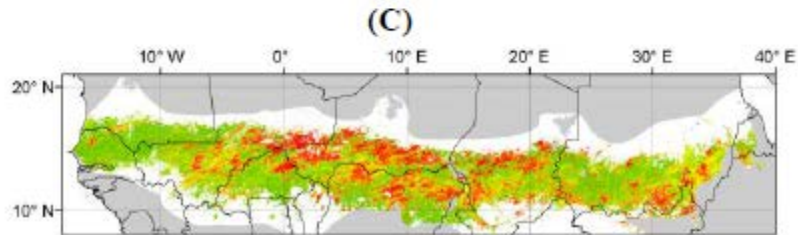
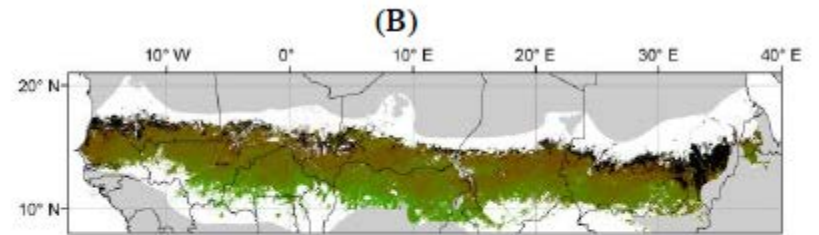
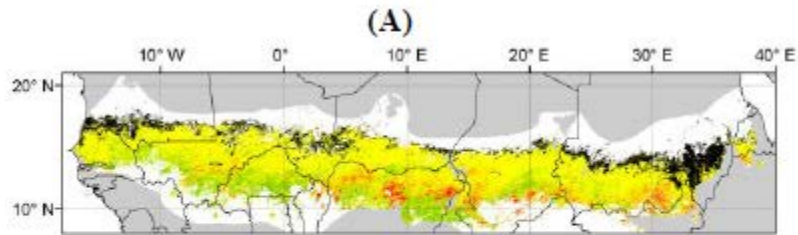
# Probabilistic forecast of agricultural drought



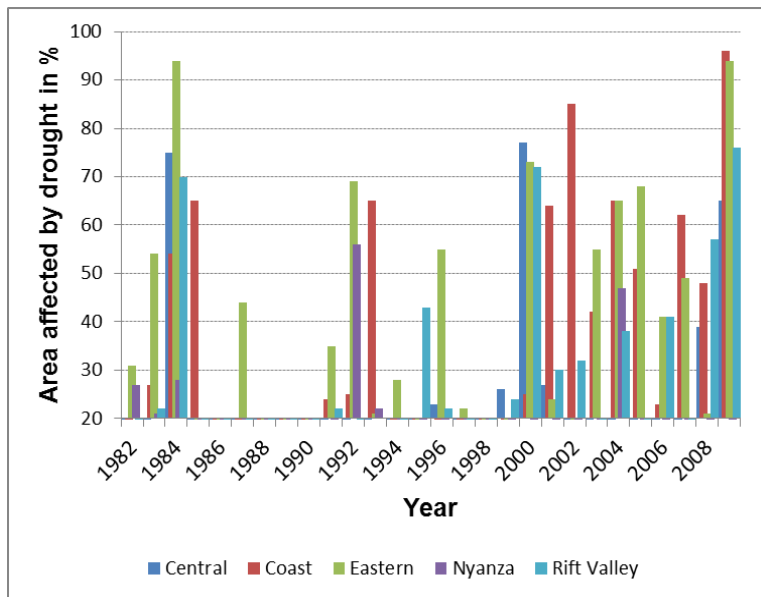
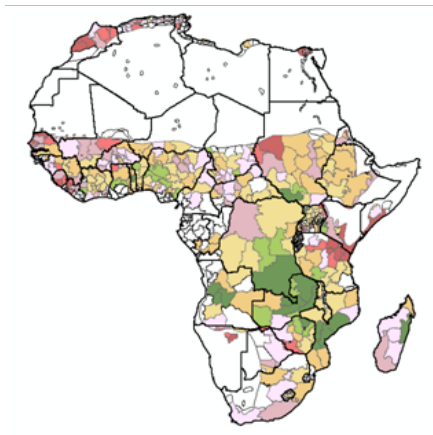
Short duration  
Medium duration  
Long duration



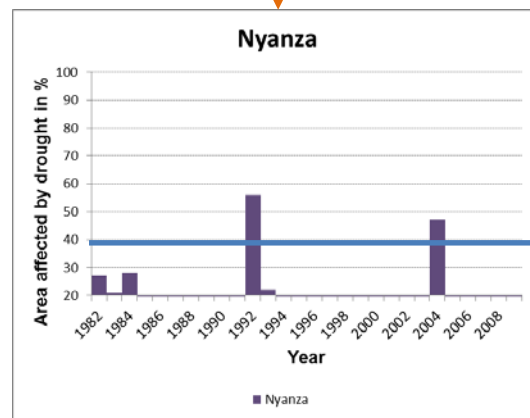
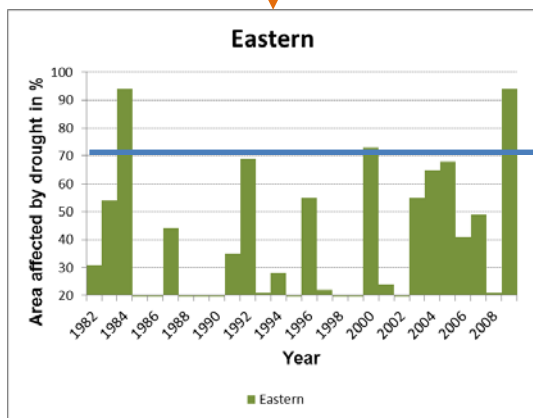
= 100 - 120 days  
= 120 - 140 days  
= 140 - 160 days



# Remote Sensing based Index for Crop Insurance

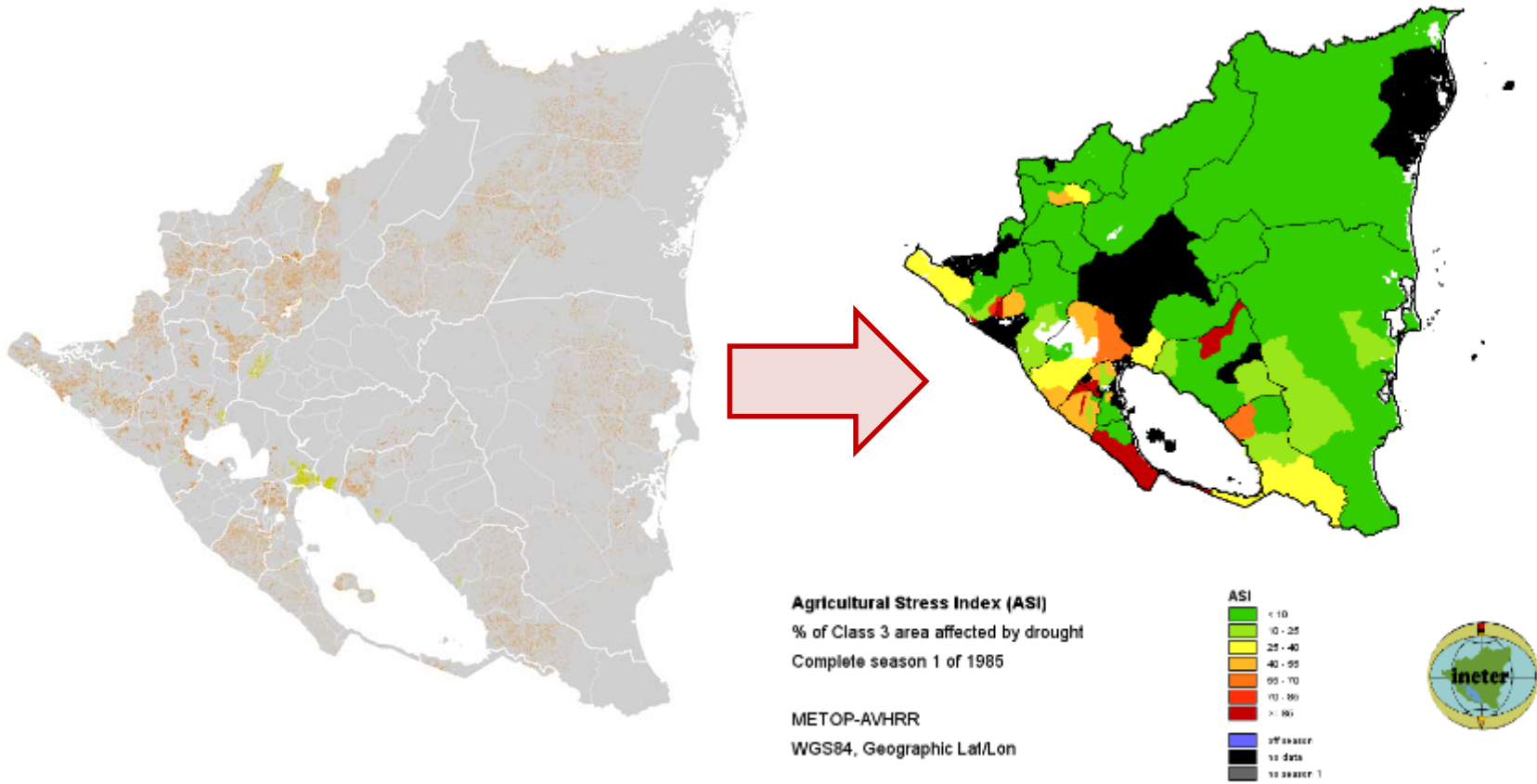


Probability by administrative unit of having more than 30% of the agricultural area affected by drought during the first crop season.



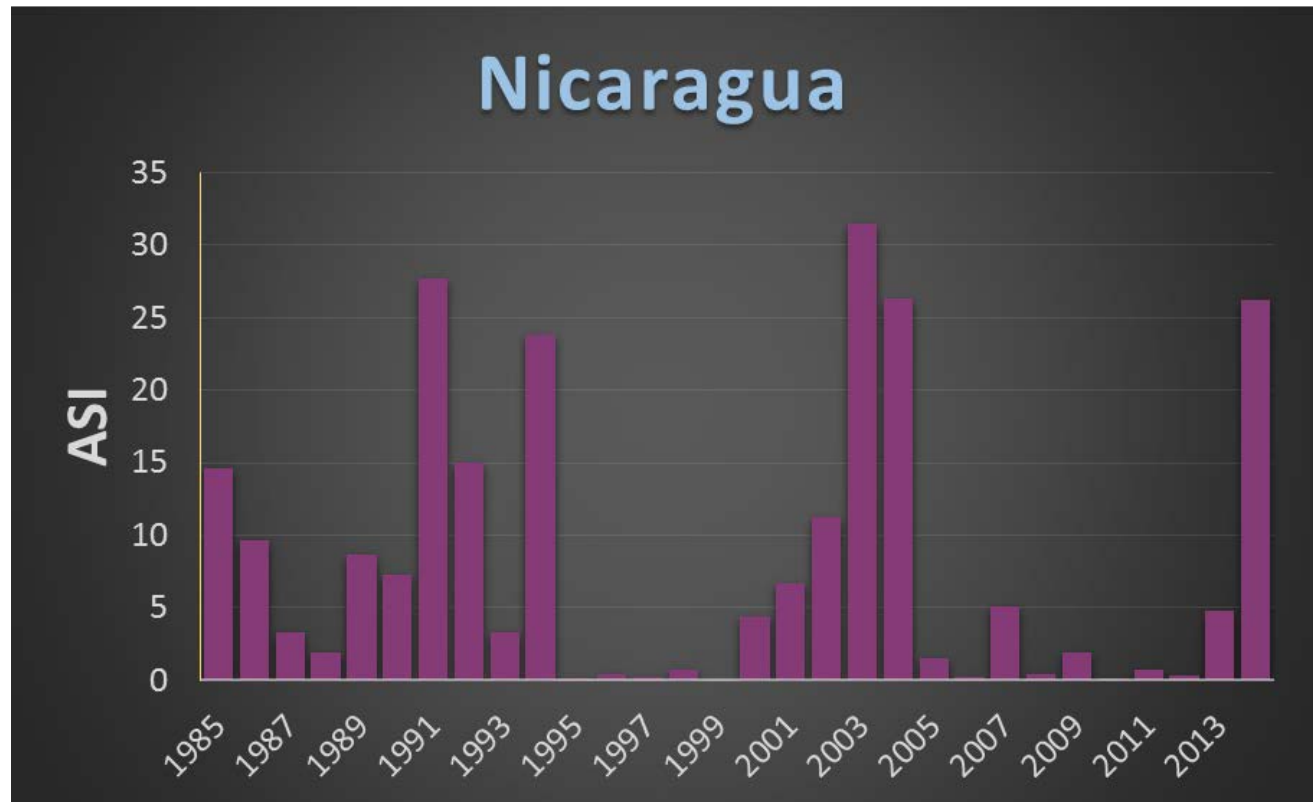
Hypothetical case of payoff at province level, using the line of 70 and 40% of agricultural area affected by drought in Kenya (1982-2010).

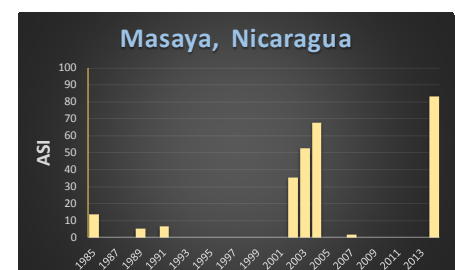
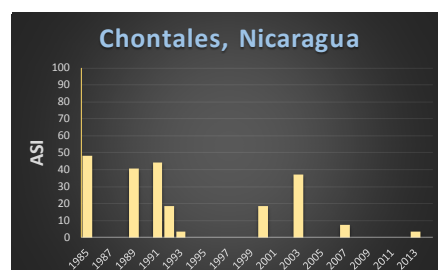
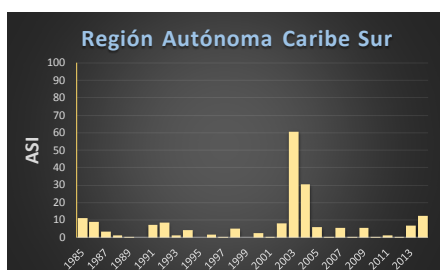
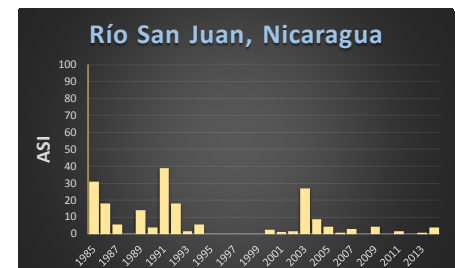
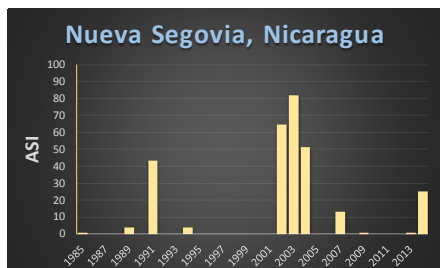
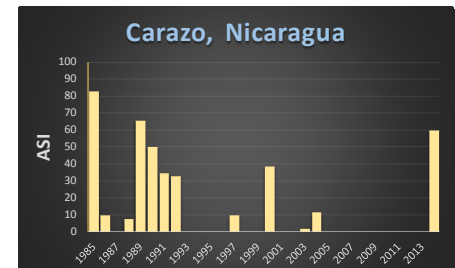
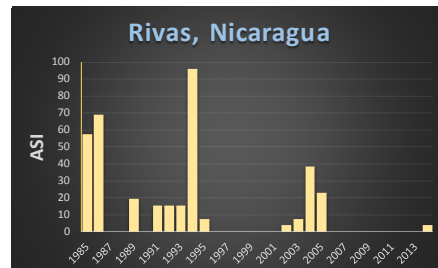
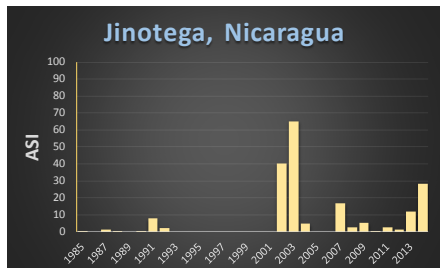
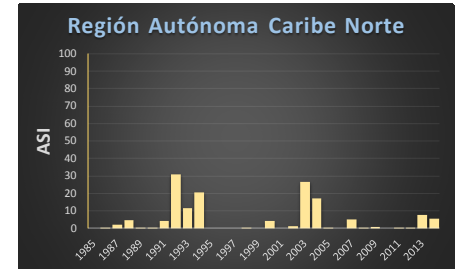
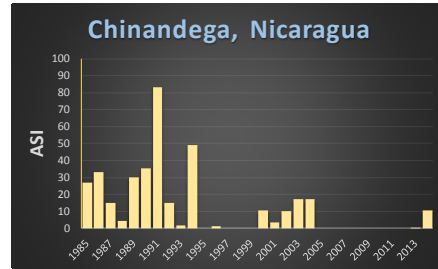
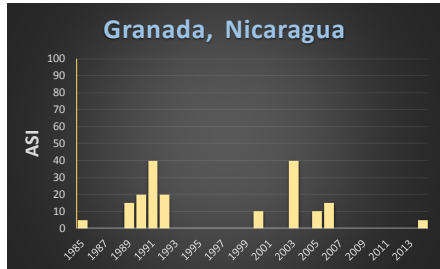
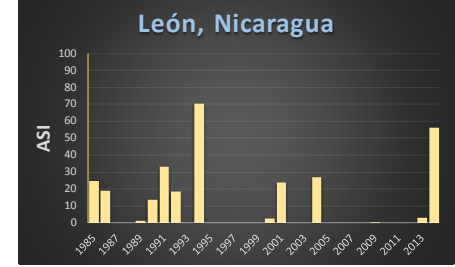
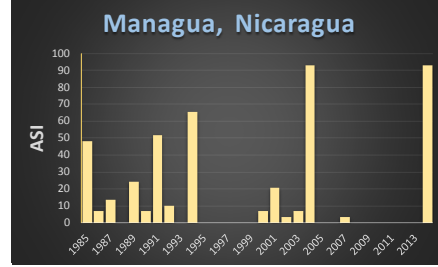
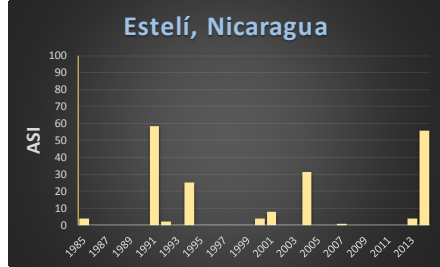
# Calibrated ASIS for Nicaragua



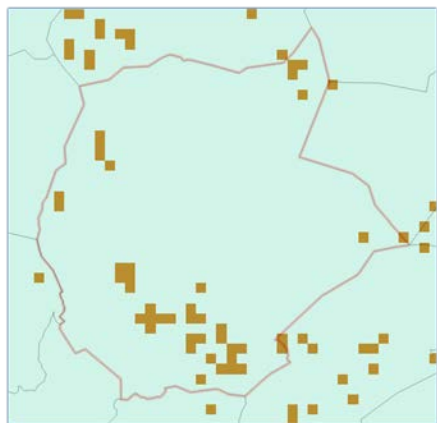


# Percentage of area staple crops affected by drought at country level

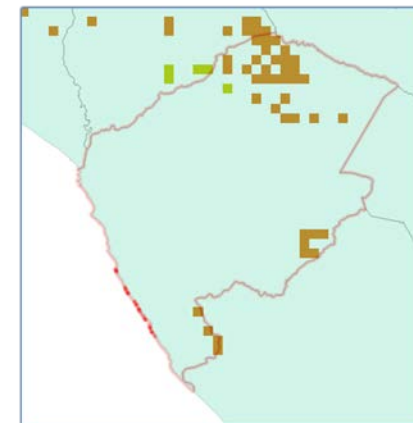
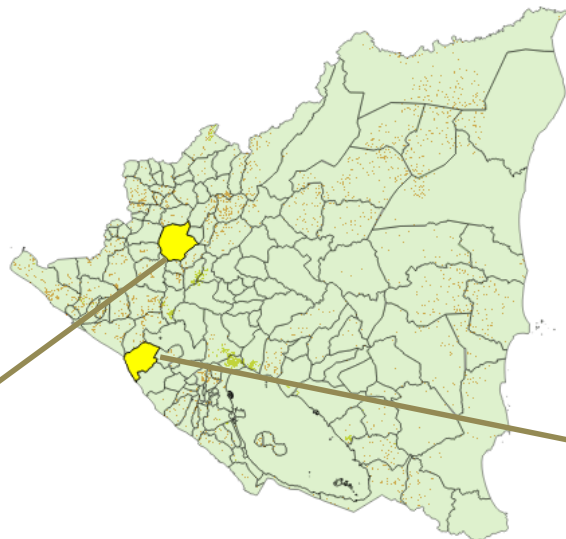




# Trigger for a indexed crop insurances based on geospatial data (1985-2014)

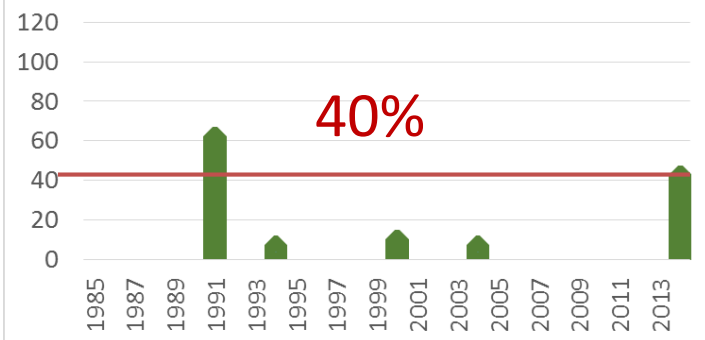


Fuente: INETER, 2017

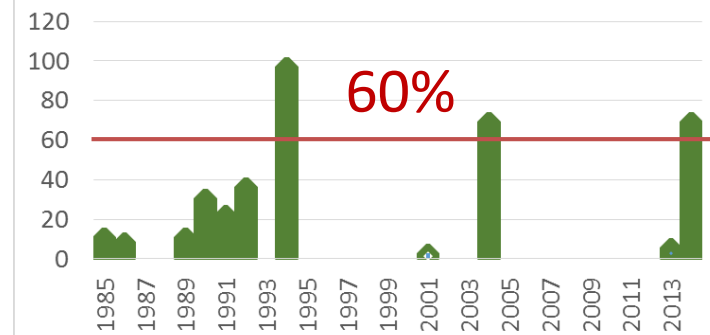


Fuente: INETER, 2017

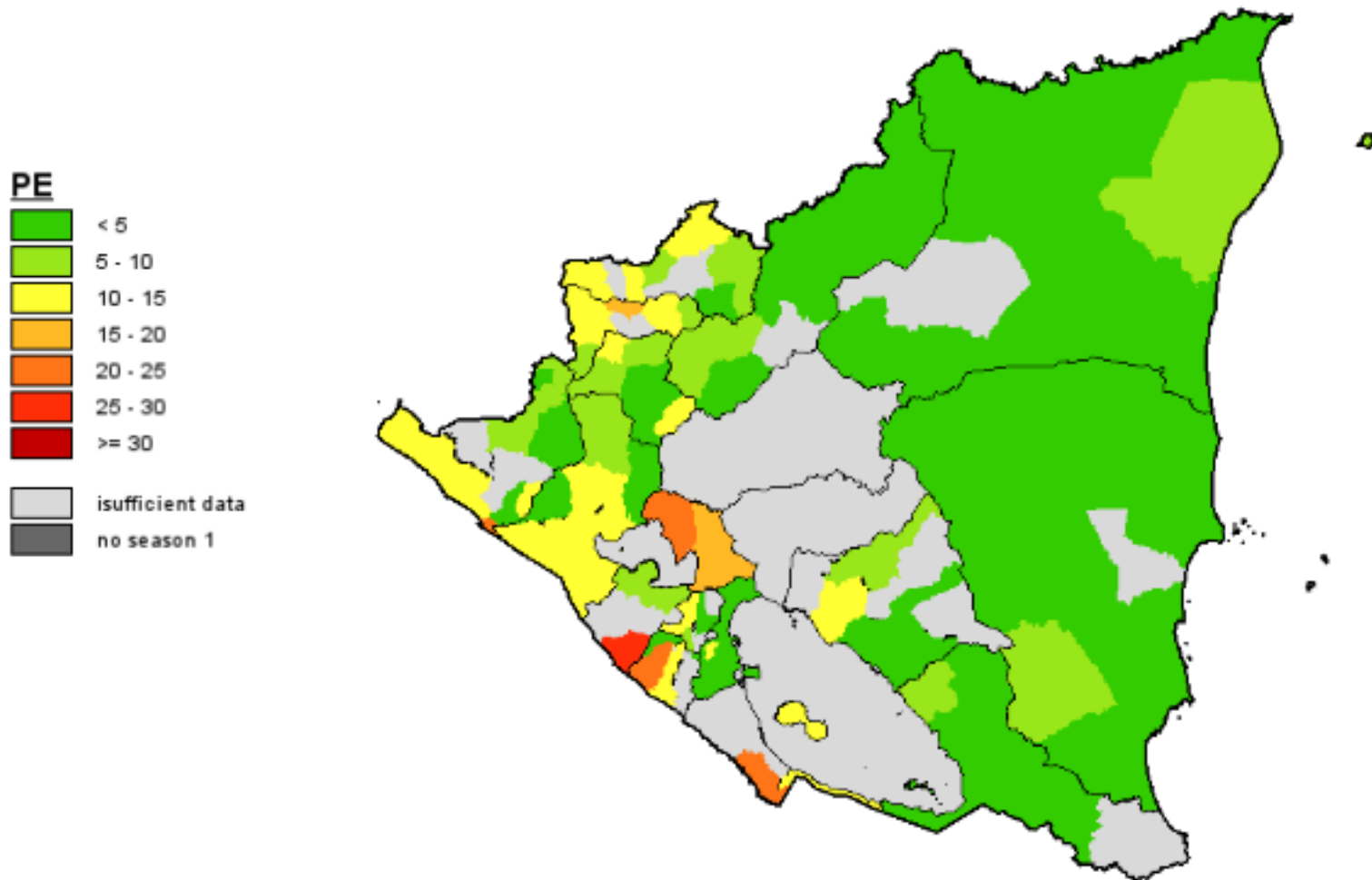
## Estelí, León



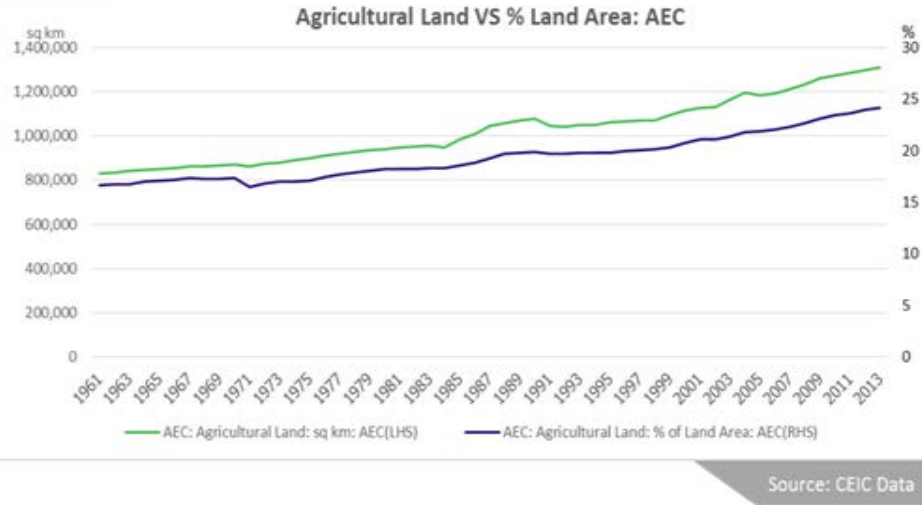
## Nagarote, León



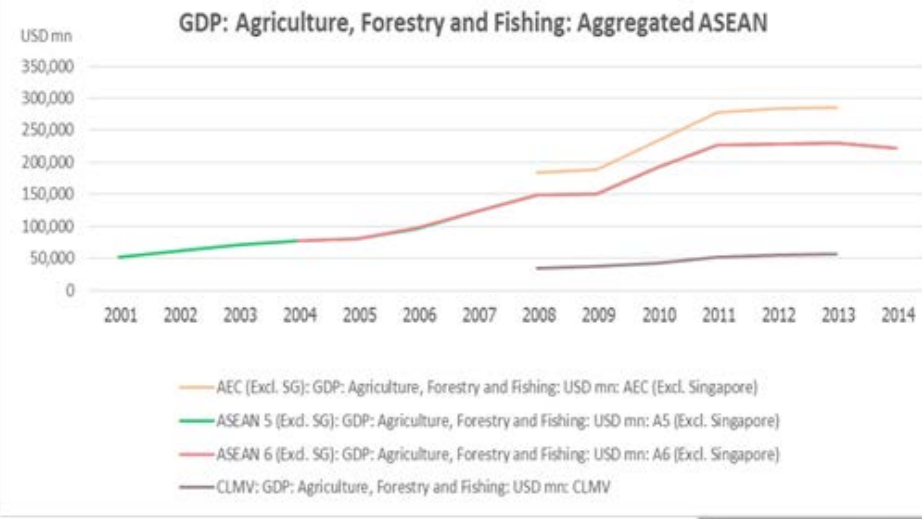
# Probabilidad histórica de ocurrencia de sequía agrícola por municipio (50% área granos básicos afectada) durante las siembras de Primera



# ALMOST 25% OF TOTAL LAND AREA IN ASEAN REGION IS DEVOTED TO AGRICULTURE



# AGRICULTURE ACCOUNTS FOR MORE THAN USD 200 BILLION OF GDP



## El Niño 2016

- January - June 2016
- Characterized by way below normal rainfall, warmer than average air temperature, dry spell and drought



affected LGUs

**16** provinces  
**65** municipalities  
**6** cities



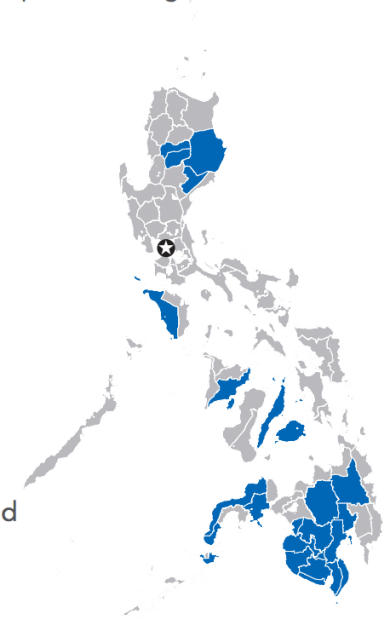
**285K**  
affected farmers



**379K**  
hectares of affected farmland



**US\$ 258M**  
agricultural production losses



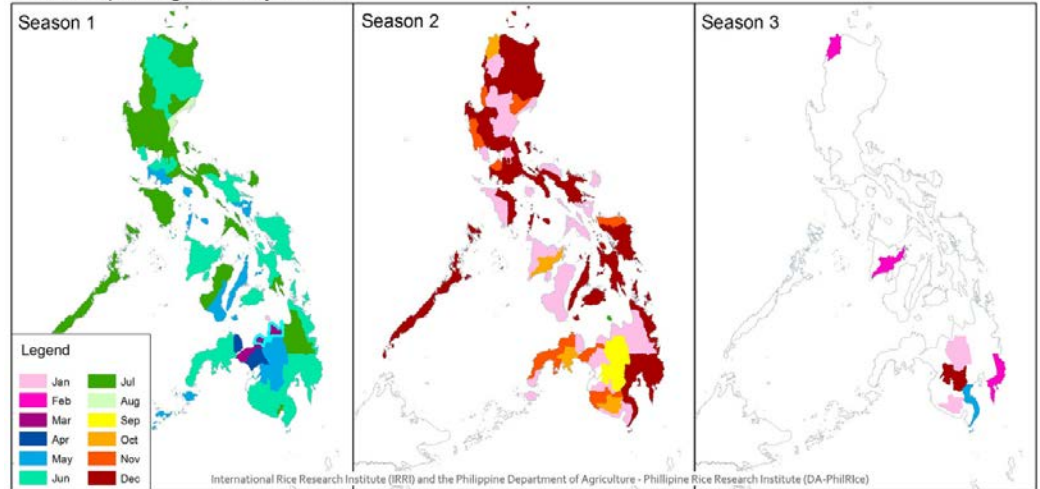
Source: UN-OCHA

# Calibration data for Philippines (raster of the location of rice areas, planting dates and crop coefficient)

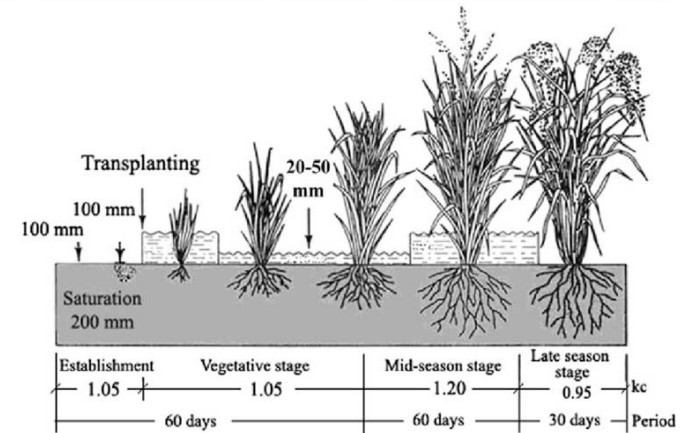


Rice Extent map of the Philippines 2000-2012 from MODIS imagery (Oct 2013 version) **Sources:** IIRI, DA-PhilRice, sarmap, GIZ

Peak rice planting month by season



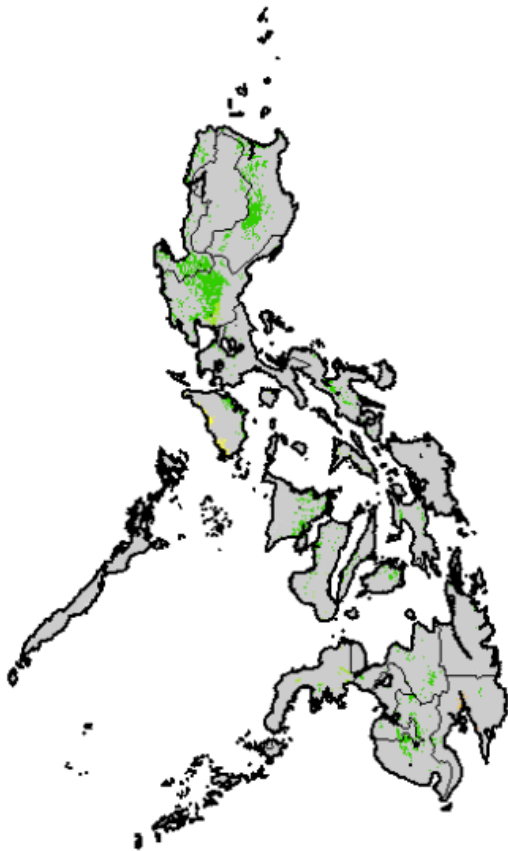
Aerobic rice (kc)  
0.95 1.00 0.97



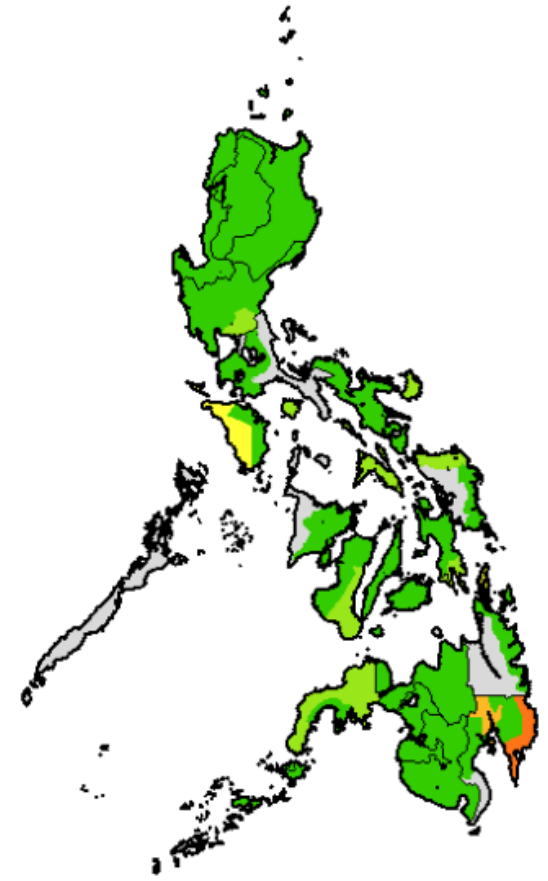
# ASIS Outputs: Percentage of rice area affected by drought:

a. at pixel level b. spatially averaged by province

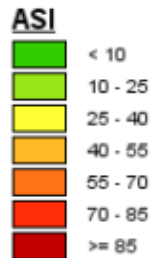
a. at pixel level



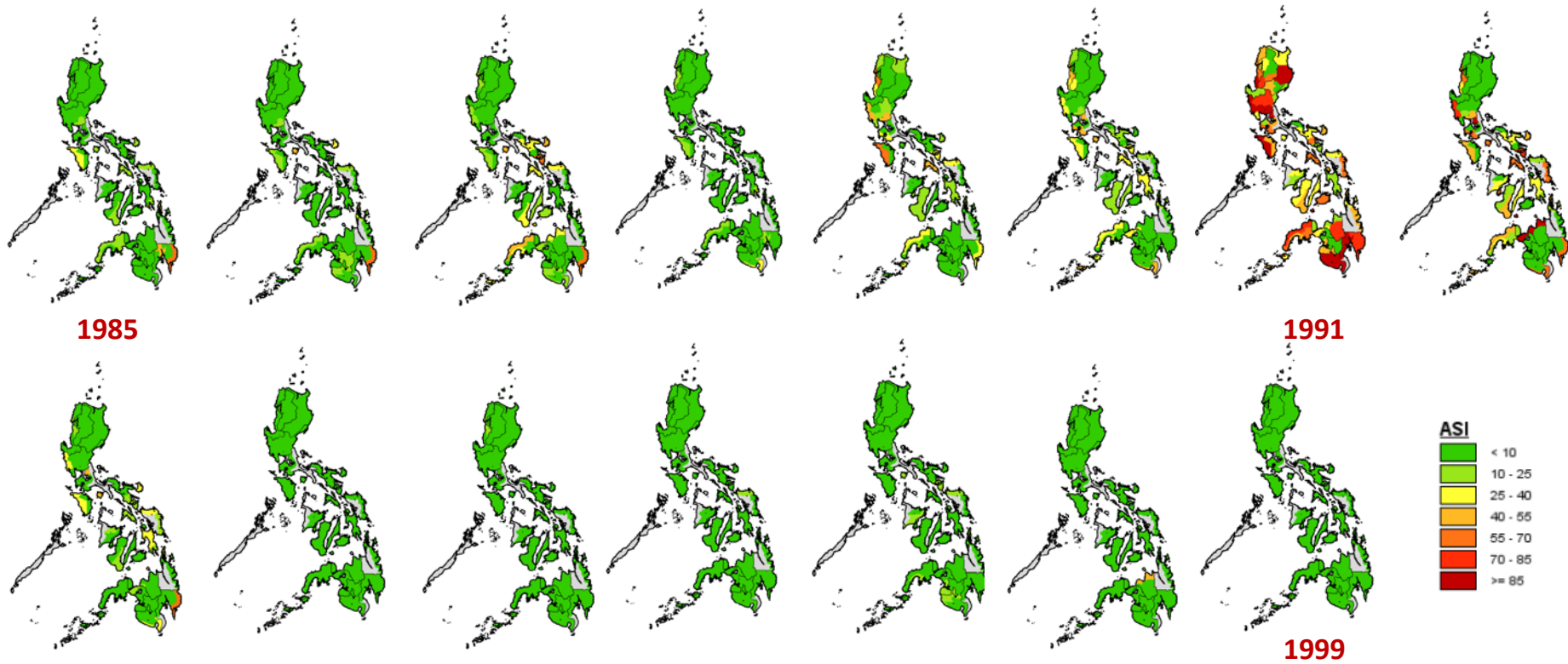
b. spatially averaged by province



First crop season  
1985



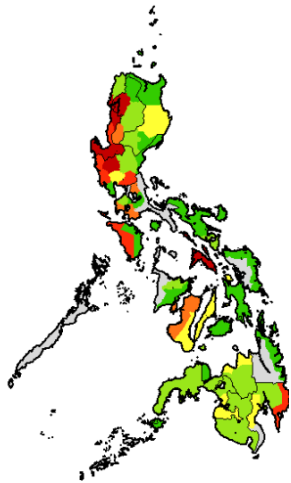
# ASIS Outputs: Percentage of rice area affected by drought for the first crop season from 1985-1999



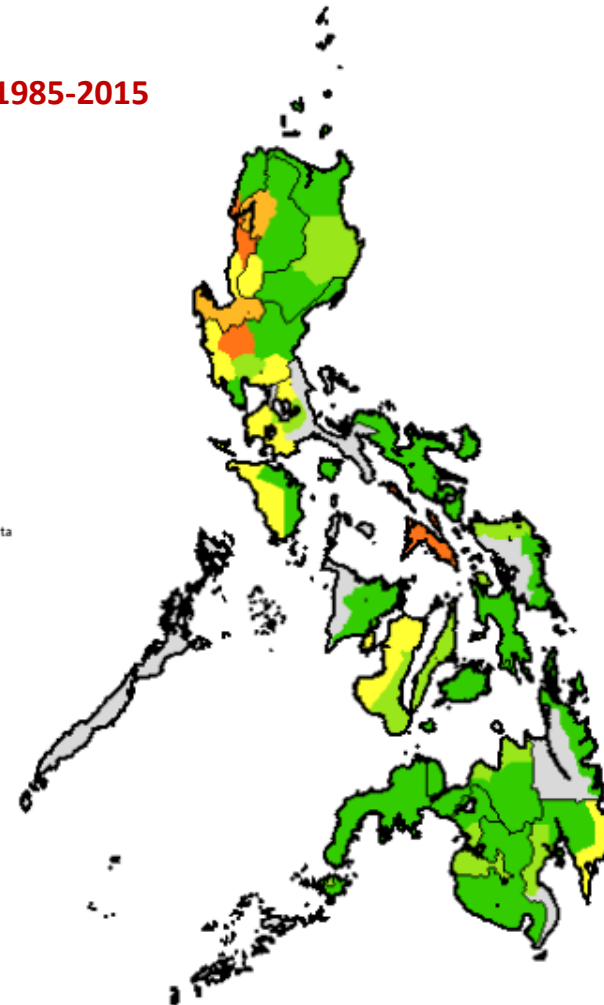


# Historical drought probability of having >50% of rice affected by drought per region during the first crop season

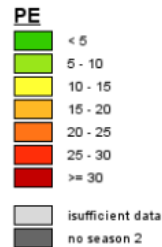
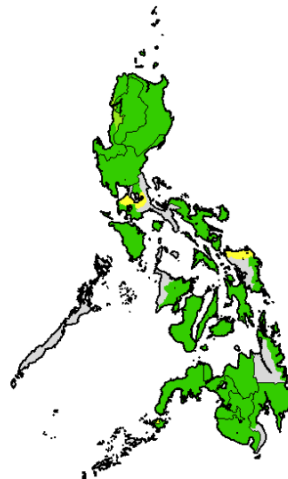
1985-1999



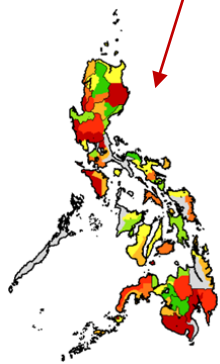
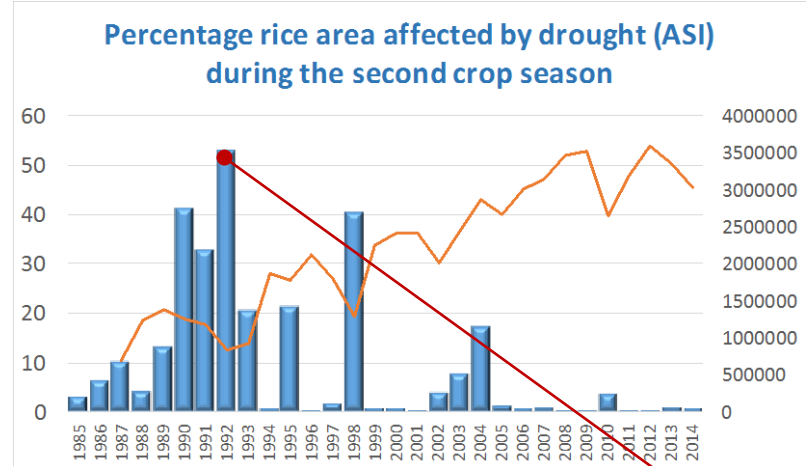
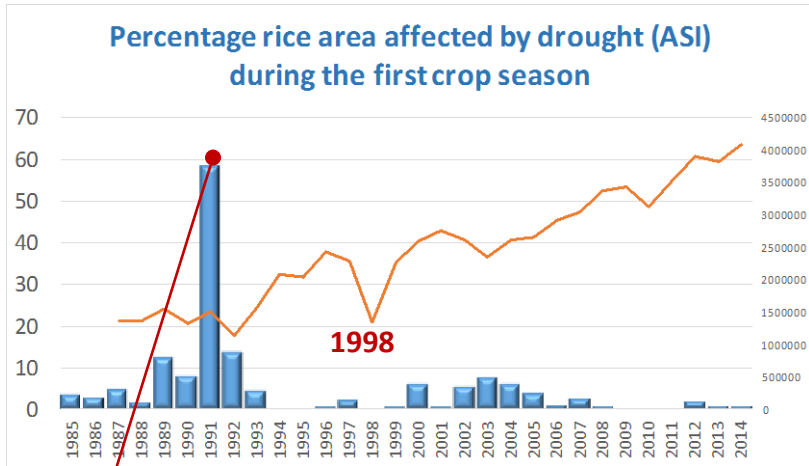
1985-2015



2000-2015

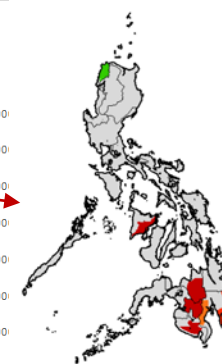
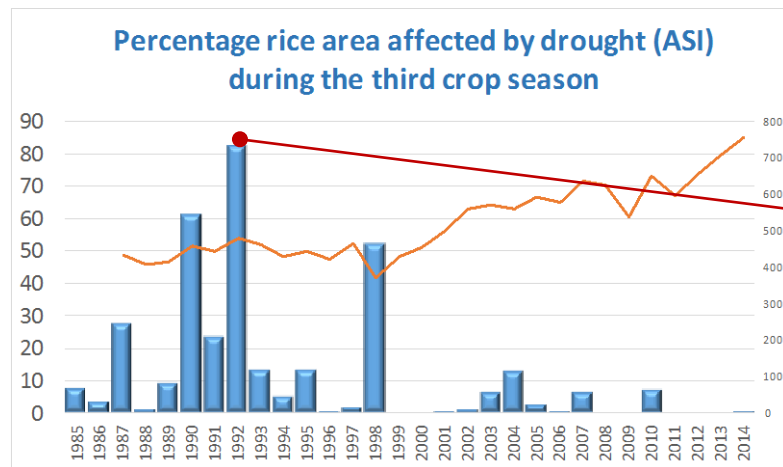


# Percentage of rice area affected by drought in Philippines

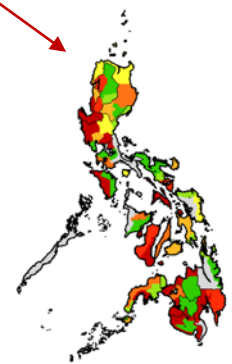


1991

ASI



1992

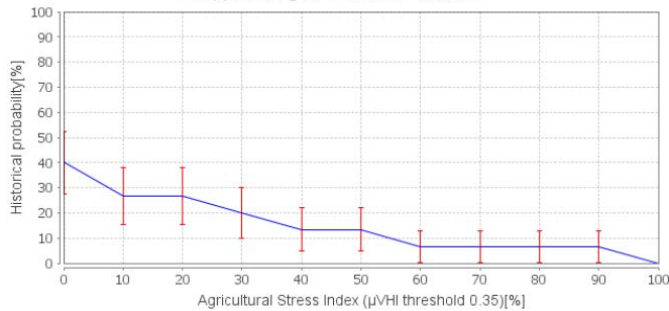


1992

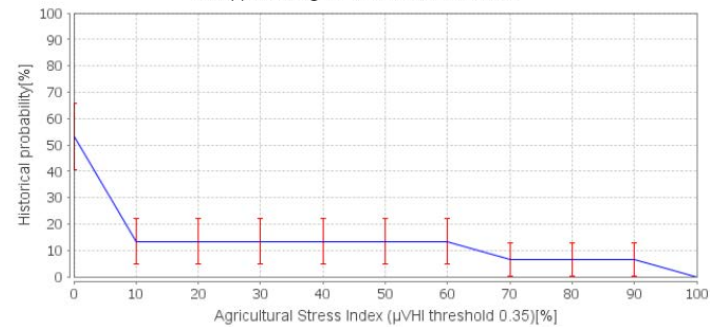
# Historical probability of having different thresholds of percentage of rice area affected during the first and second crop seasons in Misamis Oriental and Ilocos Sur provinces

Misamis Oriental

Philippines Region 1 - Class 1 - season 1

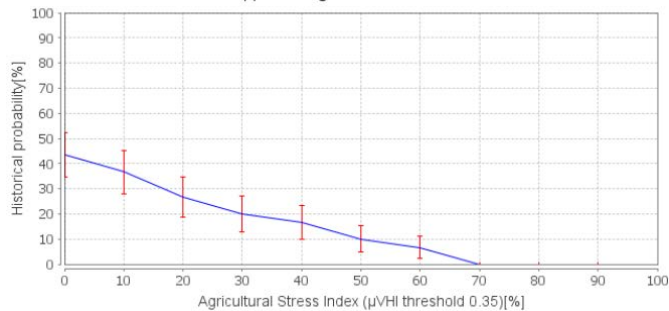


Philippines Region 1 - Class 1 - season 2

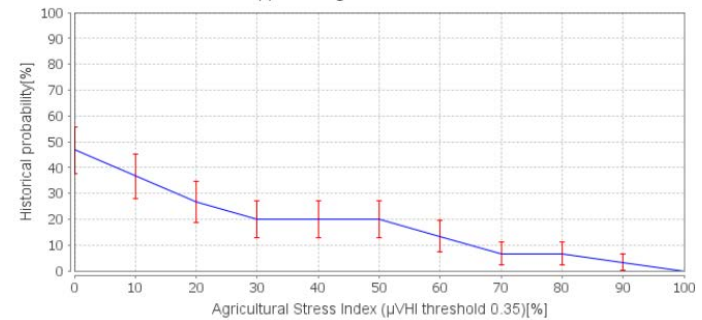


Ilocos Sur

Philippines Region 67 - season 1



Philippines Region 67 - season 2



# Syria

## Crop yield model based on ASI

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

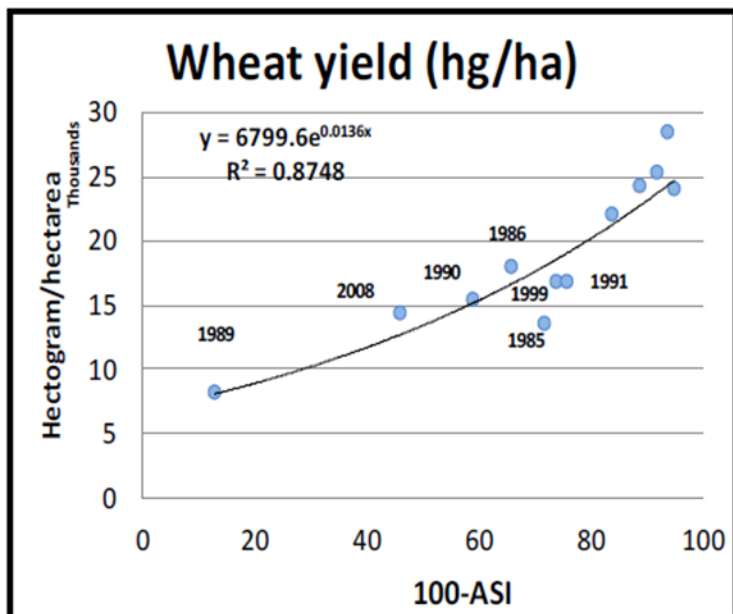
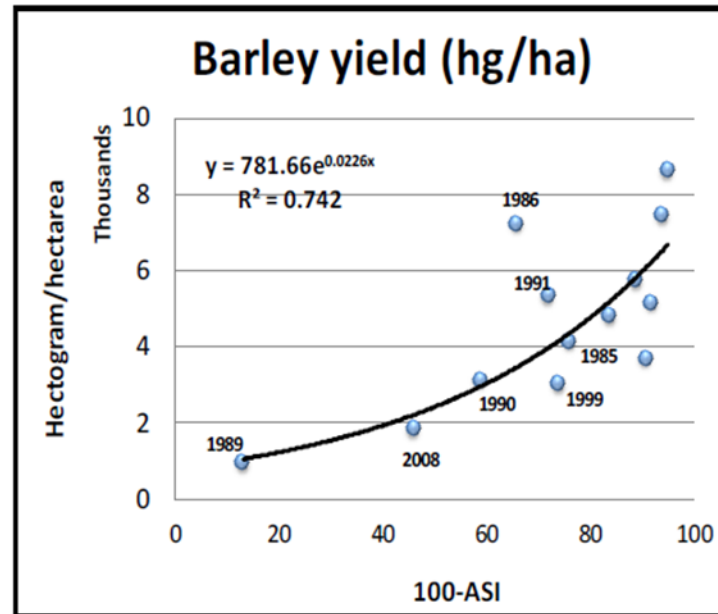
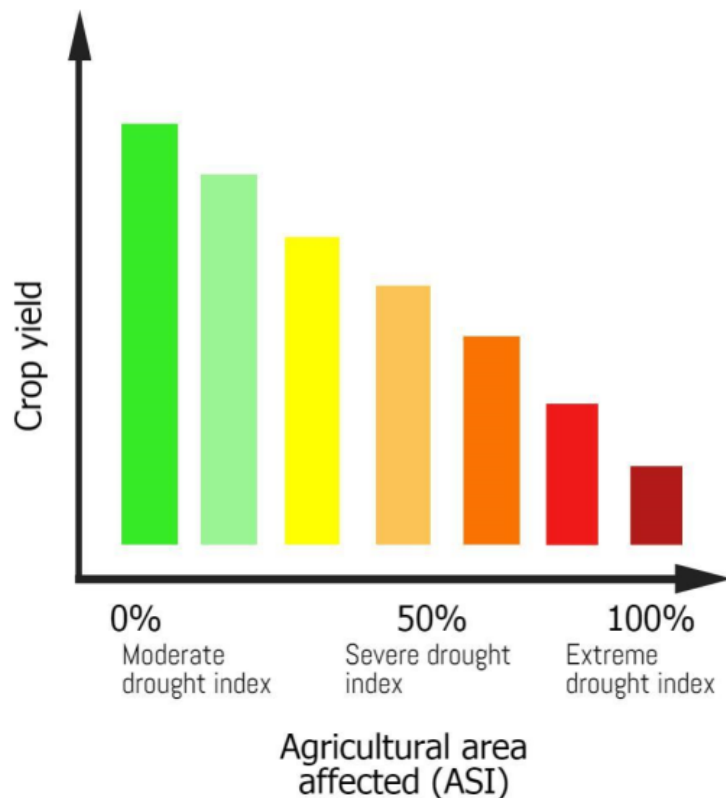


Figure 2: Barley yield model in which ASI explains 74% of the yield variation



## Agroclimatic Information System for supporting decision making



### Planning

- Monitoring
- Forecasting
- Public policy revision
- Investment planning



### Early warning - prevention

- Dissemination
- Hazard monitoring and tracking



### Contingency plan activation

- Risk reduction actions
- Water storage
- Drought resistant crops
- Short cycle crops

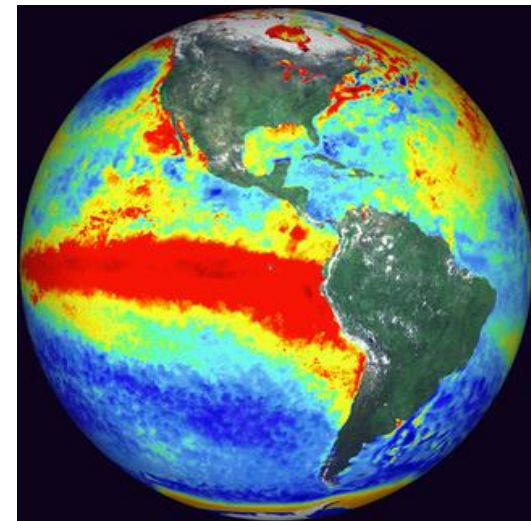
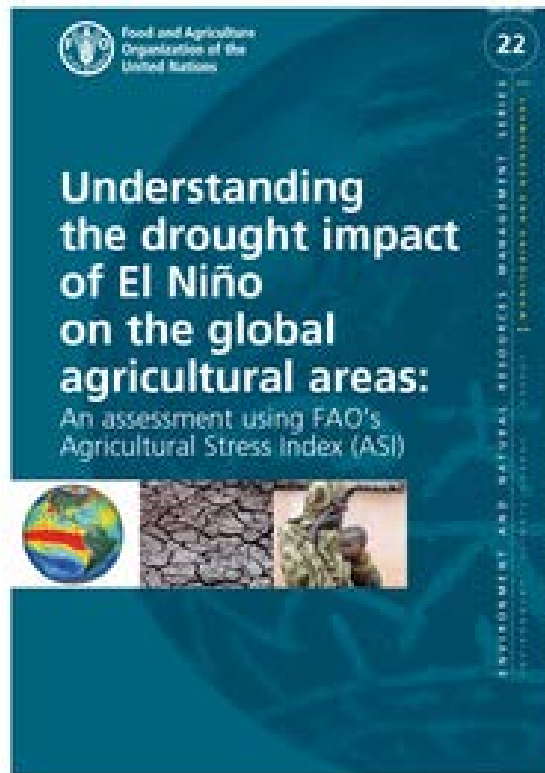


### Emergency response

- Catastrophe fund implementation
- Access to contingent credit lines
- Insurance payments
- Livelihoods rehabilitation

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

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

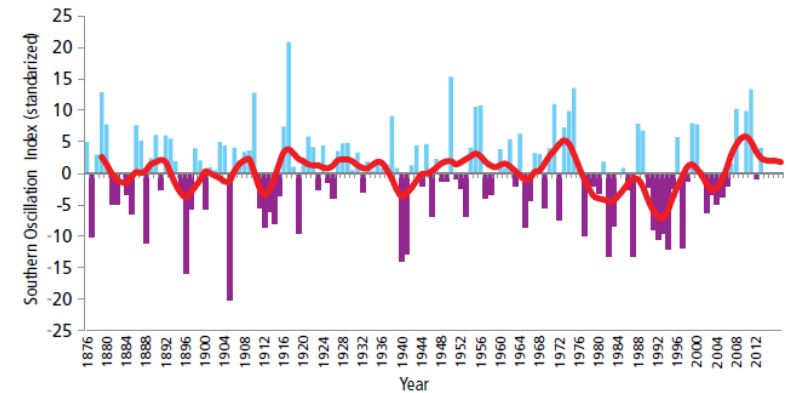


*El Niño observed from satellite. The red areas of the tropical coasts of South America indicate the pool of warm water. Source: NOAA*

# Relation between El Niño and area affected by drought (ASI)

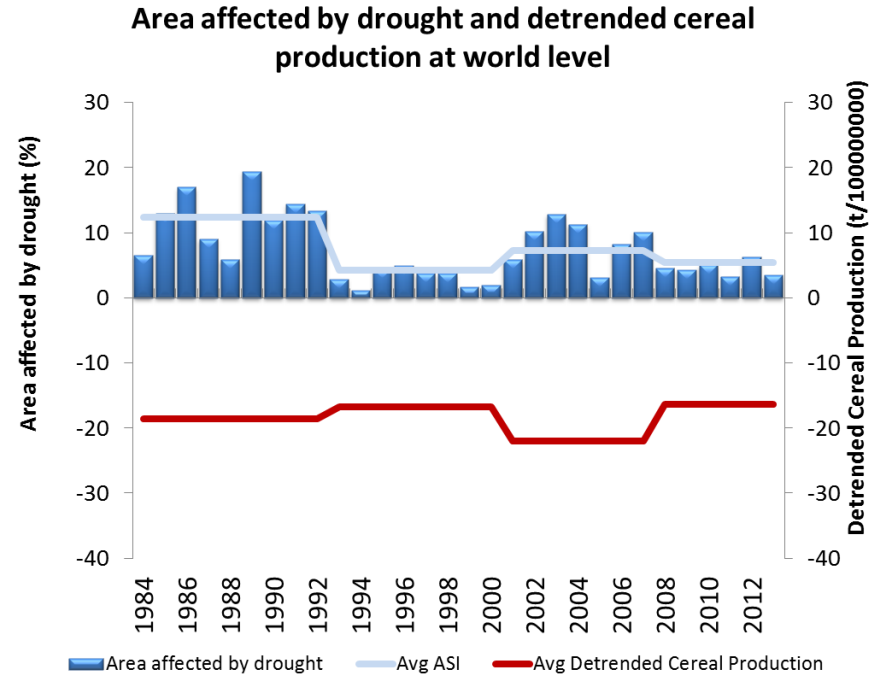
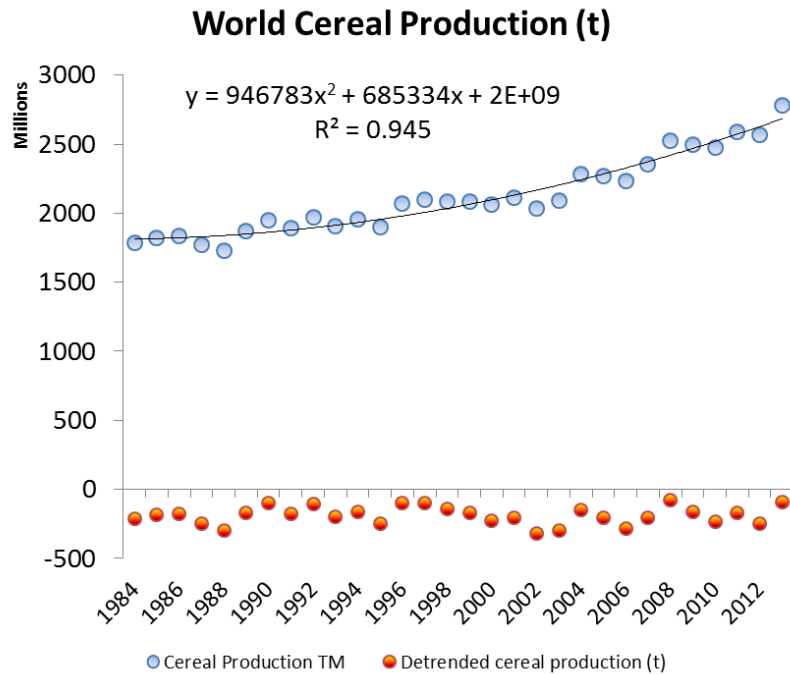


The Southern Oscillation Index (SOI) (1876-2013) calculated by the Australian Bureau of Meteorology



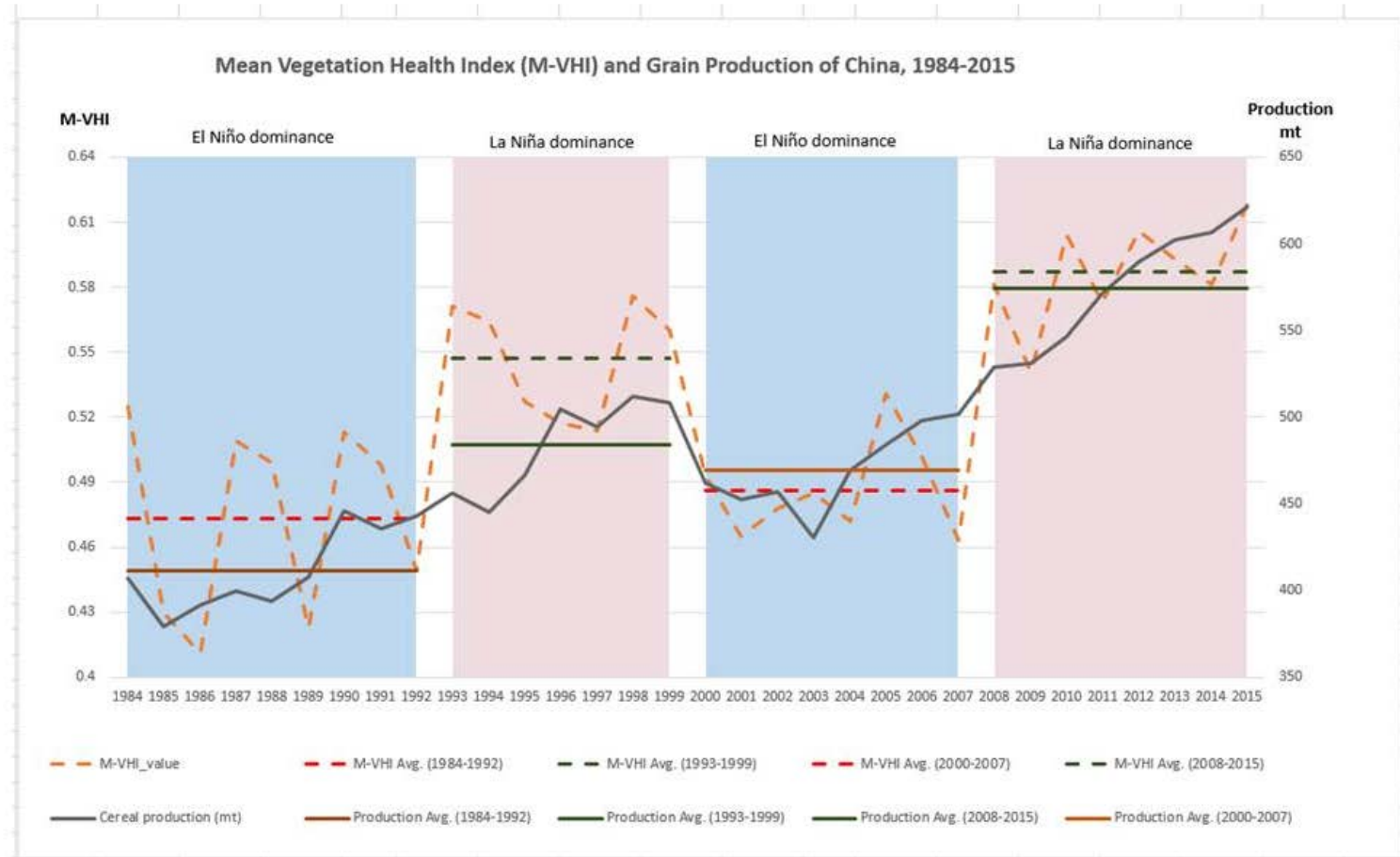
Source: <http://www.bom.gov.au/climate/current/soihtm1.shtml>

# Relation between El niÑo dominance, Area affected by drought and cereal production

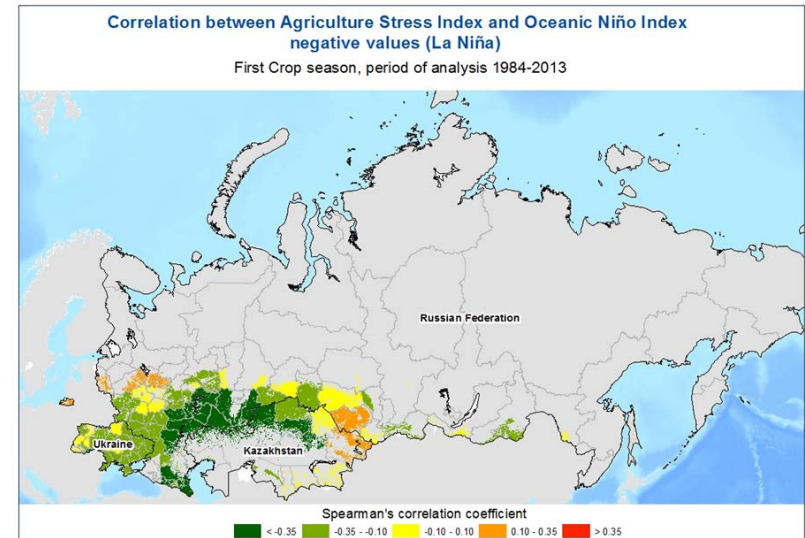
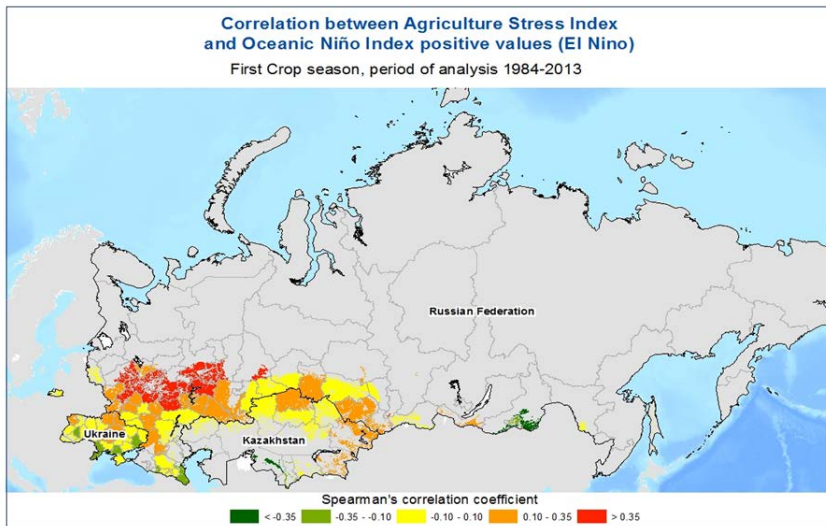




# Relación entre VHI y la Producción de granos en China (1984-2015)

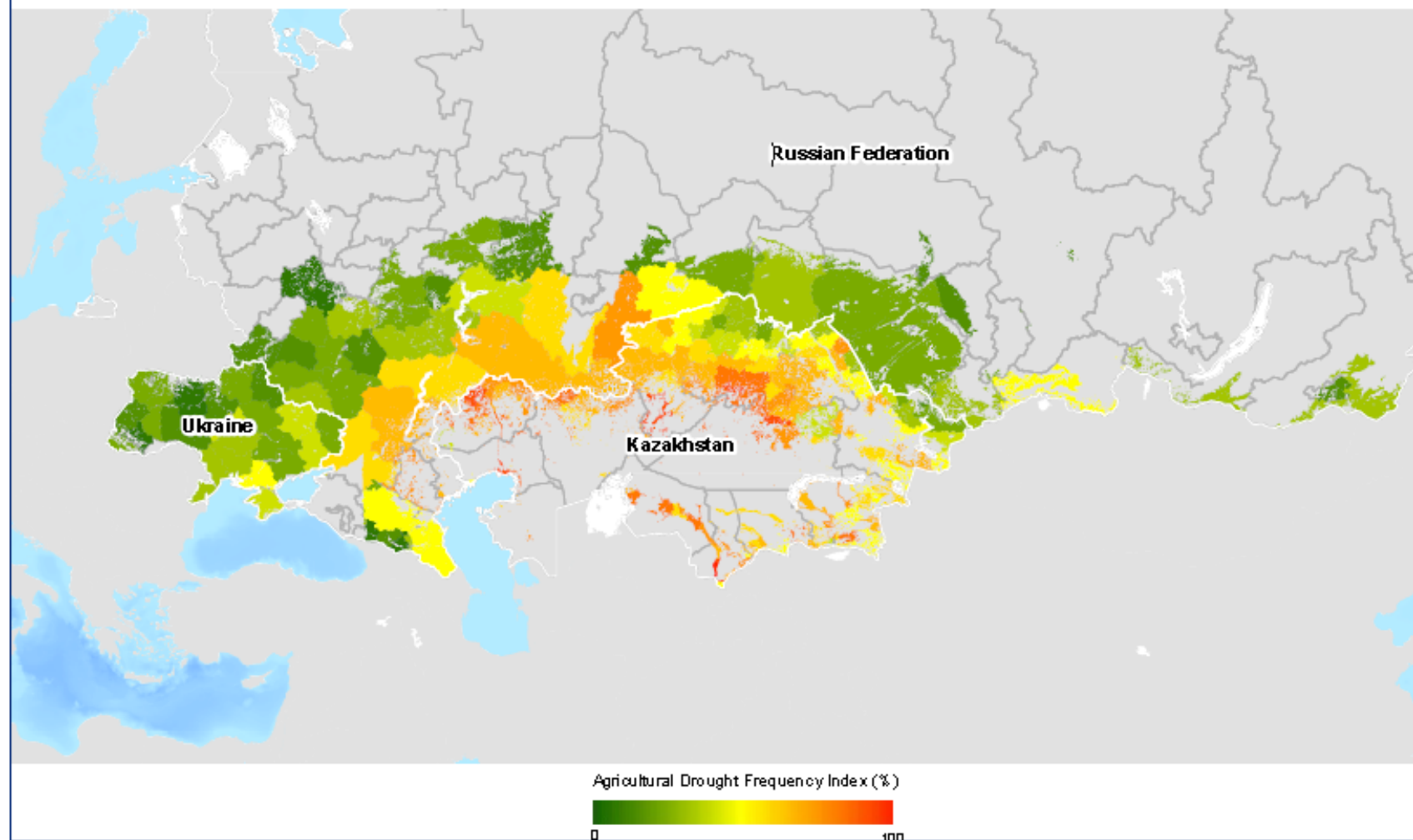


# El Niño/La Niña influence on drought in Ukraine, Kazakhstan and Russia Federation

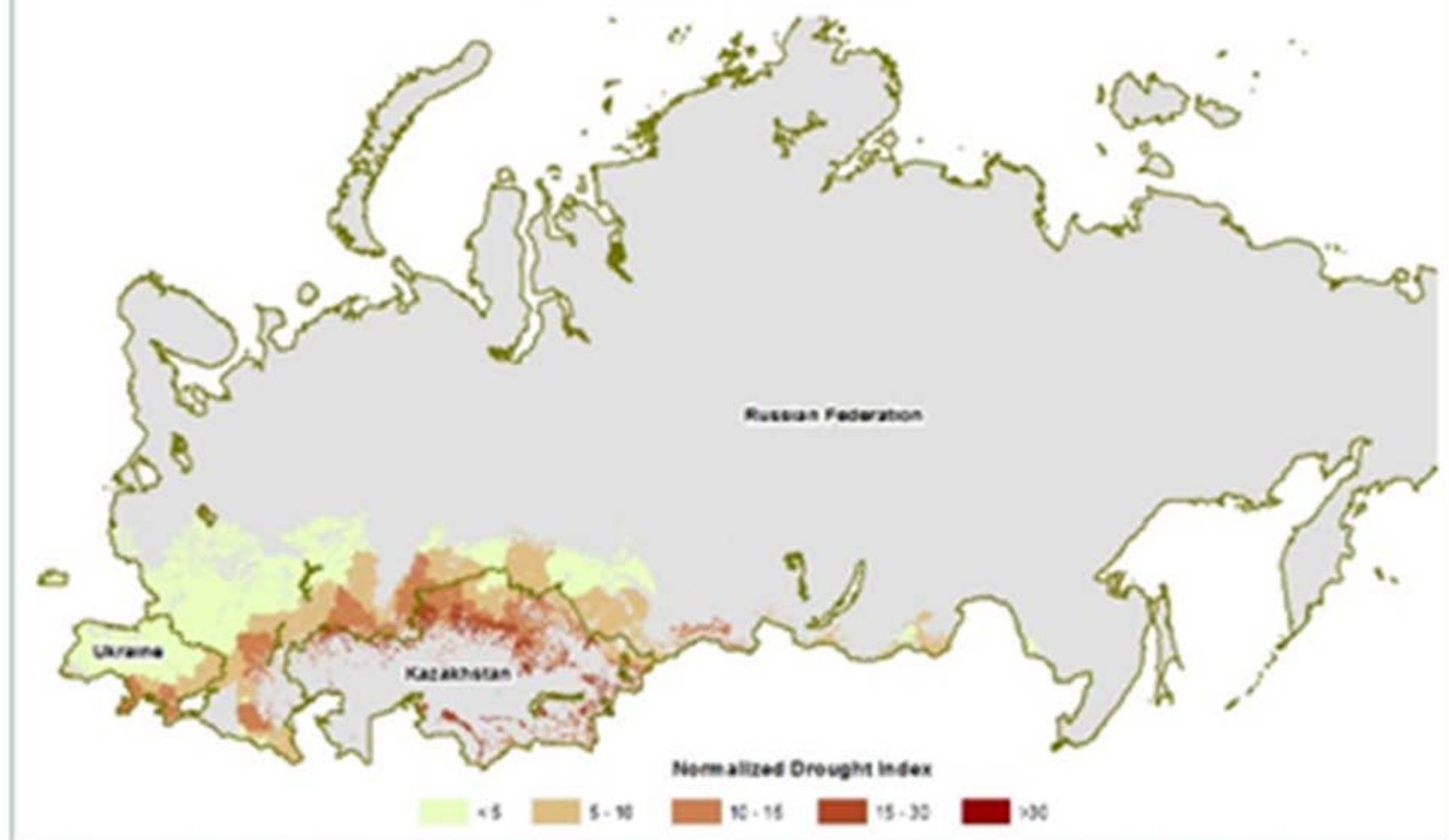


## Agriculture Drought Frequency of La Nina declared years

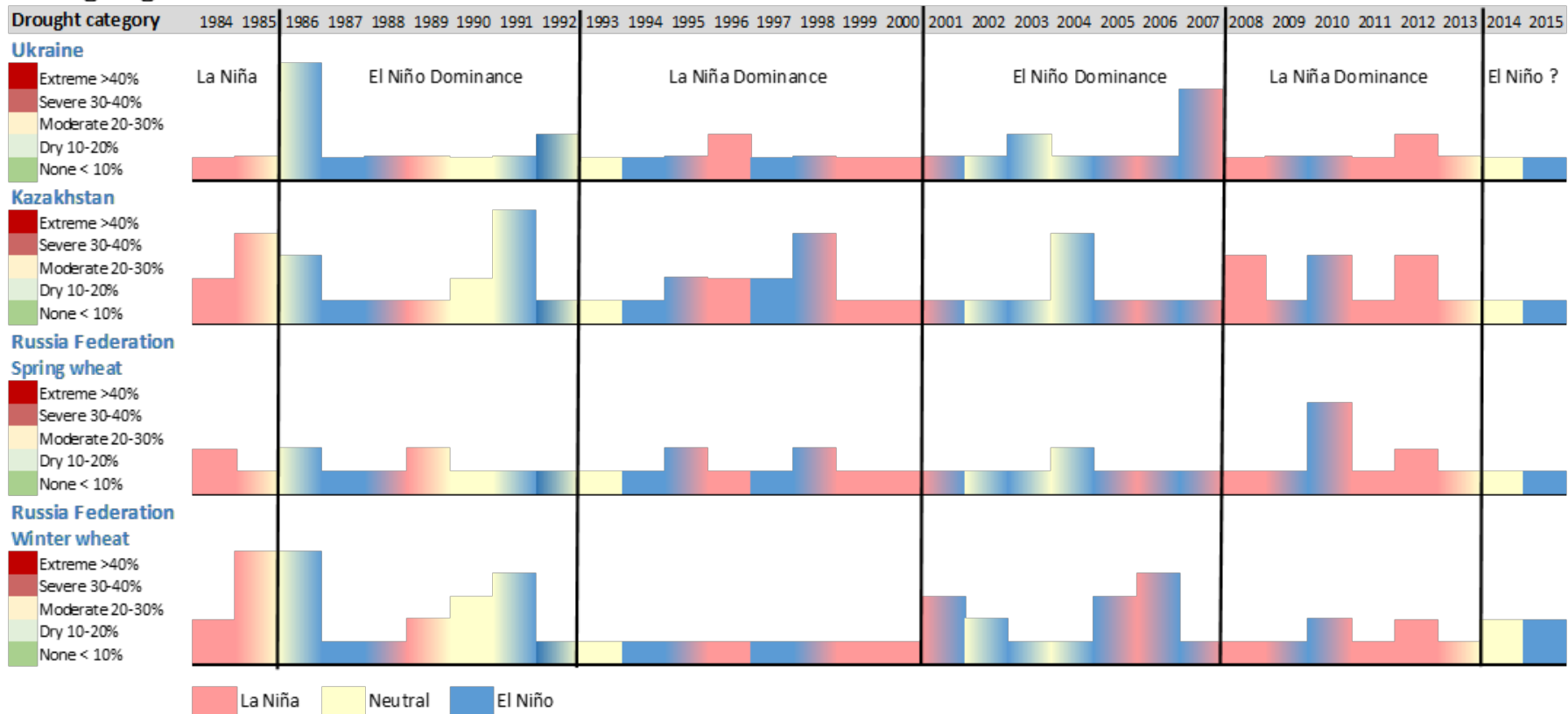
First Crop season (Period of analysis 1984-2013)



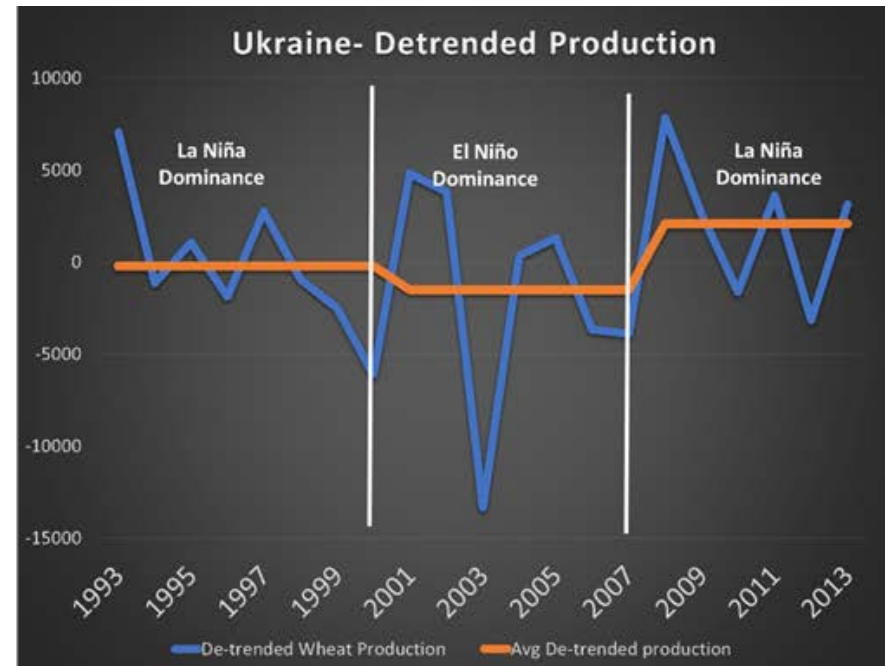
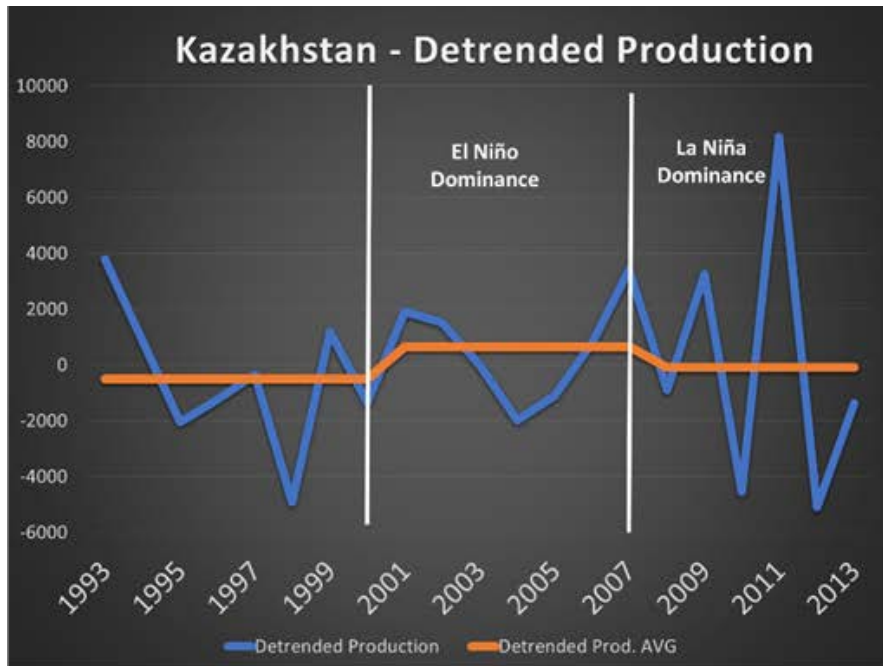
**Normalized Drought Index in RUK region**  
(Period of analysis 1984-2013)



# Drought-gram



# Detrended-Wheat Production and El Niño/La Niña Dominance



# Spring wheat yield during the El Niño/La Niña dominance, Kazakhstan

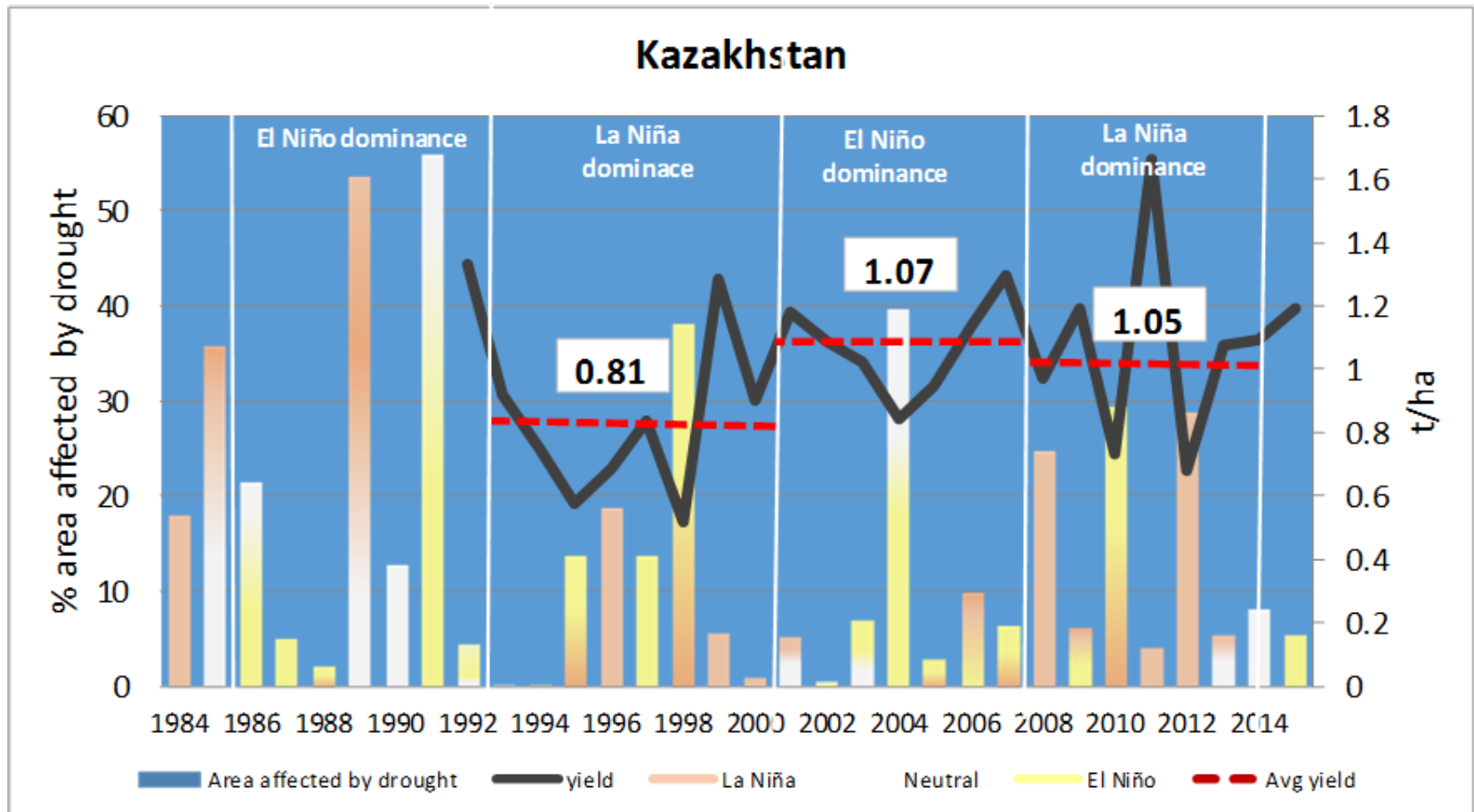


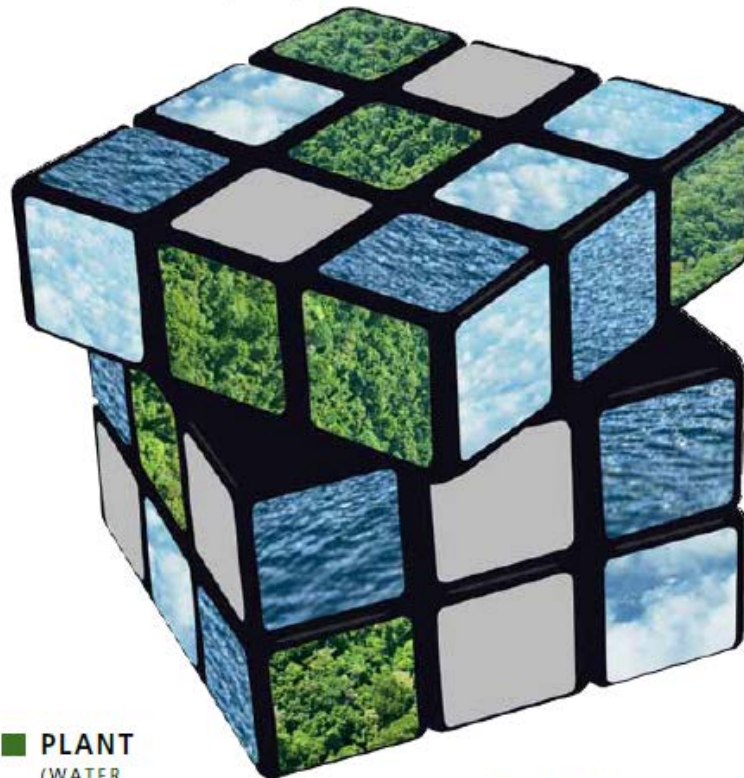
FIGURE 31

Rubik Cube description of the determinant variables of the occurrence of an El Niño phenomenon.

**ATMOSPHERE**

(INITIAL STATE, INTERACTION WITH OTHERS PHENOMENON, ENERGY BALANCE, ETC.)

**UNKNOWN**



**PLANT**

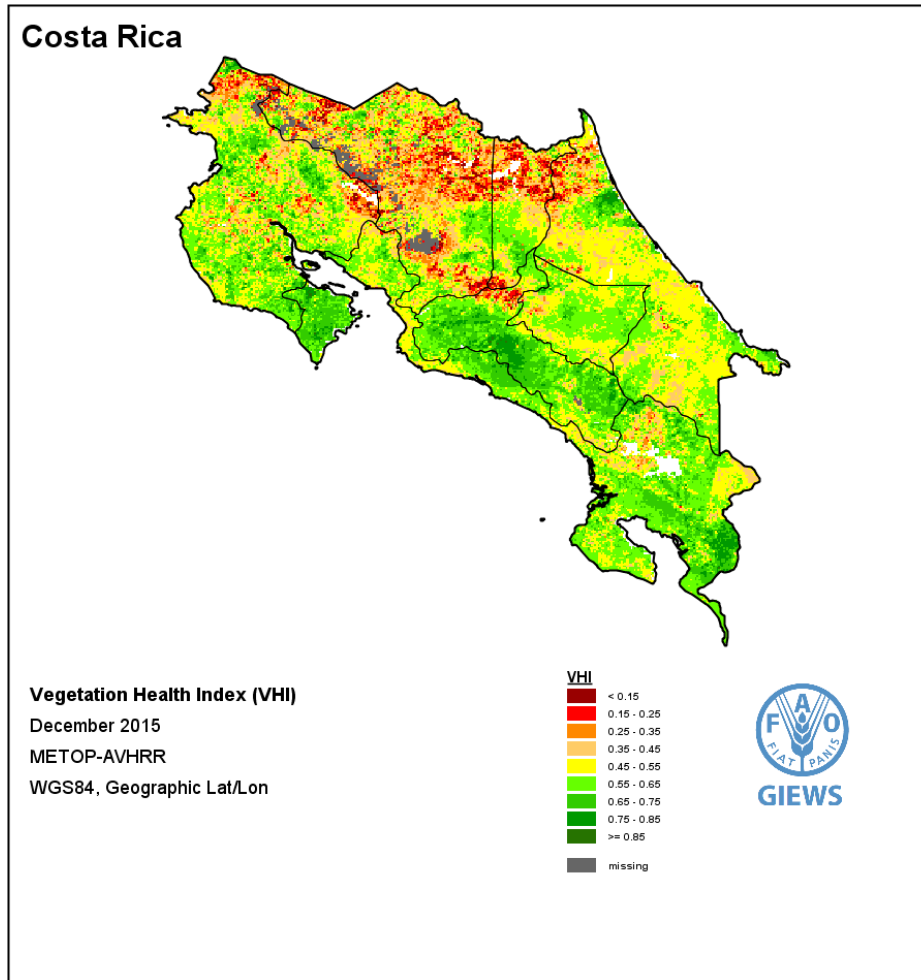
(WATER REQUIREMENTS OF THE DIFFERENT PHENOLOGICAL PHASES AND DIFFERENT CROPS)

**OCEAN**

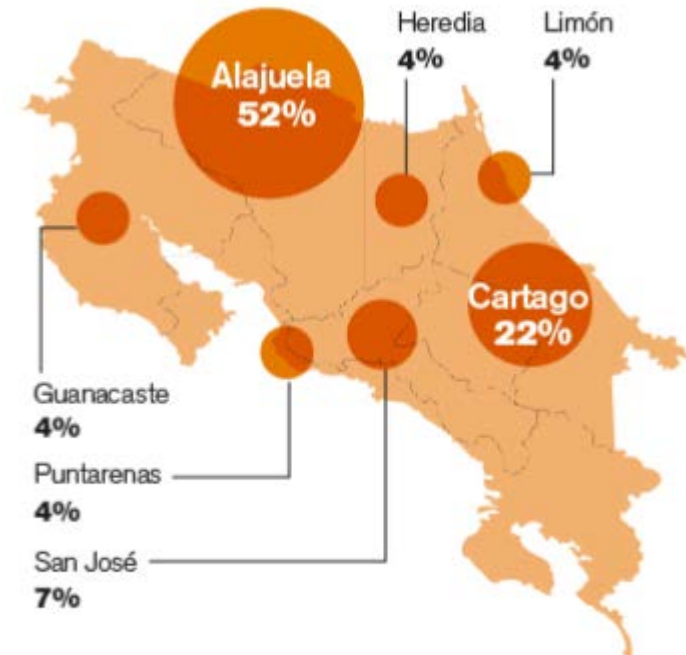
(INITIAL STATE, SEA TEMPERATURES ON SURFACES AND DEEPLY WATER, ETC.)



# Áreas de sequía e incidencia de casos de gripe AH1N1



## Procedencia



**Nota:** Un 4% corresponde a población extranjera

